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Demand Response (Peak Load Reduction) System Pilot and Feasibility Study

Final Report

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Demo City: Tianjin Economic Development Area

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Note: In February 2012, a restructuring between State Grid Electric Power Research Institute (SGEPRI) and China Electric Power Research Institute (CEPRI) was conducted at the request of the State Grid Corporation of China (SGCC), the parent company of both SGEPRI and CEPRI. SGEPRI's research functions were merged with CEPRI's research organization. As a result, the SGCC entity hosting this USTDA project was changed from SGEPRI to CEPRI. For simplicity throughout this Final Report, we have referred to CEPRI as the project client.

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Preface

A reliable power supply is critical to China's national security, economic growth and the general welfare of its population. However, without making fundamental changes to how the electric grid operates, the task of delivering adequate electricity supply is becoming more and more difficult. In terms of electricity supply, China is seeking cleaner and more economic energy sources. Older fossil-fuel generation, particularly through the use of imported fuels, raises certain energy security and greenhouse gas (GHG) emissions concerns. And, in terms of electricity demand, many segments of society — and especially the manufacturing sector and the middle class — are consuming ever-increasing amounts of electricity.

As such, China is seeking innovative ways to tackle this growing economic issue. China's leadership recognizes that new approaches to energy policy are critical to support their national economic policy and security objectives. Today, China largely addresses electricity shortages by cutting off the power supply to specific customer segments. Though generally effective in helping stabilize the electrical grid, such absolute measures severely affect such segments, especially commercial entities, altering their operations.

China continues to invest heavily in large scale renewable generation, principally wind and solar, in addition to significant transmission network upgrades. A real challenge with integrating renewable energy into the electrical grid is that wind and solar are intermittent resources. As such, additional support (ancillary services) is often required to supplement wind and solar generation utilized by grid operations. A common answer to this challenge is to build more fossil fuel peaking plants. However, automated demand response (AutoDR) offers China an important alternative, and provides the clean, fast and reliable support needed to integrate wind and solar in a more stable manner onto the electric grid.

Full adoption of a new energy resource is critical for helping to provide security to China's energy future and establishing a more reliable and low-cost electrical supply. For China, the answer has come in the form of base load and peak load reduction, which helps establish a cleaner, domestic and more affordable energy resource that benefits key stakeholders, including:

- **The government**, which seeks to limit GHG emissions, lower overall energy prices and reduce reliance on imported fuels.
- **Utilities**, who gain new and reliable tools to operate their transmission and distribution networks more effectively and efficiently.
- **Consumers of electricity**, who, as rate payers, seek greater control over their energy usage and new and mutually-beneficial relationships with their electricity provider.

Peak load and base load reduction measures are often especially appealing options because of their wide applicability. Industrial, commercial and residential users all typically have the ability to reduce their electrical usage on both a permanent (base load) and a temporary (peak load) basis. As such, policies and programs that provide adequate incentives for both base load and peak load reduction program participation are essential. From a base load reduction standpoint, incentives to invest in updated equipment and controls enable existing factories, buildings and homes to reduce their overall electrical consumption. Regulation and policies for new construction can provide the necessary directive to designers and developers to use current best-in-class efficiency equipment and controls. A key a benefit of base load reduction is a decrease in the number of power plants needed.

In contrast with base load reduction, reducing peak usage is a newer concept within China. Fortunately, participation is simplified due to the operational flexibility already built into the equipment, controls, and process designs of existing buildings and factories. Facilities can regulate their critical building and/or process parameters, thereby altering their electricity consumption profile. In this manner, these facilities effectively become "smart-grid ready" buildings. For example, commercial buildings with appropriate energy management systems have the ability to adjust their air flow and temperature, modifying their load consumption profiles with the proper use of their existing operational flexibility.

Virtually any building with electrical equipment can be outfitted with current technology to enable temporary usage reduction. In this manner, existing building stock also can be turned into "smart grid-ready" buildings. To realize the full benefits from "smart grid-ready" buildings, utilities need to connect to these facilities via a central, automated dispatch system.

In support of peak and overall consumption reduction, there is growing interest in combining peak load and base load reduction programs and technologies. While these programs have slightly different goals (overall consumption reduction vs. temporary reduction), their objectives are complementary and typically generate greater results when combined.

Realizing the promise of peak load reduction as a cost-effective alternative to constructing new power plants, the China Electric Power Research Institute (CEPRI) formed a team with the support of the U.S. Trade and Development Agency (USTDA) to investigate the potential for AutoDR using open standards in China. The resulting "Demand Response (Peak Load Reduction) System Pilot and Feasibility Study" validated AutoDR can be a valuable energy resource for China.

Executive Summary

The Demand Response (Peak Load Reduction) System Pilot and Feasibility project was performed for the China Electric Power Research Institute (CEPRI) by a team made up of Honeywell International and AECOM. The project was funded in part by the U.S. Trade and Development Agency (USTDA) under a grant agreement with CEPRI. Honeywell and AECOM also contributed significant cost-share funding.

This pilot included a field installation and demonstration of Honeywell demand-side management technologies in select commercial and industrial pilot sites to demonstrate the feasibility of adopting peak load reduction solutions within China's grid infrastructure. The pilot demonstration sites were selected jointly with the pilot city partner for this project, as well as Tianjin Economic Technological Development Area (TEDA) and CEPRI. Honeywell and AECOM also performed a review of regulatory issues, developed peak load reduction benchmarks and analyzed financing mechanisms so as to assist CEPRI in designing a national peak load reduction implementation strategy. This document presents an executive summary of the technical work performed on the project.

For China to realize the full potential from base load and peak load reduction, supportive pricing, incentives and policy likely are required. Utilities often need clear direction and funding to pursue investing in this new domestic and clean energy resource. This pilot demonstrated that technology does not appear to be a barrier to wide-scale deployment.

Project Overview

The technical work in this project consisted of eight major tasks:

- Task 1: Project Plan
- Task 2: Analysis of Available Information and Case Study Benchmarks
- Task 3: Pilot Project Selection, System Design and Incentive Strategy Proposal
- Task 4: Execute Pilot Project Implementation Plan (Pilot Demonstration)
- Task 5: Regulatory Review, Market Demand Forecast and Cost Estimates for Pilot City
- Task 6: Economic and Financing Mechanism Analysis
- Task 7: Development Impact Assessment
- Task 8: Assessment of U.S. Sources of Supply for Automated Demand Response Technology

The following sections present the key results of the Demand Response (Peak Load Reduction) System Pilot and Feasibility project.

Transmission and Distribution System Operations

China is served by two main utilities —State Grid Corporation of China (SGCC) and China South Grid (CSG). SGCC supplies electrical power for most areas of the country, except for several southern provinces. SGCC is a government-owned enterprise approved by the State Council to conduct government authorized investment activities. The mission of the company is to provide safe, economical, clean and sustainable electric power for social and economic development. The company's core businesses are the construction and operation of the power transmission and distribution network that covers 26 provinces, autonomous regions and municipalities. Its service area represents 88 percent of the national territory, supported by more than 1,500,000 employees, and serves a population of more than one billion.

TEDA Power is owned by the local government of Tianjin. TEDA Power purchases electricity from Tianjin Electrical Power Corporation, which is owned by the North China subsidiary of SGCC, and it sells electricity to industrial, commercial and residential customers inside TEDA.

Current and Projected Peak Load Reduction Policies and Potential Solutions

The National Energy Administration (NEA), in conjunction with the National Development and Reform Commission (NDRC), sets electricity prices in China. Together, these agencies set domestic wholesale energy prices and help implement the national government's energy policies. The NEA and NDRC also regulate the retail price of electricity in each province, based on a cost-plus-revenue model. They price energy based on the industry sector and the voltage at which it is delivered to the customer. No constant electricity prices exist in China, and prices vary throughout the country. The electricity pricing structure used for TEDA users is the same in principle as for electricity purchased from the state grid, but is adjusted to reflect the committee's development policies. TEDA's development and planning department implements this pricing structure.

With the recent pace of economic development in China, the demand for electricity has increased greatly, resulting in electrical power shortages — particularly during periods of peak demand in the summer, when energy use often strains the grid. In 2011, the disparity between generation and load was 30 gigawatts during critical peak times, and serious power shortages are expected to continue.

Problem: To reduce peak load in the summer time, the central government (NDRC) published a special load management policy called "Orderly Power Consumption." According to the policy, a power cut-off order can be made based on negotiation among SGCC, local government and end-customers before peak load time. This power cut-off excludes some energy users, but those who are subjected to these planned outages often suffer severe consequences.

Solution: A wide-scale peak load reduction program in China can significantly reduce the need for these planned outages and thereby offer valuable benefits for the affected electric customers. Using appropriate application design and control strategies, AutoDR can be managed to minimize effects on customers' operations. This solution provides load management benefits to the utility or grid operator, mitigates potential impact on customers, and also can provide significant economic benefits to customers. In fact, one of the biggest benefits to China here may be an increase to GDP as enterprises maintain production levels versus idling operations during power outages.

Because electricity prices in China are set by the government, and not by utilities, price-based peak load reduction is not currently applicable to SGCC. To help mitigate problems resulting from the disparity between generation and load, some form of incentive-based peak load reduction, such as interruptive load or direct load control, should be seriously considered.

Case Studies Illustrate Key Peak Load Reduction Outcomes

Four peak load reduction (also known as, demand response) programs in other parts of the world serve as compelling examples of the promise of peak load reduction. Despite the diversity in their implementation, these programs produced key findings that are relevant to the application of peak load reduction in China:

- **Commercial and industrial users are typically well-suited for peak load reduction** — A consistent learning from prior projects is that most commercial and industrial systems can participate in peak load reduction incentive programs because they can typically respond quickly to peak load signals and shed significant amounts of energy. An additional learning is that utilities in the early stages of peak load reduction development should often focus their attention on the facilities that offer the highest potential peak reduction, because of the high level of customer service associated with program implementation.
    - ➢ **Key Takeaway**: In China, commercial and industrial sectors account for more than 75 percent of national energy use, so it likely makes sense to build peak load reduction programs specifically for this segment.
- **Peak load reduction programs need strong regulatory support** — The business case to support peak load reduction is typically improved when benefits are considered beyond just avoiding the construction of a new peaking power plant. Other international programs have often relied on a supportive regulatory environment to incentivize peak load reduction program development and may have included the consideration of social and environmental benefits, as well.
    - ➢ **Key Takeaway**: China's strong support of renewable energy serves as a good starting point to incorporate complementary peak load reduction programs, which can mitigate the effects of unpredictable renewable energy generation. To pursue peak load reduction as a supportive energy management program, China should evaluate its current pricing and incentive levels.

- **Peak load reduction programs take many forms** — Various types of peak load reduction programs and supporting incentives exist.
    - **Key Takeaway**: To tap into the potential for peak load reduction among its varied economic sectors, China should consider a diverse range of programs that look beyond critical peak pricing.
- **AutoDR and contractual programs tend to be most successful** — Peak load reduction programs that reduce customer inconvenience and increase participation commitments typically have the greatest results. Contractual and automated programs not only often result in higher levels of participation, but also increase peak load reduction reliability and reduce customer attrition. While such programs are generally more expensive to implement, the return on energy saving is typically much higher. And, often-increased reliability makes AutoDR especially compatible with renewable energy generation, which can be intermittent and typically must rely on additional mechanisms to offset periodic shortfalls.
    - **Key Takeaway**: Given China's interest in incorporating renewable energy sources, AutoDR and contractual programs should be emphasized. Proper incentives are typically required for the utility to invest in AutoDR resources.
- **Customer outreach and education are critical components of a successful program —** In the case of other utility peak load reduction programs, customer education and marketing of numerous tariffs and peak load reduction program have often proven challenging and tempered the early success of the programs. Effectively communicating program goals and economic benefits is critical. Peak load reduction programs are typically customer-service intensive, requiring a substantial amount of customer interaction in the form of education, marketing and auditing, among other things.
    - **Key Takeaway**: China should provide clear guidance on incentives, program requirements and tariff choices. Further, early and high participation levels from government buildings in AutoDR programs should serve as an important example to other segments on the importance of this new domestic energy supply.

System Design and Incentive Strategy Proposal

Given China's regulatory policies and the lessons learned from several international case studies, the project team developed a proposed system design and incentive strategy for AutoDR. The results of this work follow.

Research shows that peak load reduction technology should be combined with proper demand side management programs to be most effective at reducing peak load. Also, a strategy that employs multiple programs allows the electricity provider to effectively target various customer segments by tailoring incentives to different energy-user groups. Dynamic pricing and incentive-type programs are two of the most common approaches for encouraging reduced consumption and shifting demand profiles.

Following discussions with TEDA utility management leaders and pilot site customers, specific objectives for AutoDR emerged:

1. Lower carbon emissions through reduced consumption
2. Incorporate renewable energy sources
3. Encourage energy efficiency
4. Review and understand the pilot project technology

Honeywell defined and evaluated nine program combinations based on the feedback of affected project parties, including CEPRI. The study's evaluation resulted in five recommended strategies. From these five strategies, two programs were selected for further review based on the current regulatory and electricity pricing structures in China: a revised time-of-use (TOU) pricing program and a critical peak pricing (CPP) program.

International research indicates that event-based programs, like CPP programs, typically result in higher load reduction than traditional daily TOU and emergency programs. In addition, such programs are often easier to implement from a regulatory perspective than real time pricing or other programs that require a change to the wholesale electricity market.

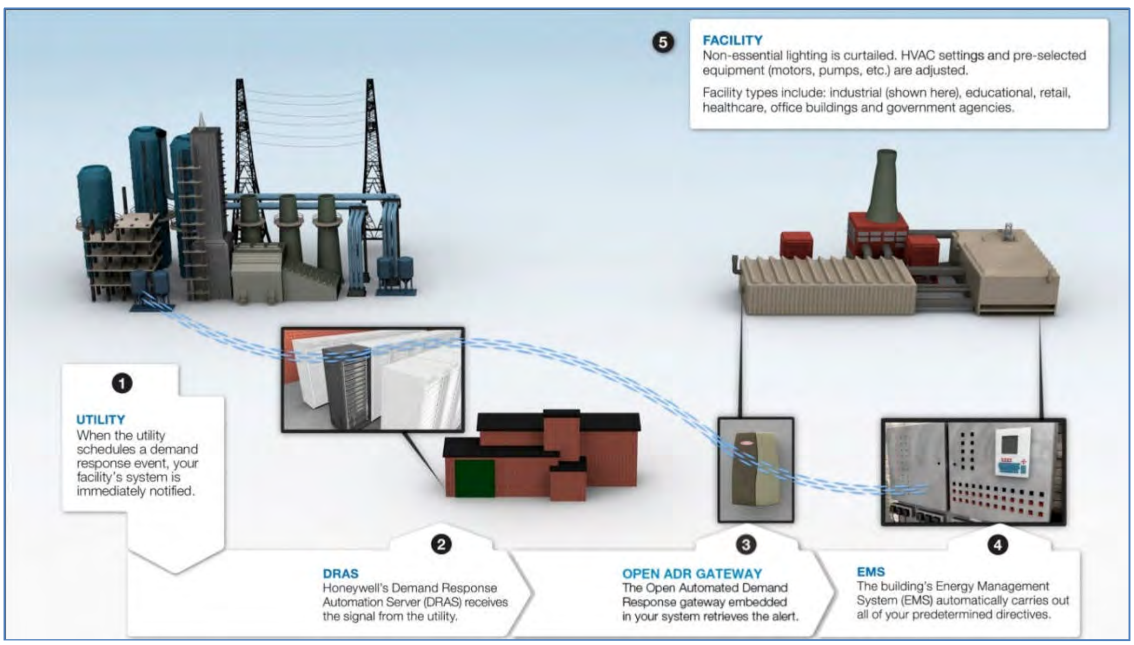
CEPRI and TEDA customer feedback indicated that the proposed peak load reduction pricing strategies (a revised TOU pricing program and a CPP program) could not be implemented by TEDA in the pilot project. The existing policy and regulatory environment prohibit local utilities from adjusting electricity rates. Because of challenges with implementing either of the proposed peak load reduction pricing strategies, this project simulated the AutoDR pricing structures.

AutoDR Technology

AutoDR technology is the recommended platform for implementing peak load reduction programs in China. This technology offers significant benefits to both the utility and the end customer, including:

- AutoDR can reduce or eliminate the need for more intrusive and impactful manual peak load reduction for entire facilities.
- Existing buildings can be retrofitted with AutoDR technology.
- New buildings and factories easily can incorporate AutoDR technology without the need to be extensively "designed in."
- The ability to utilize existing investments in building and process control systems promotes the acceptance of AutoDR technology.
- A building or industrial facility that is enabled to receive AutoDR signals (rather than using manual DR) is essentially "smart grid-ready."
- AutoDR enables a facility to reduce load in a dependable fashion, thereby providing a valuable demand-side resource for the utility and economic return for the facility owner.

The following figure provides an overview of AutoDR technology based on the OpenADR industry standard.



Pilot Demonstration

A limited pilot demonstrated the proposed peak load reduction program structure in an operational setting. This demonstration verified that open standards-based AutoDR technology is a viable alternative in China and can provide valuable benefits for transmission and distribution system operators, electric utilities and electric customers. With strong assistance and support from the TEDA government, CEPRI, and the SGCC Science and Technology (Smart Grid) Department, Honeywell was able to screen three cities and more than 20 potential sites recommended by the TEDA public utility bureau, State Grid Tianjin Power Company and TEDA Power. Following extensive site visits, technical audits and discussions with site owners, two commercial buildings and one industrial facility agreed to participate in this project as demonstration sites. The field implementations employed

OpenADR standard-based equipment and communication protocols. An overview of these sites appears to the right.

Demonstration Site	Function	Approximate Number of Occupants	Building Floor Area
TEDA Administration Building	Commercial Building	1,000	52,653 sq. m
TEDA Library	Library & Commercial Building	3,000 (visitors) +700	66,000 sq. m
Kumho Tire	Motor Vehicle Parts / Rubber Products Manufacturing	2,300	310,000 sq. m

Simulation of Peak Load Reduction Events

Due to the demonstration's limited scope, the pilot did not aim to define a proposed structure or parameters for a peak load reduction tariff that could meet all of the needs and constraints that exist in the China electric utility sector. For the pilot implementation, due to the limitation of existing China tariff system, through consultation with CEPRI, the proposed CPP and modified TOU pricing programs were applied. The pilot project demonstration used a simulated CPP signal to trigger the AutoDR events.

Pilot Demonstration Results

Analysis of measured data from the pilot demonstration showed the following key results:

- The two commercial buildings reduced their loads by approximately 15 percent, which is consistent with AutoDR applications in the United States and at other international locations.
- The industrial site's load reduction varied with production schedules. At full production, the site reduced its load by 7.7 percent. When not at full production, the site's peak load reduction shed capacity increased significantly to more than 50 percent.
- In comparison with commercial buildings, the industrial site had a much greater load shedding capacity, indicating that in the future, industrial sites should receive particular focus.
- From a load shed stability perspective, the two commercial buildings provided a more stable and consistent load-shed response, shedding between 15 and 20 percent.

Given the limited scope and simulated nature of the pilot project, this effort proved successful, and the measured results provide important validation of the use of AutoDR technology (and the OpenADR standard) in China. The demonstration encountered no major problems. Other than the simulated nature of the peak load reduction events and the work needed to host the Demand Response Automation Server (DRAS) at a data center in China, all aspects of the demonstration were accomplished in essentially the same manner as Honeywell's AutoDR programs for other electric utilities at other international locations.

- **Key Takeaway:** As a result of this demonstration, we do not believe there are material technical or operational barriers that would prevent widespread implementation of AutoDR in China.

Regulatory Review, Market Forecast and Cost Estimate

The project team estimated the potential energy impact of implementing peak load reduction programs in Tianjin and China, which included a review of certain existing regulations impacting such prospective projects. This work included estimates of demand reduction potential, a market demand forecast for peak load reduction technologies, and an annual investment plan.

Review of Certain Existing Regulations and Energy Reduction Estimates

A review of certain existing regulations related to the power sector indicates that key national objectives for China include energy conservation, energy efficiency, pricing regulations, renewable energy promotion, energy measurement and economic development through energy regulation.

- **Key Takeaway:** The proposed AutoDR programs may directly support many of China's energy goals.

While both the TOU and CPP programs help manage demand and consumption through variations in electricity rates, the two programs serve different purposes. The TOU program helps shift consumption away from daily peaks and toward less congested times, and simultaneously more accurately represents generation and transmission and distribution costs. The price patterns (valley, normal, and peak) are consistent throughout the year. By comparison, the CPP program primarily aims to reduce peak demand during the 10 to 15 highest-demand days of the year, which typically occur during the summer months. Together, these two programs typically complement each other and result in shifted and reduced consumption, along with reduced peak demand (kW).

Customer Segmentation and Penetration Rates

The study scope for this project included commercial and industrial customers in Tianjin City. Limited data resulted in grouping together all commercial customers, while the industrial sector has been broken down into two sub-categories: mining and quarrying, and manufacturing. Each of these three industry sectors are expected to behave differently within the peak load reduction programs based on their operational patterns.

For commercial customers, we assumed that only larger commercial buildings (office buildings, shopping centers, large hotels, large government administration buildings, etc.) would initially participate in the peak load reduction program. We estimated that in Tianjin about 1,200 commercial buildings, each comprised of 10,000, square feet, would satisfy such criteria for participation in the peak load reduction program. For industrial customers, the prospective program universe included all enterprises estimated to generate 200 million ¥ in gross industrial output, which equated to approximately 8,400 manufacturing enterprises in Tianjin.

The assumed participation rate for the commercial sector was 20 percent, and for the industrial sector was 12 percent.

- **Key Takeaway:** With clear government directives, China penetration rates may far exceed current experiences in other countries--particularly with the construction of new commercial and industrial buildings.

Price Response and Peak Load Impact

The study also included a survey of current research on price elasticity to understand how commercial and industrial sectors in China might respond to electricity price changes. Because of the maturity of western peak load reduction programs, international research on electricity price elasticity is primarily focused on western case studies. However, limited studies about price responsiveness in China exist.

Those limited studies helped to inform how western price elasticities might be adjusted for the Chinese market. Generally, customers enrolled in short-notice programs are least responsive, while customers in CPP programs and other price-responsive events are typically more likely to respond to changes in electricity prices. Specifically, healthcare and commercial industries tend to be less responsive than manufacturing or public works industries, which have greater control of when and how they consume electricity.

Peak load estimates for each industry sector are based on AECOM Building Engineering data from Tianjin, U.S.-based consumption data, the National Statistical Yearbook and additional international peak load reduction program benchmarks. Peak demand is estimated to grow 2 percent per year to reflect the increase in energy intensity per building or enterprise.

A methodology developed by Lawrence Berkeley National Laboratory (LBNL) was applied to the estimated peak loads for each industrial enterprise and commercial building. The following table summarizes the expected peak load reductions.

	Industrial Enterprises		**Commercial Building**
	Mining and Quarrying	**Manufacturing**	
Average Peak Demand per Customer Unit (kW) in 2013	1,469 kW	872 kW	408 kW
Estimated % Load Impact	31	9	18
Estimated Reduced Peak Demand (kW)	461	78	75
Estimated Resulting Peak Demand During CPP Event (kW)	1,008	794	333

Source: AECOM Building Engineering, based on data from the National Statistical Yearbook, International DR Program Benchmarks, Various Sources.

Annual Electricity Load Savings

Annual electricity savings (kWh) for the CPP and TOU programs were calculated separately. The U.S. Electric Power Research Institute determined in a 2008 report that each kilowatt of CPP peak load reduction results in approximately 65 kilowatt hours of annual electricity savings. We applied this number for consumption savings associated with the CPP program.

For the TOU program, a separate calculation used average consumption curves developed by AECOM Building Engineering, based on data from the National Statistical Yearbook and international peak load reduction program benchmarks.

Given that the revised TOU pricing strategy adjusts prices only for peak times, load reduction is limited to seven peak hours per day. Mining and quarrying enterprises are estimated to reduce overall consumption by approximately 3 percent per day (just under 800 kilowatt hours), with manufacturing enterprises saving roughly 1.2 percent per day (just under 200 kilowatt hours), and commercial customers reducing consumption by approximately 0.6 percent (just slightly more than 20 kilowatt hours) per day.

Tianjin Peak Demand and Total Load Savings

Employing the aforementioned assumptions, Tianjin's peak load reduction peak load reduction potential associated with the proposed CPP program is estimated to be roughly 36 megawatts in 2013, the first year of operation. This represents an estimated 0.3 percent in peak load savings. The savings amount is expected to grow to 616 megawatts, or 1.8 percent in peak load savings, by 2022. By that time, such peak savings would help to avoid the need to build an additional, smaller-scale coal or nuclear power plant.

- **Key Takeaway:** The combined benefit of the TOU and CPP programs is estimated to result in 1,180 gigawatt hours of electricity savings in 2013, climbing to 2,674 gigawatt hours by 2022 — for an estimated savings total of 1.4 to 1.6 percent of the annual electricity consumption in Tianjin.

China Peak Demand and Total Load Savings

Based on the assumptions and methodology used for Tianjin's prospective peak demand savings, China's national peak load reduction potential associated with the proposed CPP program is an estimated 2,700 megawatts in 2013, the first year of operation. This represents approximately 0.2 percent in peak load savings, and is expected to grow to 39,200 megawatts, or 1.5 percent, in peak load savings by 2022. By that time, this peak load savings would be equivalent to reducing China's generation demand by 20 two-gigawatt coal power plants.

The 1.5 percent peak load reduction estimate is based on somewhat conservative participation assumptions of a single program. With more aggressive participation rates or with a larger suite of peak load reduction programs, the potential for peak load reduction in China could be significantly greater. A full-participation scenario in China, involving 100 percent of industrial customers and 100 percent of eligible, large-scale commercial customers could result in peak load reduction of up to 9.3 percent. Coupled with base load reduction programs and additional peak load reduction options, the results could be even greater.

- **Key Takeaway:** The combined prospective benefit of the TOU and CPP programs is estimated to result in electricity savings of 64 terawatt hours in 2013, climbing to 113 terawatt hours by 2022. This represents an estimated total savings of 1 to 1.2 percent of the annual electricity consumption in China.

Indicative Cost Estimate and Investment Plan (2012–2022)

Honeywell's proposed system, which has been implemented in the TEDA pilot buildings, relies on off-site hosting of the AutoDR application and DRAS. The purchased hardware and software requirements include a utility-based non-production test server, and a customer-based demand response gateway. In Tianjin, equipment demand is estimated to grow slowly, from fewer than 400 units per year, up to 1,200 units per year, with total hardware and software demand estimated to grow to approximately 9,100 by 2022. In China, equipment demand is estimated to grow from fewer than 24,000 units per year to as many as 48,000 units per year, with total hardware and software demand estimated to total 368,000 by 2022. The costs and benefits of the peak load reduction program implementation were evaluated to estimate the scale of the necessary potential investment plan.

Indicative Economic and Financing Alternatives Analysis

The project team performed an indicative economic analysis of AutoDR in both Tianjin and, more broadly, across China. The work also involved a review of potential financing alternatives.

Economic Analysis

As part of the economic analysis that may be associated with AutoDR, we prepared a net present value (NPV) of the proposed implementation strategy (2012–2022), the estimated benefit-cost ratio, the program's internal rate of return (IRR) and an estimate of the payback period from the utility's perspective. The team also tested the project cost components using certain sensitivity analyses.

Given the expected increase in tariffs associated with the revised rate structure — and despite initial capital costs – the TOU and CPP programs together are expected to result in a significant economic gain for implementing utilities.

- **Key Takeaway:** The results for the proposed peak load reduction program in Tianjin and China indicate the potential for healthy returns on the utilities' investments at both the local Tianjin and national levels.

Broad Capital Estimates

Both the CPP and the revised TOU programs are expected to result in significant positive net returns when compared with Tianjin's current TOU program (see table below). In Tianjin, the CPP program alone is expected to result in an NPV gain of ¥10.7 billion by 2022.

Summary of Indicative Benefits and Costs of Prospective DR Program Implementation[1]

(Billion ¥)	2012 Year 0	2013 Year 1	2017 Year 5	2022 Year 10	Total 2012-2022
Tianjin					
CPP Program					
Total Benefits	-	0.26	1.58	3.52	
Total Costs	(0.07)	(0.06)	(0.35)	(0.34)	
Net Revenue (Benefits-Cost)	(0.07)	0.20	1.24	3.18	
Net Present Value of Revenue					10.74
Cumulative NPV Cash Flow	(0.07)	0.12	2.39	10.74	
TOU and CPP Program					
Total Benefits	-	21.3	30.9	46.6	
Total Costs	(0.1)	(0.1)	(0.3)	(0.3)	
Net Revenue (Benefits-Cost)	(0.1)	21.3	30.6	46.3	
Net Present Value of Revenue					231.3
Cumulative NPV Cash Flow	(0.1)	20.0	108.7	231.3	
China					
CPP Program					
Total Benefits	-	14.6	95.6	235.6	
Total Costs	(5.9)	(4.7)	(28.5)	(25.3)	
Net Revenue (Benefits-Cost)	(5.9)	9.9	67.1	210.4	
Net Present Value of Revenue					650.2
Cumulative NPV Cash Flow	(5.9)	3.4	122.6	650.2	
TOU and CPP Program					
Total Benefits	-	1,193.0	1,807.8	3,057.4	
Total Costs	(5.9)	(4.7)	(28.5)	(25.3)	
Net Revenue (Benefits-Cost)	(5.9)	1,188.3	1,779.2	3,032.1	
Net Present Value of Revenue					13,820.3
Cumulative NPV Cash Flow	(5.9)	1,115.2	6,142.2	13,820.3	

Source: AECOM.

NPV and Benefit-Cost Ratio

Using a discount rate of 6 percent, the Tianjin CPP program alone is expected to result in a net increase of ¥10.7 billion in revenue (current ¥) in the first 10 years of operation. Similarly, a nationwide peak load reduction program is also expected to result in a net revenue increase of more than ¥650 billion in the first 10 years of operation.

After the first year of operation, the benefit-cost ratios for the two scales of implementation over the first 10 years of operation are expected to fluctuate between 3:1 and 10:1. In the United States, peak load reduction (also known as demand response) programs have typically been found to result in benefit-cost ratios ranging from 2:1 to 6:1.[2]

[1] Numbers in "( )", reflect negative numbers; Net Present Value represented in 2012¥.

[2] Faruqui, Ahmad, et al, "The Power of Five Percent: How Dynamic Pricing Can Save $35 Billion in Electricity Costs," The Brattle Group, May 16, 2007.

Internal Rate of Return

Because of the nature of the system that Honeywell has proposed, very little upfront capital investment is required for the proposed AutoDR CPP program. The utility's internal rate of return (IRR) for Tianjin's peak load reduction program implementation is estimated to be around 340 percent.

In China, the IRR of the AutoDR CPP program implementation is estimated to be around 230 percent. The scale of China's implementation, coupled with the number of utilities, decreases the estimated IRR, as compared to Tianjin's implementation.

Payback Period

Based on the proposed structure of the programs and supporting technologies, both the Tianjin and nationwide implementation programs are expected to break even after just one year of operation.

Sensitivity Analyses

As part of the economic analysis of peak load reduction program implementation, sensitivity analyses for Tianjin's CPP strategy implementation were conducted on certain key economic inputs to understand the potential effects of positive or negative changes in the inflation rate, peak to off-peak price ratio, CPP ratio, hardware and software costs, tax rate, and assumed discount factor. Typical ranges for the sensitivity analyses are +/- 20 percent of the base variable.

Each of these analyses provides insight as to the extent to which certain external factors may affect the viability of the peak load reduction program. Only one variable's impact has been evaluated in each analysis. Simultaneous changes in multiple variables may and often will result in un-modeled results.

The peak to off-peak pricing ratio, the CPP ratio and the discount rate appear to have the largest impacts on overall project viability. However, even for these variables, changes of +/- 20 percent do not appear to result in revenue loss, reinforcing the prospective CPP program's feasibility.

Because the TOU program is not expected to have significant additional costs but instead is expected to result in net revenue gains, the sensitivity analyses have been conducted around solely the CPP program, which does have implementation costs.

Consideration of Certain Potential Financing Alternatives

We considered four primary potential financing alternatives:

1. Full customer expense
2. Partially subsidized installation
3. Special purpose funds (bonds)
4. Concessionary financing via international banks

Each of the financing alternatives considered involves a different level of customer support, and relies on varying levels of financial risk. Due to the nature of the proposed TOU and AutoDR program, and the limited upfront capital expenses, the application of these financing alternatives is often less necessary than for more traditional, capital-intensive infrastructure projects. Because the upfront investment is expected to be covered by increases in revenue and other financial benefits by the second year of operation, the utility is expected to cover its costs without relying on the mechanisms explored below.

CEPRI believes that SGCC will finalize funding mechanism details upon further scale-up verification of the technology. Given that the agency does not plan to rely on external funding sources such as international banks, State Grid would likely consider full customer expense, partially subsidized installation or special purpose bonds in order to cover initial implementation costs. An indicative review of concessionary financing from international banks was performed to provide an overview of an alternative approach to financing.

In program development, utilities often rely on a combination of funding sources and financing alternatives for their peak load reduction program implementation.

Development Impact Assessment

As with most energy systems, the impact, costs and benefits of implementing peak load reduction programs in China will not be evenly distributed. Without regulatory support, utilities may bear an uneven share of program implementation costs and reap few financial benefits to justify the burden. Program impacts, both positive and negative, are expected to be distributed among many stakeholders, including utilities, energy generators, the government, customers and general society.

- **Key Takeaway:** Chinese government support for utilities is critical to achieve expected and widespread benefits from AutoDR programs.

Environmental Implementation Review

Despite the program's size, the peak load reduction program will likely require minimal infrastructure development, which is expected to result in very little environmental impact. The largest change may be associated environmental benefits. With an expected annual electricity savings of 113.3 terawatt hours nationwide by 2022, greenhouse gas emissions associated with the TOU and CPP programs are expected to be greatly reduced.

- **Key Takeaway:** Findings from similar programs indicate that increased customer awareness and engagement lead to higher participation levels in peak load reduction programs, and overall reduced energy consumption.

Additional Social and Development Impact Review

The project is also expected to have positive impacts as it relates to infrastructure development and technology transfer, market-oriented reform within the energy sector, and human capacity building and productivity enhancement.

Assessment of U.S. Sources of Supply for AutoDR Technology

A study of U.S. sources of supply for AutoDR technology produced a summary of potential suppliers, as well as a prominent industry organization that is promoting the technology. An overview of the benefits of AutoDR and the industry standards supporting AutoDR also is provided.

Key Findings

1. The potential benefit to China could be significant from supporting programs to encourage peak load reduction. By example, if the participation rates for the CPP incentive program alone were increased to 50% of industrial buildings and 80% of eligible commercial buildings, then the peak load reduction has the potential to be as high as 5.2% of China's peak load.
2. For China, automated peak load reduction could be an extremely valuable energy resource. This project demonstrated the capability of Honeywell's AutoDR solution to temporarily reduce peak load through mutual interaction between utilities and their customers. Technically, this technology meets the key requirements of China's DSM demo city initiatives. The project has also laid foundation for AutoDR's further promotion and application in China.
3. Government policies and incentive mechanisms serve important roles in establishing the conditions for participation levels of commercial and industrial buildings. Further effort is encouraged to explore appropriate incentive programs in China.
4. This project demonstrated that automated peak load reduction may offer many advantages over manual or even semi-automated approaches. Examples of the benefits may include more reliable shed reduction, faster response, less labor intensive operations, and improved monitoring of event performance.
5. "Smart Grid-ready buildings" have the potential to provide a valuable resource to assist China in achieving its permanent and temporary load reduction targets.
6. Advantages may be realized by combining base load and peak load reduction activities. Building owners are likely to operate with greater efficiencies and utilities likely will experience large and more consistent results. Such an outcome supports the objectives of China's efforts to promote DSM Cities.

7. When including economic, social, and environment factors, the large scale implementation of peak load reduction in China could yield the benefit-to-cost ratio in the range of 2:1 to 10:1.

Next Steps: A Path Forward

Looking ahead, China has announced clear support for base load and peak load reduction with the funding of the Smart City Initiative for 2013-2015. China has an important opportunity during this timeframe to evaluate AutoDR on a larger scale and prepare for a nationwide deployment starting in 2016. In preparation, China should establish a peak load reduction program and test plant to evaluate:

- Large scale participation
  - 150-200 megawatts within each Smart City dedicated to AutoDR
  - Statistically significant participation levels across each major customer segment
  - Broad utility planning and operations support through all phases of this evaluation

- Appropriate incentive structures for facility-side participation
  - Level of one-time installation incentive
  - Level of annual capacity ("stand-by") incentive per kilowatt
  - Level of peak load reduction event participation incentive per kilowatt hour
  - Selection of appropriate tariffs for different customer segments

- New mandates
  - Use of open standards
  - Use of automation
  - Participation levels for government buildings
  - New construction regulations requiring "smart grid-ready" buildings
  - Re-classify "smart-grid ready" buildings so as to lessen the frequency of forced/ emergency outages
  - Linking base load and peak load reduction activities
  - Allowing AutoDR to be counted toward meeting GHG emission targets

- Performance parameters beneficial to transmission system operators
  - Ancillary services support for wind generation integration
  - Peak load reduction test plans
    - Advanced notice requirements for events
    - Duration and frequency parameters
    - Telemetry requirements

- Performance parameters beneficial to distribution system operators
  - Network/ circuit level support, reinforcing stressed feeders
  - Deferring capital expenditures for stressed sub-stations
  - Peak load reduction test plans
    - Advanced notice requirements for events
    - Duration and frequency parameters
    - Telemetry requirements

- Performance parameters beneficial to generation planning
  - Additional capacity resources
  - Peak load reduction test plans
    - Advanced notice requirements for events
    - Duration and frequency parameters
    - Telemetry requirements

- Engagement model with distribution electric utilities
  - Clear participation targets across customer segments
  - Clear megawatt targets
  - Guidance on incorporating new energy resources into utility planning and operations

- Funding alternatives

- o Identify specific funds dedicated for the AutoDR incentives
- o Performance requirements specified for accessing these funds

Using the above structure for the 2013-2015 Smart City implementation period may assist China in releasing a detailed national deployment plan for base load and peak load reduction in 2016. This methodical approach will help China in attempting to realize the significant indicative savings potential identified in this "Demand Response (Peak Load Reduction) System Pilot and Feasibility Study."

Building on this successful pilot, Honeywell and AECOM are ready to assist SGCC, CEPRI and other stakeholders in taking these steps necessary to develop base load and peak load reduction programs in China over the next several years.

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1 Introduction and Project Plan

Virtually any building with electrical equipment can be outfitted with current technology to enable temporary usage reduction. In this manner, existing building stock also can be turned into "smart grid-ready" buildings. To realize the full benefits from "smart grid-ready" buildings, utilities need to connect to these facilities via a central, automated dispatch system.

With the support of the U.S. Trade and Development Agency (USTDA) (Grant GH201161074, starting October 2011), Honeywell, AECOM and the China Electric Power Research Institute (CEPRI) formed a team to investigate the potential for AutoDR using open standards in China. The resulting Demand Response (Peak Load Reduction) System Pilot and Feasibility Study described in this report validated that AutoDR can be a valuable energy resource for China.

The first stage of this project, described in this section, was to identify the stakeholders, design a work plan, discover data and information requirements, and create a schedule of execution. The remaining sections of this report summarize the research, design, and development activities of the project team along with the results of our field-based demonstration project.

1.1 Project Organization

The project team (Honeywell and AECOM) worked closely with CEPRI and TEDA to ensure a successful project, with adherence to the agreed upon project timeline. The overall project organization chart, with key stakeholders identified, is shown in Figure 1-1.

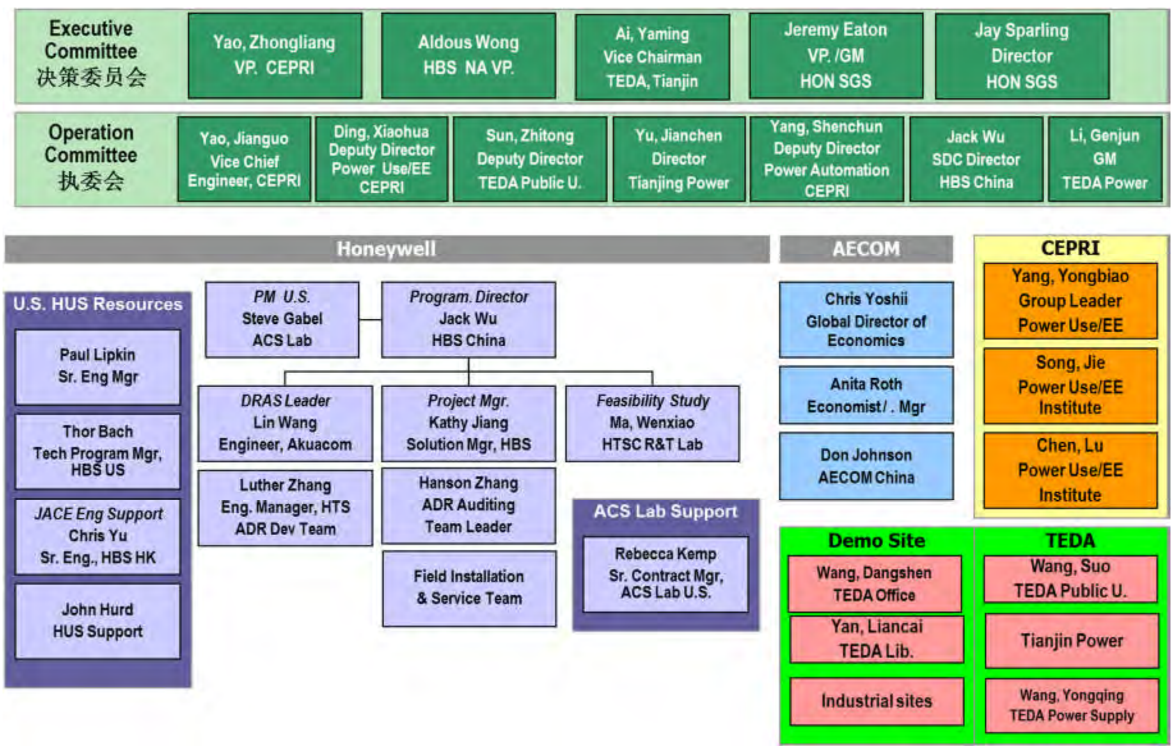


Figure 1-1. Project Organization Chart

1.2 Project Design

We identified six areas for which we needed to gather data and requirements:

1. An approach to implementing demand response technology and automation
2. Scope of the field demonstration and preliminary identification of pilot sites
3. Automated demand response (ADR) architecture for the field demonstration

4. Analysis of China's power sector
5. Demand response case studies

These areas are described briefly below; the details of post-planning execution are given in later chapters of this report.

1.2.1 Demand Response Technology and Automation Approach

Honeywell's approach to ensure success in ADR projects is based on the following process:

- Collaboration with the customer facility staff to assess the facility's energy demand characteristics
- Gaining facility staff approval for ADR shed strategies
- Integrating ADR shed strategies with existing control systems at the customer facility

A high level overview of the Honeywell/Akuacom demand response architecture is shown in Figure 1-2.

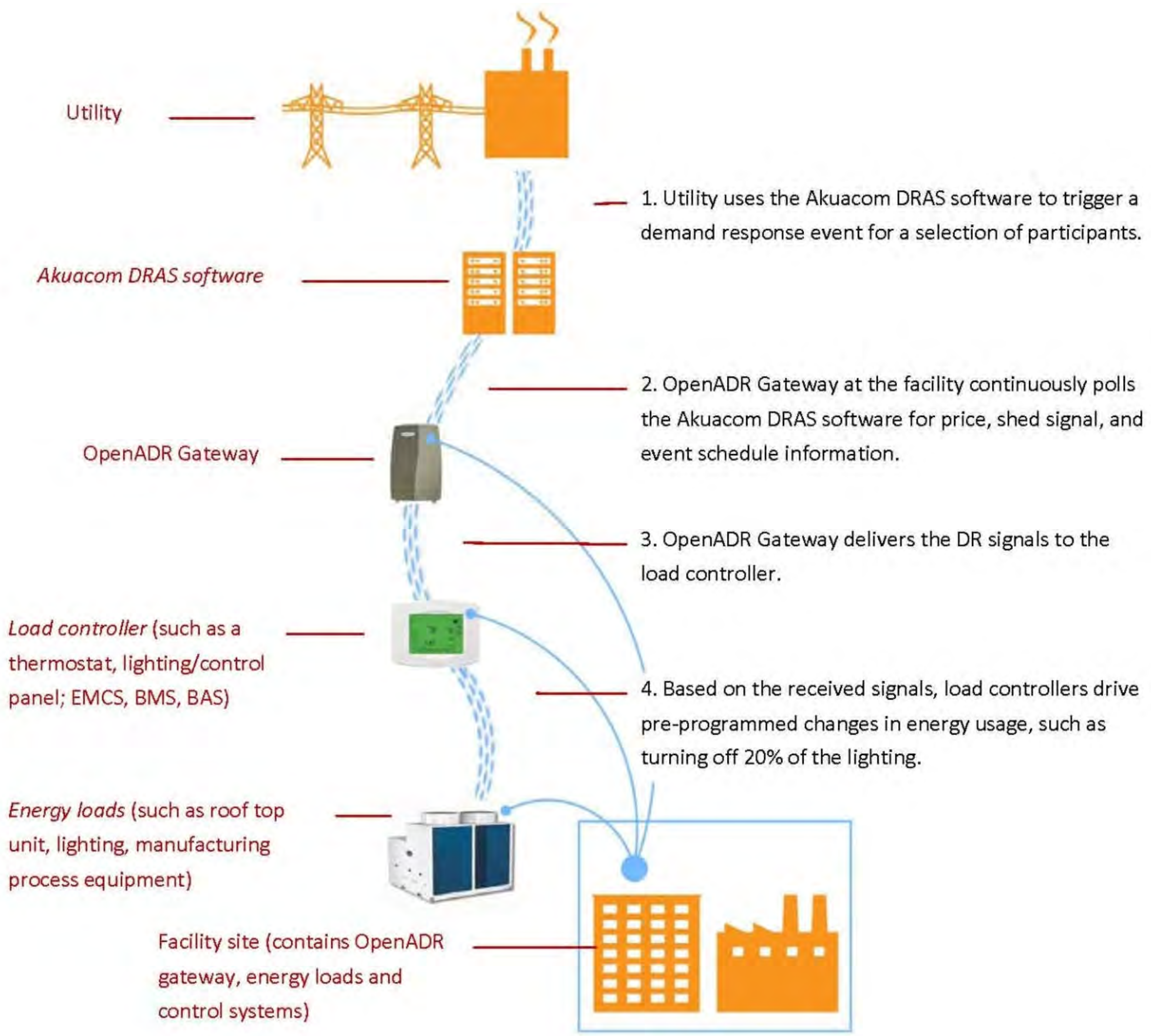


Figure 1-2. Honeywell ADR System Architecture

The Honeywell process for implementing demand response projects is as follows:

- Audit Facility: The Honeywell project team will perform a demand response-focused energy audit walk-through alongside the facility staff and/or management representatives. During this portion of the project, Honeywell's goal is to fully understand the facility's equipment, controls, schedules, and business critical requirements.

- Develop Shed Strategies: The Honeywell project team will identify and quantify electrical shed potential within the facility. Working closely with facility representatives, Honeywell will develop and present for approval demand reduction opportunities leveraging our ADR program experience and control systems expertise.
- Implement Customer Approved Shed Strategies: The Honeywell project team members will work in collaboration with facility representatives to develop project milestones, and timelines.
- Utility Interaction: The Honeywell project team will interact with the electric utility to retrieve energy consumption data necessary for a facility assessment. This data may be in the form of 15-minute interval data directly from the utility, a facility sub-meter, or retrieved from the building automation system.
- Install OpenADR Gateway: The Honeywell project team will install an OpenADR Gateway in close proximity to the central Building Automation System (BAS). The OpenADR Gateway is mounted in accordance with local codes and standards and is approximately the size of a small laptop computer. The OpenADR Gateway will be connected to the Local Area Network (LAN) and communicate via the internet to the Akuacom Demand Response Automation Server (DRAS) software used by the electric utility to communicate DR event and pricing signals.
- Integrate OpenADR Gateway with BAS: The Honeywell project team will coordinate the integration of the OpenADR Gateway with the BAS. The preferred deployment method is for shed strategies to be programmed into the BAS. The OpenADR gateway will poll (outbound) the Akuacom DRAS software every minute for new OpenADR signals issued by the utility. Upon receipt of a new signal, the OpenADR gateway, in turn, signals the BAS system via digital outputs (DO) to implement a pre-programmed shed strategy. The Honeywell project team works closely with the facility BAS integrator to test the deployment and ensure shed strategies are functioning as agreed by the customer.
- Launch Akuacom DRAS Software Customer Interface: The Akuacom DRAS software features a password-protected, web-based Customer Interface featuring event and real-time energy usage information. The Honeywell project team conducts facility staff training on and provides user's guides for the ADR customer interface.

The OpenADR Gateway is an embedded controller/server platform designed for remote monitoring and control applications. The unit combines integrated control, supervision, data logging, alarming, scheduling and network management functions, integrated input/output (IO) interface with Internet connectivity and web serving capabilities in a small, compact platform. The OpenADR Gateway supports a range of protocols including LonWorks®, BACnet®, Modbus, oBIX as well as numerous other building automation protocols and internet standards.

1.2.2 Field Demonstration Scope and Demonstration Site Selection

Honeywell worked closely with TEDA to identify candidate sites for the demand response demonstration that met these basic criteria:

- Within TEDA area, a site has some visibility and strong awareness of energy conservation and environmental protection; has successful energy saving projects.
- The selected buildings are both representative of the area and have different functions and designs from one another.
- Each site includes a good building automation system or centralized energy adjustment/control channels (for industrial sites).
- Sites each carry a significant electricity load.
- Sites show considerable electricity load changes between peak and non-peak periods.
- Some main electricity consumption equipment, such as chillers, VSD motors, linked compressor pumps are adjustable.
- Sites show potential for further energy savings.
- Sites have good energy metering systems, preferably submeters.
- Sites employ experienced people who can help during the project implementation.
- Site management has strong initiative and interests in participating in the demo project.

While several candidate sites were identified early, we ultimately conducted the demonstration at three sites, summarized in Table 1-1 and described further in Section 3. Appendix A includes more detail of the selection process and other information about initial project planning.

Table 1-1. Selected Demonstration Sites

Demonstration Site	Function	Approximate Number of Occupants	Building Floor Area
TEDA Administration Building	Commercial Building	1,000	52,653 sq. m
TEDA Library	Library & Commercial Building	3,000 (visitors) +700	66,000 sq. m
Kumho Tire	Motor Vehicle Parts / Rubber Products Manufacturing	2,300	310,000 sq. m

1.2.3 Field Demonstration ADR Architecture

Honeywell worked closely with CEPRI and TEDA to define the ADR architecture for the demand response demonstration. The recommended high-level architecture is shown in Figure 1-3.

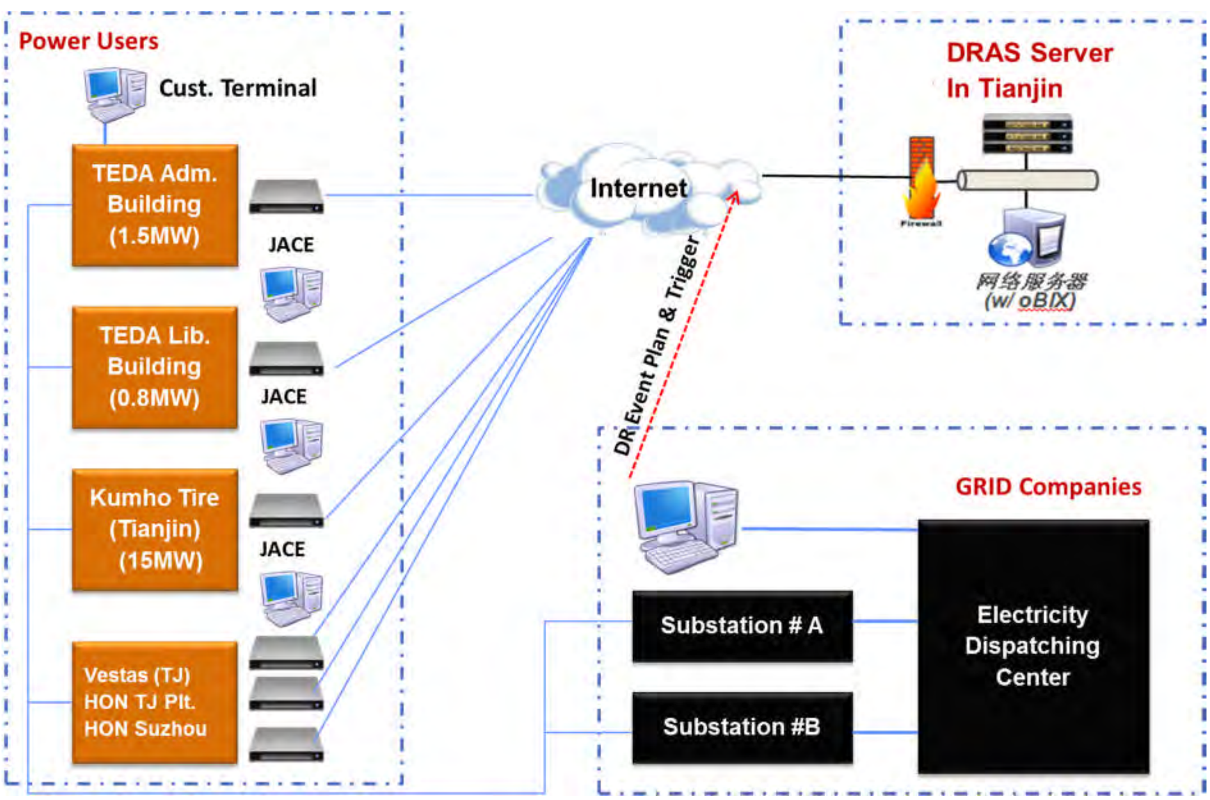


Figure 1-3. Field Demonstration ADR Architecture

This architecture is typical for Honeywell ADR application in other parts of the world, for example, in Canada. The architecture was agreed on by TEDA Power where an ADR event will be triggered according to electric load conditions in the Electricity Dispatch Center by a stand-alone computer with public internet access.

The DRAS was to be located at a Data Center within TEDA, and upon completion of the project period, the demonstration ADR client equipment would remain in place to become the property of the site owner if site owner wishes. The ADR DRAS hardware/software will remain as the property of

Honeywell. The Open ADR gateway (JACE) and shadow meter connection scheme is shown in Figure 1-4. Honeywell's Open ADR gateway is described in Appendix I.

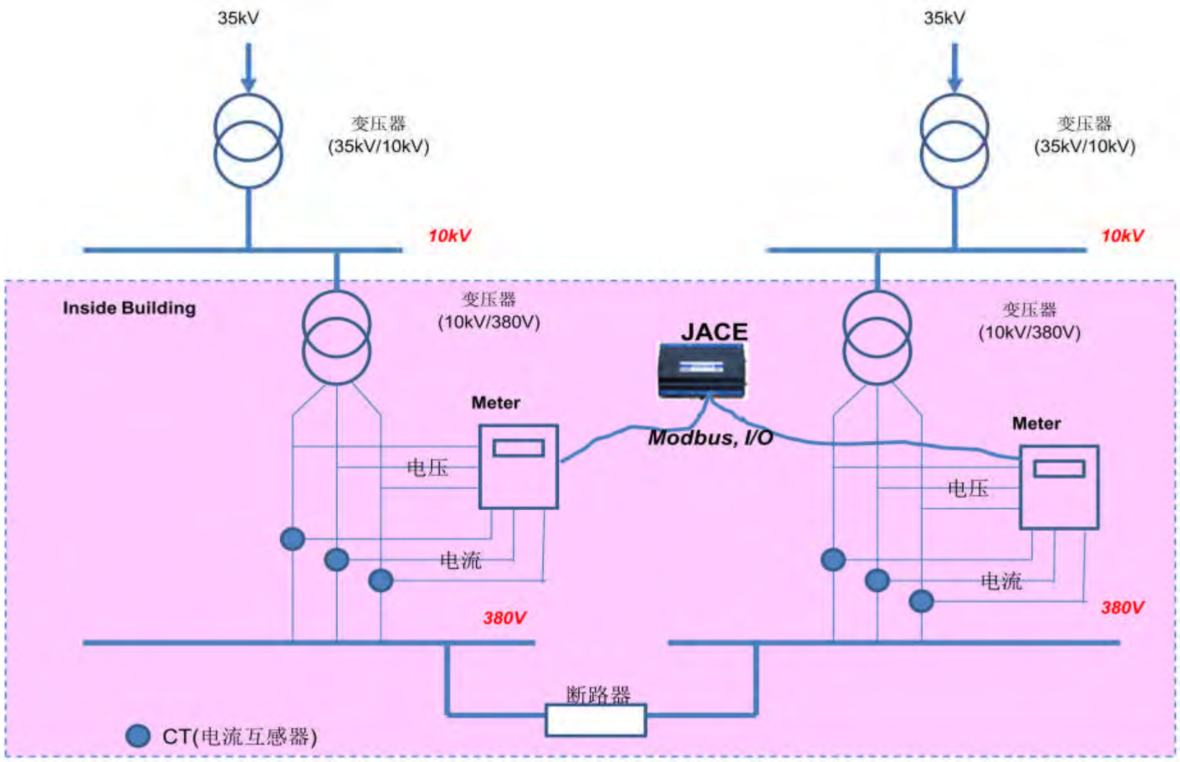


Figure 1-4. Building Shadow Meter Connection Diagram

1.2.4 Analysis of China Power Sector

AECOM and Honeywell, working closely with CEPRI and TEDA investigated regulatory, government policy, and other issues that would affect the potential for widespread of demand response technology in China. Results of this work are described in Section 2.

1.2.5 Demand Response Case Studies

AECOM conducted several case studies to evaluate the progress of four successful demand response programs around the world that could serve as benchmarks for implementation in China. Results of the case study work are given in Section 2.5.

1.3 Plan, Milestones, and Requirements

The project team prepared a detailed work plan that included descriptions of the tasks as defined in the project TOR (shown in Table 1-2), along with milestones, data requirements, a manpower plan, and data requirements.

The rest of this report describes how we executed the work plan and met the project requirements.

Table 1-2. Project Tasks

Task	Task Title	Key Deliverables
Task 1	Develop a Work Plan and Define Overall Parameters of the Study	• Project Plan
Task 2	Conduct an Analysis of Available Information and Develop Demand Response Benchmarks	• Report describing the power sector in China • Report describing the progress of four selected demand response programs
Task 3	Selection of the Pilot Project City, Critical Peak Pricing Strategy Proposal, and System Design & Specifications	• Selection of the pilot project city • A recommended demand response strategy • Demand response system design and specifications for the pilot project
Task 4	Execute Pilot Project Implementation Plan	• Implementation of the demand response project at the pilot city • An interim report describing data collected, analysis results, and recommendations
Task 5	Review Regulatory Issues and Develop Market Demand Forecast and Cost Estimates for the Pilot Project City	• Report on laws and regulations that would have an effect on the application of demand response • Market demand forecast for the pilot project city • Cost estimate for implementation of demand response program at the pilot city
Task 6	Conduct Economic Analysis and Financing Mechanism Analysis	• Report on an economic analysis of the pilot project • Report on potential financing options and estimated costs to the consumer
Task 7	Conduct an Environmental and Development Impact Assessment	• Report on the environmental, social, and developmental impacts of the project,
Task 8	Conduct an Assessment of U.S. Sources of Supply	• Report describing U.S. sources of supply for demand response technologies
Task 9	Prepare and Submit Draft Final Report	• Draft Final Report • Executive summary document • Presentation of findings and recommendations • Workshops (two total)
Task 10	Prepare and Submit the Final Report	• Comprehensive Final Report • Executive summary document • Presentation of findings and recommendations

2 Information Analysis and Case Study Benchmarks

This section presents an analysis of available information about the power sector in China to examine the current state of transmission and distribution systems ownership, operation, regulatory policies, and standards for demand side management technologies. Also included is an evaluation of the progress of four international demand response programs that can serve as benchmarks for implementation in China.

2.1 Review of Available Information

The following subsections describe the information we reviewed to evaluate the current conditions in China.

2.1.1 Current state of Standards for Demand-side Management Technologies

Over the past few years, demand-side management standards activity has centered on promoting increased use of automated demand response (DR). The most prominent demand response standards in the United States and internationally to date are the OpenADR 1.0 standard, led by Lawrence Berkeley National Laboratory (LBNL) since 2002. More recently, an effort is underway to enhance and extend the original OpenADR capability. This new effort, OpenADR 2.0, is driven by a large group of utility, customer, and vendor stakeholders. In addition, during 2011, new standards activity has been initiated within the International Electrotechnical Commission (IEC). The IEC PC 118 Smart Grid User Interface project committee has begun work on standards relating to user interfaces for demand-side management. The following sections give an overview of the progress for each key demand-side standards activity.

2.1.1.1 Open Automated Demand Response (OpenADR)

Open Automated Demand Response (OpenADR) is an open, non-proprietary standard that enables electricity providers and system operators to communicate DR signals using a common language with each other and their customers over an IP-based communications network, such as the Internet. This automation is enabled by a set of open application programming interfaces (APIs) that provide two-way communications between the electricity provider and electric customers through a central demand response automation server (DRAS).

Work on this standard began in 2002 at the Lawrence Berkeley National Laboratory (LBNL) Demand Response Research Center (DRRC), with funding from the California Energy Commission's (CEC) Public Interest Energy Research (PIER) program. The initial development was enhanced through a series of field pilot demonstration projects that were performed with the large investor-owned electric utilities in California [**LBNL-5273E**].

The result of this work was published as a formal specification (OpenADR 1.0), by the California Energy Commission in 2009 [**CEC**]. This standard was included in the National Institute of Standards and Technology "Smart Grid Interoperability Standards Framework" as a key standard for demand response within the smart grid [**NIST Framework**]. An overview of the technical elements of OpenADR 1.0 can be found in various documents available on the DRRC website [**DRRC**]. The technical details of OpenADR 1.0 can be found in the specification [**CEC**].

To extend the OpenADR 1.0 standard and integrate it with other standards that will make up the smart grid, the NIST Smart Grid Interoperability Panel (SGIP) has enlisted the support and participation of standards bodies and smart grid stakeholders in the development of the OpenADR 2.0 standard.

2.1.1.2 OpenADR 2.0

As the work of the SGIP began, the DRRC provided the OpenADR 1.0 standard to a newly formed project committee of the Organization for the Advancement of Structured Information Standards (OASIS). This committee, Energy Interoperation (EI), is developing the data models and the specification for the new "OpenADR 2.0" standard. The Utilities Communication Architecture International Users Group (UCAIug) OpenADR Task Force supports this work with gap analysis and informs the EITC about additional requirements from the service providers. The OASIS EITC work has also received technical contributions from other smart grid technical resources, including the North American Energy Standards Board (NAESB), and the Independent System Operator/Regional Transmission Organization Council (IRC) **[EITC]**. The resulting EI specification has come to be known as OpenADR 2.0. A high level overview of the enhancements added to the OpenADR 2.0 standard is shown in the Table 2-1 [**OpenADR 2.0**].

Table 2-1. OpenADR 1.0 and OpenADR 2.0 Comparison

OpenADR 1.0	OpenADR 2.0
• Open specification • No certification program • Small, but growing number of vendors • Geared towards specific DR • programs	• Formal industry standard • Test tool, test plan, & certification program • Backed by an industry alliance • Conforms to NIST Smart Grid Interoperability Framework • Expanded architecture to include pricing, telemetry and other services

The OpenADR 2.0 standard uses the OASIS Energy Market Information Exchange (EMIX) specification to describe energy product and pricing information, and the OASIS Web Services Calendar (WS-Calendar) specification to describe schedule information [**EITC**]. The EMIX and WS-Calendar specifications are also key elements of the SGIPs smart grid standards development plan.

The EI specification defines a set of services and interactions in a web services implementation, although fully compliant services and operations can be implemented using other technologies. The specification defines a set of three functional profiles, each of which includes a selection of interfaces, services, and options required for a particular purpose. The EI profiles are:

- OpenADR profile (referred to as the OpenADR 2.0 profile)
- TeMIX (Transactive EMIX) profile
- Price distribution profile

As of January 2012, the EI specification has been approved as Committee Specification 01, and is ready for implementation. An overview of the technical elements of OpenADR 2.0 can be found in a recent paper by LBNL [**LBNL-5273E**]. The technical details of OpenADR 2.0 can be found in the EI specification [**EITC**] [**EI v1.0**].

A team of smart grid stakeholders working under the SGIP is collaborating to finalize the OpenADR 2.0 standard in 2012 and promote its adoption into the SGIPs Catalog of Standards (CoS) [**CoS**]. When completed, the OpenADR 2.0 standard will be submitted to the IEC for adoption worldwide.

2.1.1.3 OpenADR Alliance

The OpenADR Alliance is a nonprofit corporation created to foster the development, adoption, and compliance of the OpenADR 2.0 standard (based on the EI specification), through collaboration, education, training, testing, and certification. The Alliance is promoting the worldwide acceptance of OpenADR 2.0 for price- and reliability-based demand response. The Alliance currently includes more than 30 utility, nonprofit, government, and corporate organizations.

In 2011, the Alliance published two key requests for proposals (RFPs) to promote the development of OpenADR compliant products. The first RFP solicited industry providers to develop test tools that will enable companies to pre-test their products for OpenADR 2.0 compliance. The second RFP solicited industry providers to develop and provide conformity and interoperability testing and certification services for OpenADR 2.0 compliant products. The compliance program will be based on the OASIS EI specification. The testing and compliance program will follow the SGIP Test and Certification Committee's (TCC) Interoperability Process Reference Manual (IPRM).

In October 2011, the Alliance held its first interoperability test event ("plug-fest"). Ten early adopter companies joined the plug-fest, to demonstrate interoperability between EI networks and clients, along with an early "alpha" version of a certification test suite. The plug-fest demonstrated basic handshaking between implementations, as well as exchanging OpenADR messages to create, change, and cancel demand response events. The work of the Alliance can be followed by visiting its website **[OpenADR Alliance].**

2.1.1.4 IEC PC 118 Smart Grid User Interface Project Committee

This new IEC project committee was created in 2011. The draft provisional scope describes the committee's work as "targeted at the relationship and common requirements of key demand side objects, … the standards will cover the architecture of smart grid user interface, function and performance requirements of demand side systems … The main aspects include terminologies, use cases, functional specifications, general interface requirements, information model, information exchange model, communication protocol, security and protection, as well as conformity tests" [**PC 118**].

The IEC National Committee of China is serving as the secretariat of this committee. The first meeting of the committee and its working groups was held in Tianjin, in February 2012. A contingent of technical leaders from NIST, OASIS EI, and the OpenADR Alliance participated in that first meeting, to collaborate and assist in planning the work of the committee.

2.1.1.5 China State Grid Relative Standards

State Grid has released one series of specifications Q/GDW 374-380 for its AMI system, which is called User Power Consumption Acquisition System. Based on two-way communication of AMI, demand side management is planned to be implemented. Especially existed demand side management policy "orderly power utilization" will be assisted with such AMI system. The following gives technical requirements relative with demand side management of Q/GDW 373–380.

- Load control. Utility can send pricing information to smart meters through such system so that users will adjust their power usage mode to respond to the price signals. Utility also can send control command to smart meters/load controllers, then smart meters/load controllers will open/close load switches to cut off/restore power supply to end-users.
- Billing management. For pre-pay users, utility will alert users when pre-pay money remains very low or will cut off power supply to users if pre-pay money is used over.
- Demand side management. Two-way communication between utility and users for such system can assist "orderly power consumption". When power system is emergent or forecasted to be emergent, utility can send load shedding commands to users through such system and load shedding will be executed automatically or manually by users.

2.1.2 Transmission and Distribution System Structure and Information for State Grid

China is served by two main utilities—SGCC (State Grid Corporation of China) and CSG (China South Grid). SGCC supplies electrical power for most areas of the country except for several southern provinces (see Figure 2-1). SGCC was established on December 29th, 2002. It is a government-owned enterprise approved by the State Council to conduct government authorized investment activities. SGCC was ranked the 8th in the Fortune Global 500 in 2010 and is the largest utility in the world. The mission of the company is to provide safe, economical, clean and sustainable electric power for social and economic development. The company's core businesses are the construction and operation of the power transmission and distribution network that covers 26 provinces, autonomous regions and municipalities. Its service area represents 88% of the national territory, supported by more than 1,500,000 employees to serve a population of over one billion. SGCC has subsidiaries for North China, Northeast, East China, Central China and Northwest.

		Headquarters	Installed Capacity (GW) Year 2010
	North China	Beijing	166
	Northeast	Shenyang	89
	East China	Shanghai	203
	Central China	Wuhan	200
	Northwest	Xi'an	86
	China South Grid	Guangzhou	

Figure 2-1. Areas Served by SGCC

SGCC not only supplies electricity to end-customers, but also manufactures many primary and secondary devices, including transformers, switch, protection and controls, and so on.

TEDA Power is not owned by SGCC, but by the local government of Tianjin. TEDA Power purchases electricity from Tianjin Electrical Power Corporation, which is owned by the North China subsidiary of SGCC and sells electricity to industrial, commercial, and residential customers inside TEDA (Figure 2-2).

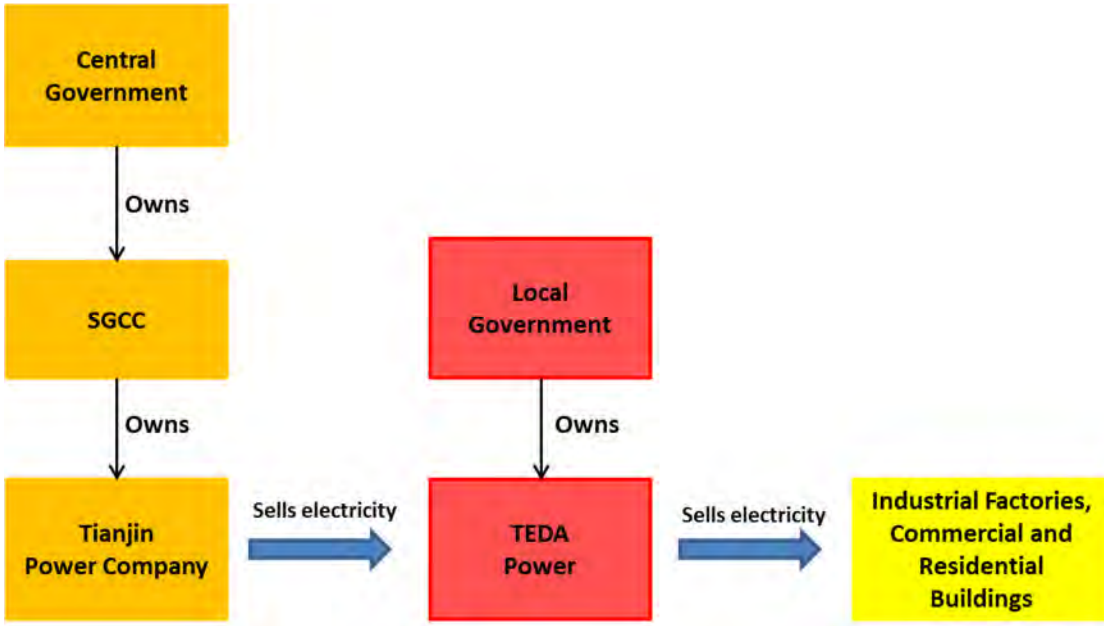


Figure 2-2. Relationship between SGCC and TEDA Power

SGCC has begun to aggressively deploy its AMI system—User Power Consumption Acquisition System. The final stage of the system will acquire power consumption information from all customers and implement electricity bill payments before usage. SGCC has installed tens of smart meters every year since 2009. Besides automatic metering with the User Power Consumption Acquisition System, more technical requirements, such as demand side management, are being added.

Source: http://www.sgcc.com.cn/dwxx/qydwyxqk/zgfhyjfhl/248716.shtml

2.1.3 Current and Projected Electric Tariffs

Electricity prices in China are set by the National Energy Administration (NEA) in conjunction with the National Development and Reform Commission (NDRC). Together, these agencies set domestic wholesale energy prices and help implement the national government's energy policies. In addition to setting the price for the wholesale market, the NEA and NDRC also regulate the retail cost for electricity in each province based on a cost plus revenue model. Energy is priced based on industry sector as well as on the voltage at which it is delivered to the customer. There is not one constant electricity price in China, prices vary throughout the country.

Typically, the higher the voltage at which electricity is delivered, the lower the cost per kWh, which allows the utility to adjust price based on the cost of transmission and distribution to a particular customer. The lower the voltage, the more expensive it is for the utility to convert its high-voltage-level energy after transmission, and the more energy loss is expected during distribution due to inefficiencies. Similarly, varying the price of electricity based on consumer allows the utility to recover the varied costs of transmission and distribution and offer more favorable rates within sectors that have been targeted for national development.

In Tianjin, electricity consumption prices are calculated as a two-part tariff:

$$C = B*M + D*T$$

Where:

C: Total monthly electricity bill [RMB/month]

B: Basic demand charge, based on maximum demand or transformer capacity [RMB/kW/mth, RMB/kVA/mth]

M: Maximum demand in a month sampled at 15 minute interval [kW] or transformer capacity [kVA]

D: Electricity Consumption Price [RMB/kWh]

T: Total consumption per month [kWh/month]

The electricity pricing structure used for TEDA users is the same in principle as for electricity purchased from the state grid, but is adjusted to reflect the committee's development policies. The pricing structure for TEDA is implemented by the organization's development and planning department.

Variations in demand charge calculation exist. In some cases, customers are required to purchase a minimum level of transformer capacity (e.g. 60%). In other cases, customers can submit an application to the local power service bureau (PSB) to apply for their expected maximum demand for the following month. If the actual demand falls below the applied demand level, the customer would still pay for the applied demand. However if the actual demand exceeds the applied demand, then the customer will be charged a penalty on the exceeded portion – typically at double the demand charge.

For example, if a large-scale industry consumer is on a tariff scheme that charges based on transformer capacity of 400KVA, the basic electricity price per month is 25.7*400=10280 RMB/month. If the user consumes 100000 kWh per month and the electricity degree electricity price is, for instance, 0.62 RMB/(kWh), then the total charge per month is:

$$C = 25.7*400 + 0.62*100{,}000 = \textit{72,280 RMB per month}$$

The two-part tariff specifically affects industrial and commercial customers. Other sectors such as residential and agricultural do not charge a basic electricity price. For these sectors the charge is solely based on monthly consumption (D*T).

Furthermore, for select large energy consuming sectors, the electricity degree electricity price of electricity varies according to a peak-valley schedule. Peak time is defined as 8:00 to 11:00 and 18:00-22:00, valley time is from 0:00 to 8:00 and normal prices are charged in the shoulder hours from 11:00 to 18:00 and 22:00 to 0:00.

Table 2-2 summarizes the electricity degree electricity price and the basic electricity price for various consumer sectors in Tianjin.

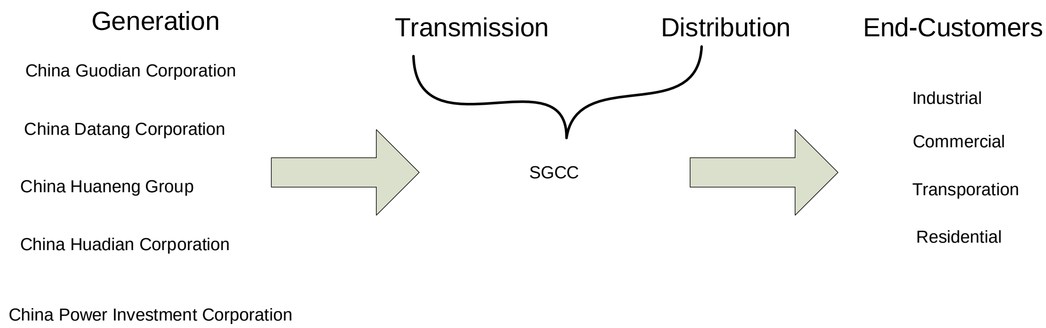
Table 2-2 Tianjin Electricity Rates (2011)

	Voltage Category	Consumption Price (D) (¥/kWh)			Basic Demand Charge (B)	
		Peak	Normal	Valley	Maximum Demand (¥/ kW/ mo)	Transformer capacity (¥/ kilo volt-ampere/mo)
Resident's household power consumption	<1 KV		0.49			
	1-10KV		0.48			
	35-110KV		0.48			
Ordinary industries, commercial and other power consumption	<1 KV	1.31	0.86	0.43		
	1-10KV	1.29	0.84	0.42		
	35-110KV	1.27	0.83	0.41		
Middle and small fertilizer enterprise	<1 KV		0.86			
	1-10KV		0.84			
	35-110KV		0.83			
Large-scale industries' power consumption	1-10KV	0.94	0.66	0.39	25.7	17.0
	35-110KV	0.91	0.64	0.37		
	110-220KV	0.90	0.63	0.36		
	>=220KV	0.89	0.62	0.36		
Calcium carbide, electrolytic caustic soda, synthetic ammonia, electric oven phosphorus.	1-10KV	0.91	0.64	0.38	25.5	17.0
	35-110KV	0.88	0.62	0.37		
	110-220KV	0.87	0.61	0.36		
	>=220KV	0.86	0.60	0.35		
Middle and small fertilizer enterprise	1-10KV		0.38		25.7	17.0
	35-110KV		0.36			
	110-220KV		0.35			
	>=220KV		0.35			
Agriculture industries' power consumption	<1 KV	0.80	0.53	0.28		
	1-10KV	0.78	0.52	0.27		
	>=35	0.76	0.50	0.26		

Source: Tianjin Development and Reform Commission, http://www.tjzfxxgk.gov.cn/tjep/ConInfoParticular.jsp?id=28629

2.1.4 Relevant Generation and Transmission Information

Like transmission and distribution networks, generation is also government-owned in China. Five big generation companies were formed in 2002 when generation and transmission was separated by government. These companies are China Guodian Corporation, China Datang Corporation, China Huaneng Group, China Huadian Corporation, and China Power Investment Corporation. Currently, the Big Five own about half of all installed capacity in China. SGCC purchases electricity from generation companies and sells it to end-customers. Electricity price is regulated by the government (National Development and Reform Commission). Electricity price from a generation company sold to SGCC is based on its generation cost. For example, the electricity generated by a coal-fired thermal plant in Shanxi is given the lowest price compared to others, as Shanxi has plenty of coal mining and the price of coal is low.



Source: http://baike.baidu.com/view/2214304.htm

Figure 2-3. SGCC's Electricity Transmission Process

2.1.5 Demand-Response Polices, Technology Solutions, and Benefits

With high-speed economic development in China, the need for electricity consumption is quickly increasing, resulting in very heavy electrical power shortage in recent summers. In 2011, the disparity between generation and load was 30GW during critical peak times. Such serious power shortages are expected to continue. To reduce peak load in summer time, the central government (NDRC: National Development and Reform Commission) published one special load management policy, which is called "Orderly Power Consumption." According to the policy, one power cut-off order is made based on negotiation among SGCC, local government, and end-customers before peak load time. SGCC can employ mandatory power cut-offs as predefined power cut-off orders during peak time. Usually, economic and social impacts are considered when employing a power cut-off order. The following energy users are excluded from the power cut-off sequence:

- Public service organizations including government, broadcasting, communication, transportation, prison, and so on.
- Chemical factories or mining, where serious human injury/device damage may be caused by power outage.
- Hospitals, financial units, and schools.
- Utilities that supply water, heating, and other energy sources.
- Residential and water irrigation.
- Key industrial projects and the military.

Four defined levels of power shortage are described by color, as shown in Table 2-3. Each level is subject to a different power cut-off sequence.

Table 2-3. Power Shortage Level Definitions

Level		Power Shortage Percentage of Maximal Load	Level Color
I	Critical	More than 20%	Red
II	Very High	10%-20%	Orange
III	High	5%-10%	Yellow
IV	Normal	Less than 5%	Blue

In practice, energy users to be out of service during peak load time are usually:

- On-going construction projects.
- Industrial sectors not encouraged by government.
- High energy usage factories.
- Lighting for city landscaping.

Figure 2-4 shows the power cutoff decision process.

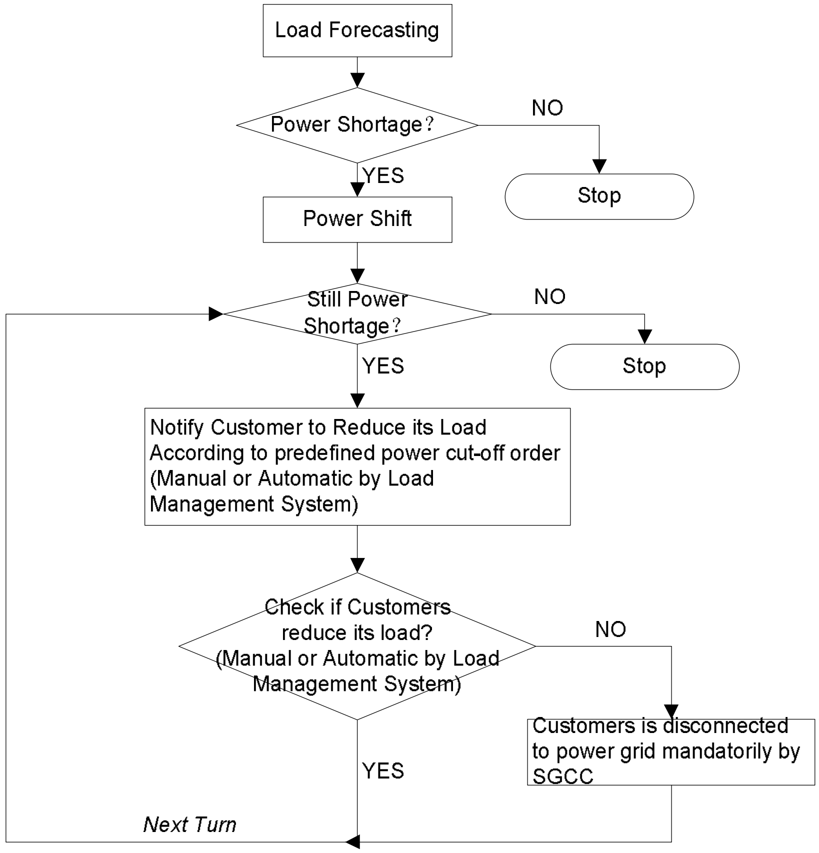


Figure 2-4. Power Cutoff Process

In China, electricity price is decided by government, not by utility; therefore, price-based demand response is not applicable to SGCC. Incentive-based demand response, such as interruptive load, direct load control, and so on, should be seriously considered.

Source: http://www.ndrc.gov.cn/zcfb/zcfbtz/2011tz/t20110428_408768.htm

2.1.6 Laws, Policies, and Regulations Related to the Power Sector

The Chinese government has long been involved in the regulation and management of the power grid, power utility revenue generation, transmission and distribution services, electricity pricing, incorporation of renewable energy sources, and additional grid-related technologies and services. This section reviews key energy sector-related laws and regulations set forth by the National government. While not all of the laws and policies are directly related to smart grid development, it is clear that China is working to develop a regulatory environment that supports smart grid and related technologies. Since 1996, China has implemented laws mandating energy conservation, renewable energy incorporation, energy consumption measurement, and supported various monitoring and control technologies. In 2010, the Nation Energy Administration (NEA) specifically encouraged the implementation of smart grid systems to support intelligent energy distribution in China.

The two tables in Appendix C summarize key laws and policies set by the Chinese government. The tables include assessed impact of the measure on smart grid and, potentially, demand-response development in China. It is clear that over the past two decades, China has increasingly looked to develop a more efficient and responsive energy system. The direction of the policies indicates that China is being primed for a technological overhaul to its power grid. There are also signals that the State is slowly evaluating the potential for more dynamic pricing models as well.

Such national-level changes have likely come about as a result of a decade of demand side management pilot projects in Beijing, Jiangsu, Hebei, Shanghai, and other provinces and municipalities. While almost none of these pilot projects have resulted in full-fledged DSR projects, it is hoped that the turning tide of a supportive regulatory framework will lower barriers for such future efforts.

In a review of laws and regulations related to the power sector, six recurring topics emerged related to smart grid and demand response development.

1. **Energy conservation** – The State has issued a series of laws mandating energy conservation plans. In addition to requiring public institutions to strengthen consumption measurement, monitoring and management, the laws also require institutions to report annual consumption levels. Coupled with laws supporting investment in conservation technologies, these national laws increase awareness of consumption patterns. In its 2010 rural grid reform technical principles, the NEA encourages automated communication systems, such as smart grids and smart meters. Smart grid and demand response technologies both directly support conservation awareness, and consumption measurement and management. Appropriate demand response incentives have been shown to effectively reduce consumption at peak times and overall.
2. **Energy efficiency** – In addition to supporting energy conservation, the State has placed a heavy emphasis on increasing energy efficiency. Laws issued at the national level promote energy efficiency through encouragement of related technologies as well as regulation of equipment and processing techniques that are deemed inefficient. The promotion of efficient technologies reduces energy demand and helps increase awareness of energy issues. Customer awareness and education has been shown to be a key factor in the success of additional energy management programs, such as demand response.
3. **Pricing regulations** – Energy pricing in China is regulated at the State level. Such regulatory restrictions limit local utilities' ability to introduce conflicting pricing schemes and energy reduction incentives. In addition, restrictions on how local utilities can manage or apply profits that may arise from programs discourage utilities from implementing new energy reduction programs. A recent shift in NDRC policy, which allows for time of use pricing strategies, may eventually lead to more easily implemented DR programs. However as the regulations currently stand, neither the State nor local utilities can introduce traditional demand response programs.
4. **Renewable energy promotion** – The State has repeatedly emphasized the importance of integrating renewable energy resources into the grid. Additionally, the NDRC has issued measures supporting advantageous pricing policies for wind, solar and biomass energy. Smart grid and demand response program development are both key factors in successfully integrating renewable into a robust energy system. While smart grid technologies allow for the integration, demand response programs have been shown to help address reliability issues with renewable energy sources.
5. **Energy measurement promotion –** Since the mid-1990s, the State has required energy consumers to install metering devices. Interval meters help measure energy consumption patterns and pave the way for energy communications and smart metering devices which not only allow for interval metering, but also increase consumption awareness and communication.
6. **Energy use to support economic and social development –** In 1996, the State passed a series of laws mandating local governments to consider economic and social development as well as environmental protection in the planning of their energy systems. Smart grid systems and supporting demand response programs directly link energy consumption and system development with financial and environmental impacts. Additionally, varied pricing and incentive strategies allow the State and utilities to promote valuable industries and discourage polluting or otherwise unproductive processes without necessarily disrupting economic growth.

2.1.7 Benchmarking and Performance Evaluation of Distribution Companies

The NDRC developed criteria to evaluate the performance of energy saving and demand side management for power utilities in 2011. The criteria require power utilities (including SGCC) to save 0.3% of total electricity consumption over the previous year and reduce peak load by 0.3% of maximal load of the previous year.

Source: http://www.ndrc.gov.cn/zcfb/zcfbtz/2011tz/t20111208_449720.htm

2.1.8 Current Status and Potential of ESCOs in China

ESCOs (Energy Service Companies) are companies that invest in energy saving procedures and equipment and take a portion of the resulting savings as revenue. From a macroeconomic point of view, the ESCO industry is a catalyst for unlocking the theoretical cost and energy savings that exist in the huge stock of existing inefficient buildings and industrial equipment. ESCOs are necessary since the owners of these buildings and equipment often lack the expertise or capacity to make energy efficiency improvements themselves. Therefore, a healthy ESCO industry has environmental and economic importance far beyond its own modest revenues and employment. Nowhere is this more evident than in China, which has one of the worst ratios of energy use to GDP in the world, as well as perhaps the world's largest collection of energy inefficient buildings. The Chinese government understands this and has made the fostering of a domestic ESCO industry an important policy goal.

2.1.8.1 Development of China's ESCO Industry

The development of ESCOs in China to date is a story of the significant technical, market and policy challenges facing state sponsorship of a needed industry, with preliminary results showing promise, but the industry not yet completely established or success guaranteed. . Recognizing the potential and need for energy efficiency improvements in China, the World Bank/Global Environment Facility in cooperation with the Chinese government in 1998 initiated the China Energy Conservation Project. The goal of the Project was to create a national ESCO industry from scratch, and to accomplish this it created three pilot ESCOs in Beijing, Tianjin and Shandong, and the Energy Conservation Information Dissemination Center to serve as a research and resource center for the industry.

Phase II of the Energy Conservation Project created the China Energy Management Association (EMCA), a national association of ESCOs under the administration of the powerful National Development and Reform Commission (NDRC), in 2004. To address difficulties ESCOs were having in getting loans the I&G loan guarantee program was initiated. The idea is that the EMCA would provide technical support and the I&G program would provide financial support to new ESCOs.

With official sanction and financial encouragement the industry grew: according to EMCA figures, by the end of 2006 1426 energy efficiency projects had been initiated, RMB 4.26 billion (US$ 668 million) had been invested, and 2.8 million tce (tons coal equivalent) of energy and 1.81 million tons of carbon (tC) had been saved. Furthermore, the number of ESCOs, annual investment and annual revenue were all growing quickly.

However, as the industry grew it became clear that a number of market and policy conditions were constraining further growth and limiting success. One problem was that a lack of standards and qualified third party reviewers were making the measurement and verification of savings – crucial for ESCOs' business model – difficult. On the policy side, tax regulations were crushing: ESCOs faced a 10% tax on interest payments and a 17% value-added tax on energy savings investments, even if it did not take title on energy saving equipment until after the contract period, and even if part of the investment were services that should be taxed at only 5%. In 2008 it was estimated that an average clean energy project could expect to pay a third of its total revenues in taxes. If ESCOs instead assign equipment as receivables to banks, banks treat this as bad debt and discount its value by 30%. Restrictions on lending to the steel and cement sectors, intended to head off overcapacity, made it difficult for ESCOs to contract with one of their prime markets. And usury laws prohibited interest rates over 8% on loans, which was insufficient to cover perceived risk and made loans difficult to obtain. Furthermore, Chinese law did not permit developers to give a discount to foreign carbon credit purchasers in order to receive funds in advance, cutting off a key source of bridge financing.

In the marketplace, ESCO loans for energy improvements were both too small and perceived to be too high risk to interest large banks. With no tangible output or product, banks found the loans difficult to understand or categorize. On the customer size, the culture of Chinese companies (perhaps because of China's sustained economic boom) is geared towards quick projects with large returns – ESCO projects with long contracts and predictable but modest returns struggled to gain interest and acceptance. Combined with the universal difficulty ESCOs face of getting large companies to engage in what looks to them like a small, complex transaction not addressing their core business, these market factors made industry expansion challenging.

But policy makers continued to support the goal of an independent ESCO industry. In 2010, the State Council promulgated a series of laws and regulations to further encourage ESCO development:

- Banks and other financial institutions were encouraged to develop new financial products to meet ESCOs' financial needs. The procedures for energy performance contracting (EPC) financing applications were to be simplified, and ESCOs were allowed to use the fixed assets of an EPC project as collateral to apply for a mortgage loan.
- ESCOs were exempted from the payment of business tax for revenue generated from EPC projects and from the payment of VAT on the free transfer of the EPC assets to customers.
- ESCOs were exempted from income tax for three years starting from the first revenue-generating year and were entitled to 50% percent of the standard income tax rate for the next three years.
- All reasonable fees paid by the customer to the ESCO would be treated as tax-deductible and EPC project assets transferred by the ESCO to customers would not be treated as revenue to the ESCO.

In addition, the Standards Administration set standards for the measurement and verification of energy savings. New rules stated that the energy savings of an EPC project must be measured and verified by a qualified independent reviewer in order to receive financial subsidies from the government, and that qualified independent reviewers must be approved by the relevant energy-saving regulatory authorities. These measures gave comfort to customers and lenders.

Many challenges still remain. It has been charged that the fast growth of the ESCO industry in China is partially due to many small companies who do only one or two projects, as well as those who are registered with government regulators only to receive tax benefits, since companies only need to have 50% of projects be energy contract related, with the other 50% of business basically unlimited. On the other side, many international ESCOs operating in China are not regulated, since they do not supply financing themselves.

On the financing side, the initial World Bank-sponsored loan guarantees have expired. But the international aid community is still involved, and analysts say still needed, to help overcome obstacles and increase projects and access to financing. The World Bank is still involved through the China Utility-Based Energy Efficiency Finance Program (CHUEE), and the US EPA has been cooperating with the Chinese State Environmental Protection Agency to help Hong Kong-based ESCOs take advantage of Asian Development Bank funding and enter the China market.

2.1.8.2 Industry Description

The industry today is widely diversified, with over 500 members in the EMCA. As with other advanced service industries, ESCOs are concentrated in first tier cities and municipalities and in prosperous coastal provinces, with significant numbers also found in Sichuan. Investment in 2010 had reached RMB 4.4 billion and revenues RMB 12.4 billion per year.

There are three types of ESCOs in China today, distinguished by their field of expertise and the type of project they undertake. The first is technology oriented and undertakes projects implementing specific patent protected technologies and equipment. It is characterized by specific and clear market segments and a measurable and controlled level of risk. For these reasons this segment finds ready support from financial institutions and this type of ESCO can grow very quickly. However, overall effectiveness may be limited by access to only a few product types and overall growth may be limited.

The second type of ESCO is market oriented and relies on understanding of market demand and good relations with energy consumers. These ESCOs are "solution providers" in the energy marketplace and are not tied to any specific technology. The third type is capital oriented, and uses access to capital as its key competitive advantage. Business for this type is led by market demand and they are flexible in technologies used. These types of ESCOs are seen as more effective in the long term, although they may grow more slowly.

Similarly, there are three types of contracts commonly used by ESCOs in China: Shared savings, guaranteed energy savings, and energy management outsourcing. These are differentiated by allocation of responsibility, risk and reward. Shared savings projects have traditionally been the mainstay of the industry and are used in both building and industry efficiency projects. In this type of contract the ESCO makes energy savings investments, and the owner and ESCO share the resulting savings (that is, a predetermined portion of overall savings is paid to the ESCO by the owner.) Contracts are typically 4.5 years to 20 years in length, although in China shorter contracts prevail. Many local ESCOs focus on paybacks of three years or less.

Guaranteed energy savings projects are similar, except that the owner takes a predetermined savings amount, with any remaining savings paid to the ESCO. They have a high risk/reward profile for the ESCO, since it accrues all additional savings, but it must make up any shortfall below the guaranteed amount. These projects are more commonly used in industrial projects and their share of the total has been increasing.

Energy management outsourcing projects are those in which the ESCO takes full responsibility for energy management within a predetermined budget; they are typically found in commercial buildings such as hotels and hospitals. Contracts average 10 years, but can be up to 30 years. These contracts are still relatively few but are expected to increase.

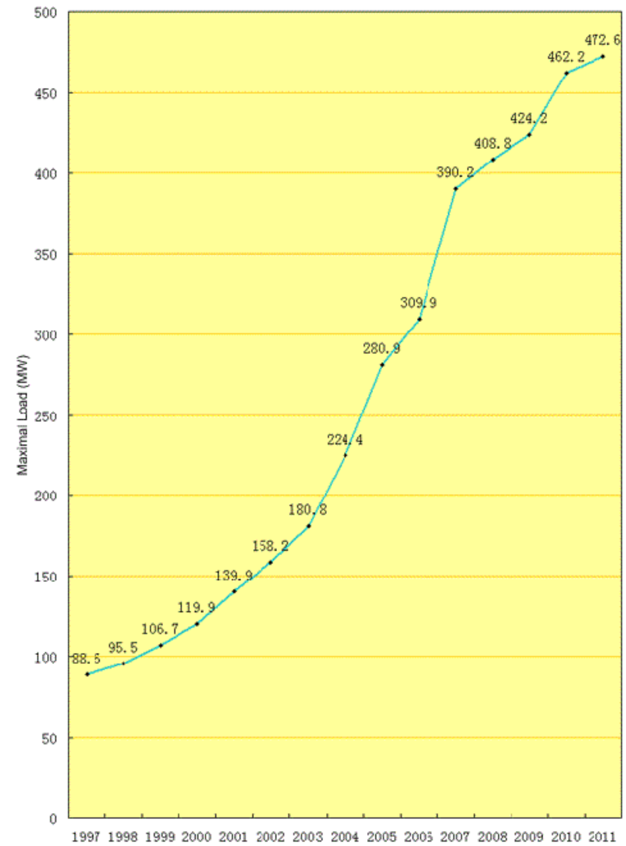
Future prospects are encouraging, although obstacles remain. As a technologically advanced green service industry, the ESCO industry is exactly the kind of sector that the Chinese government (along with many others around the world) has earmarked for development. Furthermore, success of the industry is critical in order for China to improve its very inefficient building and industrial sector; literally billions of dollars' worth of savings are at stake, as well as the imperative need to reduce environmental stress on China's air and water. With energy costs over the long term seen as almost certain to rise, with increasingly stringent government targets for energy conservation and efficiency, and with prospects for additional pollution and carbon taxes very likely, a healthy ESCO industry is a precondition for China's continued economic success. For these reasons Frost and Sullivan estimates that total ESCO industry revenue will grow from 3.4 billion RMB in 2008 to over 63 billion in 2014, an average annual growth rate of more than 50%.

2.1.8.3 Recent rules/policies affecting ESCOs

- Opinions on the Acceleration of the Implementation of Energy Performance Contracting to Promote the Energy-saving Service Industries issued by the NDRC, the Ministry of Finance, the People's Bank of China and the State Tax Bureau on 2 April 2010
- Interim Measures concerning the Administration of Financial Incentives to Fund the Energy Performance Contracting issued by the NDRC and the Ministry of Finance on 3 June 2010
- General Technical Rules of Energy Performance Contracting issued by the Standard Administration of the PRC on 9 August 2010.

2.1.9 Statistics on Electricity Consumers and Consumption Related to the Pilot Project

TEDA Power, owned by TEDA government, is responsible for construction, operation and maintenance of power distribution network inside TEDA. It also supplies power to customers. Until now, three voltage levels of power network (110kV, 35kV and 10kV) have been offered at three 110kV substations, twelve 35kV substations, and forty-one 10kV substations, 750km electrical cables, and 86km overhead lines. TEDA has more than 1000 industrial and commercial customers. The electrical load has risen sharply year by year since 1996 (see Figure 2-5). In December of 2010, the total electricity capacity of TEDA Power was 690MVA. The maximal load is 462 MW and the annual electricity consumption is 2.5 billion kWh.



Source: TEDA

Figure 2-5. TEDA Maximal Electric Load 1996-2011

2.1.10 Other Studies or Information Provided by State Grid-EPRI

CEPRI offered two additional points about the ADR application in China:

- Integration with existing control system. CEPRI prefers that DR events be automatically triggered by the utility control system, not by the utility operator.
- Balance of intermittent renewable integration into grid. With high penetration of intermittent renewable energy such as wind or solar power into power grid, more spinning reserve is needed to counter sudden disparities between generation and consumption in cases of large amounts of wind turbine or PV output.

2.2 International Case Studies

As technology develops and standards are slowly being recognized, smart grid systems have steadily gained momentum worldwide. While a number of countries intend to invest in smart grid development in the next decade, the United States, Europe (United Kingdom, France, Germany, Spain, etc.) Australia and Canada are currently considered to be the industry leaders. Each of these countries is at a varying stage of development. Having invested in more efficient smart grid systems, leading utilities are now turning their focus to the development of programs that incorporate demand-side management.

We conducted four international case studies. The case studies were selected based on a number of criteria:

- Demand response programs focused on large scale commercial and industrial customers;
- Programs were in full implementation, rather than in pilot project phase;
- The scale of the programs was large enough for relevant conclusions to be drawn;
- A range of demand response program options and technology used must be reviewed; and
- Programs reflected geographic diversity.

Each of the case studies reviews a different demand response approach: automated demand response (PG&E), two different demand response program packages (SCE, OPA), and an alternative demand response program focusing on local energy generation (UK National Grid). Additionally, two of the utilities reviewed (PG&E, SCE) also include an overview of the larger smart grid programs that the utilities have implemented. The remaining two utilities (OPA, UK National Grid) have not been directly involved in smart grid system implementation.

The following table outlines the defining characteristics of the four case studies.

Table 2-4. Four International DR Program Case Studies

Program	Location	Relevance for China
Pacific Gas & Electric (PG&E) Auto-DR	California, USA	• Large utility scale ; largest smart grid/meter program in the US • Focus on C+I customers • Energy prices regulated by larger, state agency • Auto-DR programs • One agency responsible for smart grid and DR program development/implementation
Southern California Edison (SCE) Demand Response	California, USA	• Large utility scale • Focus on C+I customers • Energy prices regulated by larger, state agency • Range of DR programs for C+I • One agency responsible for smart grid and DR program development/implementation
Ontario Power Authority (OPA) Demand Response	Ontario, Canada	• Energy prices regulated by larger, state agency • Focus on C+I customers • Local utilities implementing prices and DR programs developed by OPA • Incentive programs provide alternative to CPP or TOU
UK National Grid Short Term Operating Reserve (STOR)	Great Britain, United Kingdom	• National utility agency • Focus on C+I customers • Program relies on customers using local backup generators, rather than trying to shift or reduce overall load; alternative strategy • Program developed by National Grid, implemented at local level by regional utilities

As explored in the cases, whether these benefits are realized depends on supportive regulatory environments, a diverse range of DR options, customer education and outreach, and customer willingness to participate. A more detailed review of DR system benefits – environmental, financial and social, are reviewed in Sections 6 and 7. The detailed case studies are given in Appendix B.

The following table summarizes the key components of each of the four case studies.

Table 2-5. International Case Study Summary

	PG&E (USA)	SCE (USA)	OPA (Canada)	STOR (UK)
Coverage (hectares)	18 million	12.9 million	92 million	23 million
Number of residents	>15 million	>13 million	>13 million	60 million
Unique accounts	5.1 million	4.9 million	4.5 million [1]	N/A [2]
Residential	4.5 million (88%)		4.0 million	
Commercial	0.6 million (12%)		0.5 million	
Industrial				
Total capacity (MW)	7,342 MW (PG&E owned)	9,900 MW (SCE owned)	34,100 MW	
Smart Grid				
Starting Year	2005 – SmartMeter program		N/A for OPA	Full smart meter deployment expected in 2014-2019
Scale of project (# of meters)	8.8 million installed; 10.1 million smart meters by completion	5.1 million		100,000 installed; 53 million by 2020
Penetration %	87%			0.2%
Financing mechanisms	• PG&E profits • Customers • US Government			
Quantifiable benefits	US$990 – 2,039 million (economic and environmental)	US$2,285 million		
Intangible benefits	Fostering local smart grid-related industries	-		
Demand Response Program				
Starting year	Mid 1990s; 2006 (current version)	Mid 1990s; 2007 (current version)	2007	2007
Scale of project (# of participants)	~3,300 C+I	~19,000 C+I		35-45 companies / season
Participation requirements	Varies by load shedding program, typically limited to large scale C+I, agriculture businesses.	>100 MW usage/ year	>0.5 – 5MW load shedding capacity	>3 MW generation capacity
Incentives	• Financial participation payments • Low or no-cost technical support and infrastructure	• Reduced electricity pricing • Equipment installation incentives	Financial participation payments	• Financial participation payments • Increased energy reliability

	PG&E (USA)	SCE (USA)	OPA (Canada)	STOR (UK)
Financing mechanisms	• PG&E Ratepayers • Limited PG&E profits	SCE Ratepayers	OPA Ratepayers	N/A
Quantifiable benefits (commercial and industrial)	• In 2011, 60-70MW of peak load shed (Auto-DR) • 600 MW of potential peak load shed for all DR; but only 150 MW typically	In 2011 >800 MW of potential peak load shed (commercial and industrial)	In 2010 <400 MW of potential peak load shed	2,000-4,000 MW of potential reserve energy
Intangible benefits	• Increased efficiency, safety • Increased energy independence	• Increased efficiency, safety • Increased energy independence	Reduced demand reduces CO_2 emissions	Reduced demand reduces carbon, qualifying some participants for credits
Lessons for China	• Phased project implementation • Customer education • Public policy integration • Alternatives to critical peak pricing	• Diverse DR program options • Variable pricing, incentives and interruptible-load, demand-response approaches	China should consider DR programs as a supporting effort to larger energy efficiency efforts	China may consider its untapped private generation resources to address production gaps.

Sources: Various utilities

Key lessons learned from the four case studies are summarized below:

- **Commercial and industrial users are well-suited to DR**—A consistent lesson of all described projects is that most commercial and industrial uses are particularly well-suited for DR incentive programs because they can quickly respond to peak load signals and shed significant amounts of energy. Additionally, because of the high level of customer service associated with DR program implementation, utilities in the early stages of DR development can focus their attention on the highest potential. *In China, where commercial and industrial sectors account for over 75 percent of national energy use, it makes sense to build DR programs around these users.*
- **DR programs need strong regulatory support**—DR programs have typically not been immediately financially successful. All of the case studies reviewed have relied on a supportive regulatory environment to incentivize DR program development, and ensure that social and environmental benefits of DR are considered as well. *China's strong support of renewable energy integration serves as a good starting point for supporting complementary DR programs, which may mitigate the effects of somewhat unpredictable renewable energy availability. However, China's strict pricing and incentive restrictions will need to be addressed if the State wishes to pursue demand response as a supportive energy management program. Electricity pricing which more accurately reflects the true cost of generation and distribution additionally increases awareness among customers.*
- **DR programs take many forms**—There are many different types of DR programs and supporting incentives. In order to tap into the potential for peak load reduction among its many

economic sectors, China will need a diverse range of programs that look beyond just critical peak pricing.

- **Auto-DR and contractual programs tend to be most successful**—DR programs that reduce customer inconvenience and increase the participation commitments have been shown to have the greatest results. Contractual and automated programs not only ensure higher levels of participation but they increase DR reliability and reduce customer attrition, making the high level of effort for customer attraction better spent. While such programs are more expensive to implement, the returns on energy saving are much higher. Increased reliability makes Auto-DR especially compatible with renewable energy generation – which can be intermittent and relies on additional mechanisms to offset periodic shortfalls. *Given China's interest in incorporating renewable energy sources, Auto-DR and contractual programs should be emphasized.*
- **Customer outreach and education are critical components of a successful program—**For both PG&E and SCE, customer education and marketing have been enormous challenges, which tempered the early success of the DR programs. Being able to effectively communicate program goals and incentive strategy benefits has been important for implementation. DR programs have typically been found to be very customer-service intensive, requiring a substantial amount of customer interaction in the form of education, marketing, auditing, etc. *China may want to consider the value of energy aggregators, which act as intermediaries between utilities and customers. Aggregators are not only useful in managing customer outreach and service, but also shift certain amounts of risk associated with DR reliability off of the utility. Particularly in a place where DR energy shift will be considered as part of a larger energy plan, increasing reliability of participation and load shifting can be a valuable asset.*
- **China should provide clear guidance on incentives, program requirements and tariff choices.** Further, early and high participation levels from government buildings in AutoDR programs will serve as an important example to other segments on the importance of this new domestic energy supply.

3 Pilot Project Incentive Strategy and System Design

This section presents the demand response strategy for the pilot project and the system design and specifications including hardware, software and implementation details.

3.1 Demand Response Incentive Strategy Proposal

While technology is critical to facilitate shifts or reductions in customer energy use, research has consistently shown that demand response hardware and software must be set up together with supportive demand side management programs in order to be most effective at reducing peak load. For utilities and companies to adopt demand response systems, it is important to incorporate a comprehensive and significant program of financial and administrative incentives. Two of the most common ways to encourage reduced consumption and shifted demand are dynamic pricing and incentives, both of which are discussed in more detail in Section 3.1.4.

In a review of more than 100 US-based demand response pilot projects, the Brattle Group found that pilot projects that paired technology with effective demand response incentive programs resulted in a 23% median reduction in peak energy use.[3] This level of reduced peak demand is very significant to a national energy system. This study strongly supports the implementation of DR programs.

While DR initiatives may begin with a single program, utilities typically expand their portfolios over time to include a collection of DR programs as options for their customers. Multiple programs allow the electricity provider to target various customer markets by tailoring incentives to different energy-user groups. Tailoring incentives improves response risks associated with DR programs, making DR programs more reliable as a peak load shedding instrument and increases overall level of cooperation and system response. In support of peak and overall consumption reduction, there is also growing interest in combining DR programs with energy efficiency programs and technologies. While the two types of programs have slightly different goals (peak load reduction vs. overall consumption reduction), their objectives are complimentary and generate greater results when combined.

3.1.1 Review of Current Best Practices

A number of energy reduction incentive strategies are now in use around the world. Because no single strategy responds to the needs of all customer types, most utilities tend to develop a variety of programs to target different sectors and customers.

The success of different DR strategies depends on a number of variables that affect participation. Customer awareness, utility incentives, tariff structure, pricing, demand response technology, information distribution, climate, customer type, socio-economic factors, and other variables all affect response rates and reduction percentages.

The two most common DR program strategies are dynamic pricing and pricing incentives. Dynamic pricing models function by raising consumer electricity rates during peak consumption periods. Avoided consumption incentives typically function by providing consumers with “reward” payments for reducing consumption below customized baseline levels during peak periods. The ultimate goal of both DR strategies is to reduce the level of peak demand (kW) in specific hours rather than total consumption (kWh). Pricing policies play an important and controllable role in encouraging customers to responsibly manage their energy consumption.

Table 3-1 and Table 3-2 define and summarize the strengths and weaknesses of typical dynamic pricing and pricing incentive strategies.

This project’s analysis addresses typical DR programs in the United States and other benchmark countries covered in the case studies described in Section 2.5. Implementation details for these types of

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[3] Faruqui, Ahmad and Jenny Palmer, “Dynamic Pricing of Electricity and its Discontents.” The Brattle Group, 3 August 2011.

DR programs in China will differ from experience in the United States because of regulatory constraints and other socio-economic and political factors. The three primary dynamic pricing models commonly used in DR programs are: time of use (TOU), critical peak pricing (CPP), and real time pricing (RTP). Each provides a variable relationship between risk and reward. Risks and rewards are understood from both the utility and customer perspective. Utilities encounter a range of risk types, which vary depending on the utility characteristics. If a utility has high reliability of power supply, then the primary risk is in being able to balance electricity costs and revenue. In this case, a real-time pricing tariff reduces risk for the utility, because the utility is able to more accurately pass on its actual costs of delivering power. Customers without enabling technologies experience an increase in risk. If the utility has poor reliability of power supply, then the primary risk is in not encouraging enough energy reduction. In this case, a real-time price tariff is again low risk for the utility, because it provides the clearest and fastest signal for building owners to reduce their kW consumption during the designated time period.

For customers, lower risk programs offer reliable rates. Higher risk programs offer the potential for reduced rates for those customers who can revise their consumption patterns, and the threat of much higher rates for customers who continue consume during peak periods. TOU offers the lowest risk for both participating customers and utilities, with the lowest potential reward, while RTP programs create the highest risk with the highest potential rewards.

For avoided consumption incentive strategies, energy reduction rates also vary by program type. Demand bidding programs encourage reduction, while interruptible demand and onsite generation programs require it. Mandatory and contractual programs yield higher levels of consumption reduction with greater reliability.

Table 3-1. Dynamic Pricing Models

Incentive	Description	Strengths	Weaknesses
• Time of use pricing	• Fixed rates are set in advance, which vary based on pre-set time intervals	• Provides greater advance notice of rate, with less volatility • Currently used in China	• Unable to address changing demand or wholesale generation cost variation.
• Critical peak pricing (fixed and variable)	• Dynamic pricing builds on TOU pricing to allow utilities to vary electricity rates based on load and demand, with short advance notice.	• Provides mechanism to pass true cost of electricity production to consumers	• Without supporting technology, customers may not be aware of peak pricing, reducing effectiveness
• Real time pricing (dynamic pricing)	• Pricing signals are based on actual wholesale rates, often hourly and not necessarily set in advance.	• Allows utilities to accurately price energy without advance notice	• Requires that participating customers have supporting technology. Customer may not be able to respond to pricing signals so quickly.

Source: AECOM, Various resources

Table 3-2. Pricing Incentive Strategies

Incentive	Description	Strengths	Weaknesses	Predictability	Consumption Reduction
Demand/capacity biding program	Offer customer incentives for pledging and achieving reduced power consumption (against baseline use), often on a monthly basis.	Allows customer more flexible reduction commitments over a greater amount of time.	Because customer has more flexibility, program is less reliable for utility regarding if and when the reductions will occur May not significantly impact peak loads	Low	
Customer scheduled load reduction program	Load reduction times (weekly days) are identified by each customer, and must account for a set % of their monthly usage. Customers receive incentives for energy saved.	Customers have flexibility over when their “peak” events happen. Utility receives commitment from customer to reduce usage.	Unique reduction plans are more difficult to manage for the whole system. There are no natural baselines. Requires meter communication technology. Encourages shrinkage.	Low	
Interruptible demand program	Allows utility to require a consumer to *stop* consumption on very short notice. Participating consumers are rewarded with reduced base rates or a periodic fixed participation payment.	Typically short notice benefits utility at times of peak demand. Customer commitment coupled with strict penalties increase participation rates and reduction reliability.	May be less successful with industry or commercial customers whose energy use is less variable. Typically implemented when other economic incentives fail to reduce consumption.	High	
Utility managed program (Auto-DR)	Via installed hardware/software, the utility company has access to turn off previously-agreed appliances (often AC units) at set times or intervals. Customers can override the controls.	Utility has greatest predictability of shed amounts. Utilities can focus load shed geographically. Customer benefits from reduced usage / lower rates.	Customer has less autonomy over various appliances and energy use	High	
Onsite generation	Responding to a signal by the utility provider, customers are requested to turn on on-site generation to reduce network demand.	Customers’ energy demand is not interrupted.	Does not decrease demand, but shifts it to less efficient, less regulated sources. High potential for negative localized environmental impacts; i.e. increase in GHG emissions. Relies on large customers with on-site generation capabilities.	Medium	

Source: AECOM; Various resources

3.1.1.1 DR Pricing Considerations

Regardless of the type of DR incentive program or strategy, pricing is a key component that begins with a baseline rate. In many countries, including China, the baseline rate varies depending on customer group. *Inclining block rates* are a common rate structure, which charge a higher rate per kWh at higher levels of energy usage. Based on this starting rate, peak and off-peak hour rates are developed. Because electricity has a moderate amount of price elasticity, the ratio of the peak to off-peak rate has been shown to be an important factor in encouraging customers to adjust their energy consumption habits. Peak to off-peak ratios are determined by the issuing utility. Typically, ratios range from 1:1 to 15:1, with most demand response and dynamic pricing programs clustered between 1:1 and 7:1.[4] Traditional TOU ratios range from 1:1 to 4:1. Tianjin's current peak to off-peak TOU ratios ranges from 2-3:1.

In addition to peak-to-off-peak ratios, a number of other factors must be considered in the development of a demand response incentive program. For example, marginal costs should be considered in utility pricing, including production, transmission, distribution, administrative, customer service, and environmental costs. Other factors include:

- **A range of options** that allows customers to choose how their usage is affected increases successful participation rates.
- **Clear and simple rate structures** and billing communication also increase programmatic success.
- Pricing strategies should be **supported by energy efficiency programs** to help reduce overall usage.
- **Revenue decoupling policies** (separating electricity usage from utility profit margin of utilities) help reduce incentives for energy companies to increase sales.[5]
- **Comprehensive cost assessment** of peak capacity. Providing peak power capacity is very expensive and unprofitable for an energy system, since it is used only a few days of the year. By understanding the true cost of providing peak capacity, high pricing can be justified.

By rewarding customers who reduce consumption, DR programs could lower the financial hurdle that limits investment in advanced metering infrastructure. Initially, DR programs should be attractive to consumers with significant peak energy consumption. Ultimately, dynamic pricing would also attract retail consumers with flatter load profiles.

[4] Faruqui, Ahmad and Jenny Palmer, "Dynamic Pricing of Electricity and its Discontents." The Brattle Group, 3 August 2011.

[5] Lazar, Jim, Lisa Schwartz, and Riley Allen. "Pricing Do's and Don'ts: Designing Retail Rates as if Efficiency Counts." Regulatory Assistance Project. April 2011.

3.1.1.2 Factors Affecting Demand Response

A number of external and customer-specific factors influence demand response rates, particularly among commercial and industrial customers.[6] Table 3-3 summarizes some of these key factors.

Table 3-3. Factors Influencing Demand Response Participation

Factor	Description	Impact on Response	Program Range
External factors			
Event duration	• Length of individual events	• Some customers may not respond unless high hourly rates or incentives are applicable for a block of several hours • Some customers may be unwilling to curtail for long periods (e.g., more than 4-6 hours)	• 2-6 hours
Event advance notice	• Amount of notice provided building owner prior to beginning of DR event	• Some participants and building or process systems can respond very quickly. Others may need much more advance notice	• 10 mins – 24 hours advance notice
Event frequency	• Frequency of events in a season	• If events occur too frequently, customers may be unwillingly or unable to continue load curtailments ("response fatigue") • Conversely, experience gained from multiple events can enable customers to fine-tune their curtailment strategies	• Weekdays for TOU • 10-12 events annually for event-based programs
Event clustering	• Distribution of events of time (e.g., clustered on consecutive days, vs. isolated incidents)	• Clustered events may cause "response fatigue" – reduced willingness of customers to respond	• 2-3 consec-utive days • Maximum 4 event-days in a row
Weather	• Temperature and humidity drive HVAC use • Increased HVAC usage drives overall system demand and price	• Weather-sensitive loads (e.g., air conditioning) may be somewhat discretionary; some customers may be more responsive when rates are high or system emergencies are perceived • Conversely, some customers may be unwilling to reduce or curtail air conditioning loads during prolonged or extreme weather events	• Certain regions may show greater DR potential because of weather differences
Customer-Specific Factors			
Training, awareness, and past experience	• Past participation in similar demand response programs or tariffs, or experience managing energy commodity risk (e.g., gas markets) • Attendance at training workshops • Technical audits or information	• May enhance customers' acceptance of demand response options and ability to respond	• Shown to be a motivating participation factor

[6] Goldman, Charles, et al. "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study." Lawrence Berkeley National Laboratory: LBNL 61498, January 2007.

Factor	Description	Impact on Response	Program Range
Onsite generation	• The presence of onsite generation equipment (e.g., backup generators, gas turbines, fuel cell or renewable generation technologies) at customers' facilities	• Subject to environmental regulations, onsite generation allows customers to respond without interrupting electrical end uses • Provides customers with more response flexibility	• 30-40% increase in price responsiveness
Enabling technologies	• Building energy management systems (BEMs) provide customers with the means to program changes in usage of equipment (e.g., HVAC or lighting control systems) in response to demand response events • Energy information systems (EIS) allow customers to analyze their load usage patterns, establish their baseline energy usage, access information about demand response events or rates, and identify strategies for load curtailment	• BEMs and EIS can help improve the persistence and sustainability of load curtailments, and provide immediate feedback to customers on load curtailment performance	
Electricity intensity	• Electricity costs as a share of customers' operating expenses	• Customers whose operations are highly electricity-intensive may be more likely to participant in and respond to demand response options in order to minimize costs • Conversely, high-intensity users may view their electrical end uses as non-discretionary, making them less likely to participate or respond	• Customers whose energy costs are 30-40% of operating costs are most easily targeted
Business or operational processes	• Features of customers' business processes that impact the flexibility of their response (e.g., industrial process equipment, three-shift operations, facilities at multiple geographic locations)	• Certain types of industrial customers that can shift usage by rescheduling industrial processes (e.g., batch processes) or equipment usage (e.g., arc furnaces, aluminum smelters) may be more price-responsive.	• Mining businesses are up to 6 times more price responsive than average C+I customers

Source: Goldman, Charles, et al. "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study." Lawrence Berkeley National Laboratory: LBNL 61498, January 2007. Table 3-2, p 24.

Not included in the table is a consideration of administrative policies that mandate participation in DR programs. While mandates are less common in the United States and Europe, government-enforced participation may be particularly effective in China, where a large percentage of industry and commerce is owned by the State. In China, regulated DR participation may be more effective than price-driven participation.

In a number of international markets, including many U.S. states, there is an increase in instances of legislative and regulatory requirements to achieve annual energy efficiency goals specifically allowing for demand response to contribute to this obligation. By encouraging the integration of DR programs into energy planning, these energy markets have been able to promote DR as a viable reduction tool.

3.1.2 Summary of Important Design Components

The needs of commercial, industrial, and residential customers vary greatly and are most successfully met by tailored programs. Large, medium, and small users within a group also benefit from different incentive approaches. Because this project focuses on large commercial and industrial customers, strategies and solutions that fit their unique needs have been considered.

According to a study of large commercial and industrial DR customers in the United States, important program design aspects must include:[7]

- Appropriate levels of compensation and a variety of reimbursement options[8]
- Program flexibility that allows for various levels of participation
- Carefully considered and clearly defined frequency and duration of events
- Adequate technical support and customer education
- Reliable and easy notification processes (e.g., email, sms, phone, automatic)
- Increased metering capabilities
- Ability to aggregate load between different locations

Each of these points is incorporated into the DR strategy design.

3.1.3 Review of Client Parameters, Policies, and Data

3.1.3.1 Client Parameters

State Grid's China Electric Power Research Institute (CEPRI) has expressed significant interest in understanding how DR programs and technologies can help China achieve its energy goals. In developing a DR program, CEPRI identified the following project objectives:

- Reducing carbon emissions through reduced consumption
- Allowing for the incorporation of renewable energies
- Encouraging energy efficiency
- Reviewing and understanding the pilot project technology

In February and March 2012 meetings hosted by State Grid CEPRI, Honeywell and AECOM, CEPRI was presented with a range of DR pricing and incentive strategies for consideration. Nine separate program combinations were prepared to solicit feedback, as shown in Table 3-4. The ninth program, Regulatory Program, was presented as an alternative to traditional DR pricing and incentive models. Such a program would rely on government regulations rather than financial incentives to encourage participation and peak energy reduction.

[7] Fry, Terry et al. "Demand Response Program Design Preferences of Large Customers: Focus Group Results from Four States," Lawrence Berkeley National Lab Environmental Energy Technologies Division, 19 June 2006, Figure 2, p8.

[8] In the United States, private customers typically indicate that they require between 10-15% in annual energy cost savings to participate, while government customers are motivated by just 5%. However, utilities have noted that even when customers receive far fewer financial benefits, they continue to participate in DR programs.

Table 3-4. Range of Proposed DR Programs

Program	Pricing Model	Incentive Strategy
1	TOU (increased)	None
2	TOU	Utility managed (Auto-DR)
3	TOU	Interruptible demand
4	TOU	Demand/capacity bidding
5	TOU	Customer scheduled load reduction
6	CPP	None
7	RTP	None
8	N/A	Onsite generation
9	TOU	Regulatory program

Source: AECOM

Based on proposed pricing and incentive models, CEPRI provided the following comments to guide DR program design. Table 3-5 summarizes CEPRI's responses to specific models.

Table 3-5. CEPRI Pricing and Incentive Strategy Feedback

Dynamic Pricing Model	
Time of use (TOU)	China's current pricing model; appropriate for DR
Critical peak pricing (CPP)	May be considered for research purposes
Real time pricing (RTP)	Difficult to implement due to generation pricing model
Incentive Strategies	
Utility-managed (Auto-DR)	CEPRI preferred strategy
Interruptible demand	CEPRI preferred strategy
Demand/capacity bidding	No clear market
Customer-scheduled load reduction	No clear market, does not always reduce peak demand
Onsite generation	Not suitable for China

Source: Meeting with CEPRI in TEDA, Friday February 10, 2012.

In addition to pricing and incentive models, CEPRI provided feedback on acceptable program design parameters. The following list summarizes CEPRI's design considerations:

- Where possible, strategies should comply with scope of current laws and regulations
- A few strategies that do not comply with current regulations may be considered
- While CEPRI does not impose price strategies, it can consider pricing and incentives in a research context
- CEPRI has no clear program preference
- Strategies should be tailored to different sectors

The above parameters limit the range of DR programs that this project may recommend.

3.1.3.2 Policies Affecting DR Program Development

China's current regulatory environment as well as the structure of its power sector creates a unique set of DR program implementation challenges.

As reviewed in greater detail in Section 2.4.6, China has significant policy hurdles that prevent State Grid and local utilities from implementing large-scale DR programs. The current laws and regulations limit rate and incentive flexibility, as well as implementation of proposed DR programs. Such regulations will need to be revised in order for State Grid and local utilities to fully explore the benefits of DR.

A second policy hurdle to DR program implementation is the strong local and national emphasis on GDP growth. While changes in electricity rates in China have been shown *not* to impact change in output,[9] there is a lingering perception that energy reduction efforts conflict with GDP growth targets. Additional pilot project work to counter this negative perception may help overcome the GDP target hurdle.

Finally, due to the segmented nature of the Chinese power sector, the costs and benefits of DR programs are not evenly distributed among utilities, generators, consumers, and the government. For example, generators are separate entities from State Grid and utilities and therefore the cost benefits of reduced peak load capacity are not aligned. Determining how to reconcile the split in costs and benefits will be an important task to making DR a viable and supportable energy management solution. Some researchers have suggested that China, like California, will need to pursue some form of decoupling between energy consumption and utility profits in order to incentivize utilities to offer such programs.

If the Chinese government does decide to pursue DR as a viable solution to some of the State's energy challenges, however, administrative policies could be changed to encourage participation.

Because implementable DR strategies are limited by government regulations, this project proposes strategies that fall outside of what is currently possible. CEPRI has agreed that given the regulatory environment, such programs may be proposed for research purposes.

3.1.3.3 Data Availability and Reliability

The lack of availability of energy and sector data has been a consistent limiting factor during the DR program design process. Current and future projections of energy consumption by sector, seasonal consumption patterns, and even sector size and expected growth have all been difficult to ascertain at both the Tianjin and national level. Utility budgets and costs, which would be helpful in determining the most appropriate incentive structure, are also not available.

Additionally, due to the current pricing system in China and the inability to implement test pricing models, the DR price elasticity assumptions could not be vetted through the pilot project.

[9] He, Y.X. et al, "Electricity Demand Price Elasticity in China Base on Computable General Equilibrium Model Analysis," School of Economics and Management, North China Electric Power University, Energy Journal - November 2010. P1120.

3.1.4 Proposed Incentive Strategy

To develop an appropriate DR strategy, we used CEPRI's feedback to narrow the options for this study. Based on CEPRI's criteria, four initial options were eliminated from consideration.

Table 3-6. DR Programs for Consideration

Program	Pricing Model	Incentive Strategy
1	TOU (increased)	None
2	TOU	Utility Managed (Auto-DR)
3	TOU	Interruptible Demand
4	TOU	Demand / Capacity Bidding
5	TOU	Customer Scheduled Load Reduction
6	CPP	None
7	RTP	None
8	N/A	Onsite Generation
9	TOU	Regulatory Program

The remaining five strategies are presented in greater detail in Table 3-7. Program attributes are based on a survey of international and domestic (TOU programs in Jiangsu province and Shanghai, and interruptible demand programs in Jiangsu province, Tianjin, and Shanghai) benchmarks for similar programs. Factors such as DR event triggers and event duration are similarly based on international benchmarks, as the data necessary to develop customized assumptions for China has not been made available.

The crux of most DR strategies is how well companies respond to changes in electricity price during a DR event. This sensitivity to price increase and decrease is known as *price elasticity*. Price elasticity accounts not only for how responsive customers are to changes in price, but also how comfortable customers are with adjusting their energy consumption.

To understand how commercial and industrial sectors in China might be expected to respond to different dynamic pricing and incentive strategies, a survey of current research on price elasticity was undertaken. Due to the maturity of western DR programs, international research on electricity price elasticity is primarily focused on western case studies. However, a few limited studies on price responsiveness in China are available. Those studies in particular have helped to inform how western price elasticities might be adjusted for the Chinese context.

There are three main types of elasticities: (1) price elasticity of demand, (2) elasticity of substitution, and (3) arc price elasticity. Each of the elasticities has its own set of statistical strengths and weaknesses. For the purposes of this study, arc price elasticity was used as the basic measure of price responsiveness. This elasticity was selected for its frequency in DR literature as well as because methodologically it relies on fewer data inputs.

Based on a review of western and Chinese studies of electricity elasticity, average arc price elasticities for each of the five considered programs have been included. Studies in China suggest that, while the resident market is considerably more responsive to changes in electricity price, the industrial and commercial sectors are less so than their western counterparts. *Price elasticity information is reviewed in greater detail in Section 5.*

Note that this report presents DR strategies designed at a conceptual level for the purposes of modeling potential peak load reduction. The strategies listed below would require significant additional detail to be implemented as actual programs or policies.

Table 3-7. Considered DR Strategies

Program	Pricing Model	Incentive Strategy	Typical Target Sector (C+I)	Participation Requirements	DR Event Trigger	Event Notice (Short-run or long-run)	Event Duration	Estimated Arc Price Elasticity	Pricing Ratio (Cost to participant) ($/kWh)	Incentive (Payment to participant) ($/kW of load reduction)	Implementable within Current Regulatory Environment in China	Implementable with Pilot Project Technologies	Notes
1	TOU	None	All	None	None	None	N/A	-0.04 to -0.13	Increase peak:off-peak ratio to 5:1[10]	None	Yes	Yes	China's current electricity rates are TOU. May be modified to increase peak:off-peak ratio
2	TOU	Utility Managed (Auto-DR)	All	>100 kW	Temperature > 35°C (summer); Temperature < 0°C (winter) (CEPRI)	SR	4-6 hrs Summer only <15 events/ year	-0.05 to -0.15	Increase peak:off-peak ratio to 5:1[10]	*1-15:1 x* TOU off-peak rate Penalty =TOU peak rate x 2 Penalty imposed if customer fails to deliver contracted load shed	Maybe[11]	Yes	Preferred strategy for consideration (CEPRI)
3	TOU	Interruptible Demand	Industrial and commercial customers with onsite generation capacity	>500 kW to 1 MW		SR (30 to 60 minutes notice)	2-4 hrs year-round <15 events/ year	-0.03 to -0.10	Maintain Tianjin's current TOU pricing	Incentive of 1RBM/kWh reduced[12] Penalty = TOU peak rate x 2 Penalty imposed if customer fails to deliver contracted load shed	Maybe[11]	Yes	Preferred strategy for consideration (CEPRI)
6	CPP	None	All	>200 kW		SR (30 to 60 minutes notice)	2-4 hrs Summer only; <15 events /year	-0.03 to -0.07	Minimum 2.5:1 ratio between TOU peak and CPP rate; off-peak rates 75% below regular TOU	None	No	Yes	May be considered for research purposes
9	TOU	Regulatory Program	All	Mandatory participation		SR	2-4 hrs <15 events/ year	N/A	Maintain Tianjin's current TOU pricing	None	Yes	Yes	Government regulation mandates participation in exchange for no black-outs

Source: AECOM, International benchmarks

Italicized text indicates program design assumptions that should typically be based on energy consumption and sector data that the project team has not had access to.

[10] Energy Australia NSW PowerSmart Program for C+I customers has a 4.27 pricing ratio, the highest among international cases studied. However, a study in Jiangsu province, China, found that a 5:1 peak to off-peak ratio was the optimal ratio to reduce peak demand. A separate study in Shanghai used a 4.25:1 ratio for customers <10kV, and 4.26 for customers <1kV during summer months, and 3.34:1 for customers <10kV and 3.36:1 for customers <1kV during non-summer season. These ratios are all in line with what is seen in international cases.

[11] Shanghai and Nanjing both currently have incentives for demand curtailment (2¥/kW) for energy users. This indicates that despite policies and regulations suggesting otherwise, some incentive programs may be permitted.

[12] Based on benchmark studies from Tianjin and Jiangsu province, which use a fixed incentive of 1RMB/kWh.

Of the five proposed options, two programs were selected for further review: a revised TOU program and a critical peak pricing (CPP) program. The programs were selected based on the current regulatory and electricity pricing structures in China. TOU is already used in China, and effectively manages overall electricity consumption. Meanwhile, CPP can be added to a revised TOU structure to help manage peak demand. The two programs are easier to implement, from a regulatory perspective, than real time pricing or other programs that require a change to the wholesale electricity market. The CPP program was selected based on international research indicating that event-based programs result in higher load reduction than traditional daily TOU and emergency programs (arc price elasticity ranges). Additionally, China has already experienced success with pilot TOU and CPP programs in Tianjin, Jiangsu province, and Shanghai. The proposed program would build on the existing TOU program in Tianjin by incorporating event-based best practices. *Further discussion of the expected load reduction and informing inputs, including price elasticity, are detailed in Section 5.*

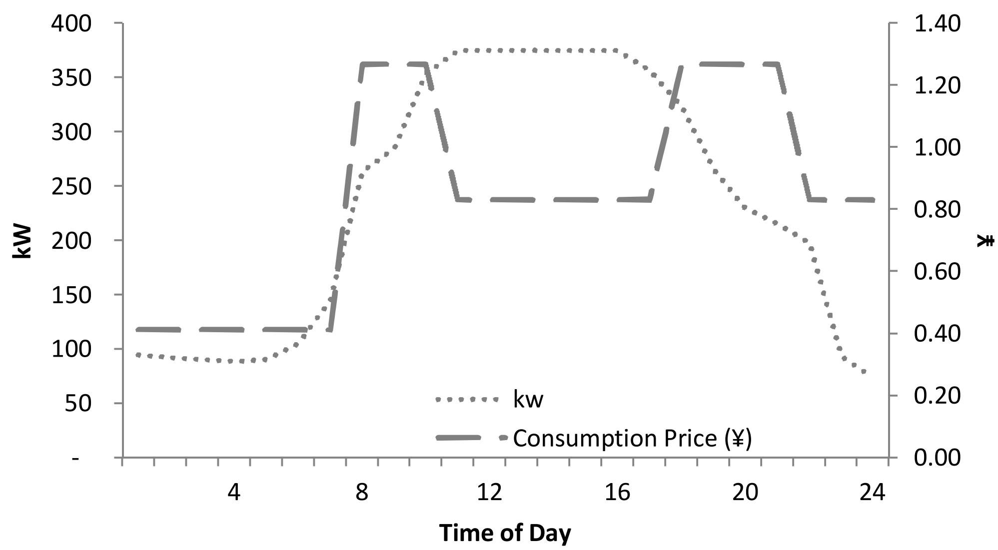
The program is intended to be layered on top of Tianjin's current TOU pricing model. The CPP strategy (proposal 6) incorporates penalties for peak consumption.

Assumptions about participation rates and price responsiveness by sector are reviewed in Section 5 as part of the market forecast and peak load reduction estimates.

3.1.4.1 Pricing Overview

Tianjin's current TOU electricity rates are presented in Section 2.1.3 and Table 2-2. Both of the proposed DR strategies build upon the current TOU model.

Additional review of Tianjin's current TOU structure suggests that the timing of the valley, normal and peak times, are not coordinated with actual valley, normal and peak demand times for the various industrial sectors. Figure 3-1 illustrates how the peak consumption hours between 11am and 6pm are charged at a *normal* rate, while otherwise normal or valley consumption is charged at higher peak rates. This pricing structure limits the effectiveness of Tianjin's TOU model to reduce consumption during high demand times. Consumption curves for the industrial sectors are much flatter than that of the commercial sector, but experience similar poor alignment with the pricing structure.



Source: AECOM Building Management, Tianjin State Grid

Figure 3-1 Electricity Consumption Patterns and Current TOU Pricing – Commercial Customer

Because of the project objective, only DR rates for ordinary industries, commercial and other large-scale industries have been developed for both the revised TOU rate and the CPP program. Residential and agricultural customers fall outside of the project scope. Basic demand charges for the DR programs remain unchanged from Tianjin's current pricing, and are not included in the pricing summaries.

Table 3-8 presents the proposed pricing scheme for the revised TOU program. Per CEPRI's request, peak TOU consumption rates have been set at 5 times that of valley prices. This is up from roughly 2.5 times valley prices. This ratio is based on previous pilot studies in Shanghai as well as other international projects. Valley and normal prices have been left at existing levels.

Table 3-8 Proposed TOU Strategy

	Voltage Category	TOU Consumption Rate (D) (¥/kWh)		
		Peak	Normal	Valley
Ordinary industries, commercial and other power consumption	<1 KV	2.14	0.86	0.43
	1-10KV	2.09	0.84	0.42
	35-110KV	2.06	0.83	0.41
Large-scale industries power consumption	1-10KV	1.93	0.66	0.39
	35-110KV	1.86	0.64	0.37
	110-220KV	1.81	0.63	0.36
	>=220KV	1.34	0.62	0.36

The CPP program pricing summary in Table 3-9 presents an event-based rate built on the revised TOU rate. To incentivize customers to participate, the TOU valley rate is set at 75% of Tianjin's regular valley rate. Additionally, based on findings from previous pilot projects in China, the peak rate has been adjusted to reflect a 5:1 peak to off-peak ratio. The CPP event rate is set at 2.5 times Tianjin's TOU peak consumption rate, or 2.5:1. This reflects the minimum that an event should be priced over the TOU peak rate. This minimum 2.5:1 ratio is the lower threshold to induce a customer response to price. If customers can shift consumption to off-peak, or valley times, they may be able to benefit from participation in the DR program. The ratio of the CPP event rate to the adjusted TOU valley rate falls around 12.5:1, on the high end of the range of international event-based DR programs (1-15:1, with an average ratio of 7:1).

To maximize the success of the CPP program, it's assumed that any participating customer will also be outfitted with the appropriate auto-DR hardware and software.

Table 3-9. Proposed Critical Peak Pricing Strategy

	Voltage Category	CPP Peak Event Rate (¥/kWh)	TOU Consumption Rate (D) (¥/kWh)			Ratio of CPP Peak to TOU Valley Rate
			Peak	Normal	Valley	
Ordinary industries, commercial and other power consumption	<1 KV	4.01	1.60	0.86	0.32	12.5:1
	1-10KV	3.93	1.57	0.84	0.31	12.5:1
	35-110KV	3.87	1.55	0.83	0.31	12.5:1
Large-scale industries power consumption	1-10KV	3.62	1.45	0.66	0.29	12.5:1
	35-110KV	3.48	1.39	0.64	0.28	12.5:1
	110-220KV	3.39	1.35	0.63	0.27	12.5:1
	>=220KV	3.36	1.34	0.62	0.27	12.5:1

Source: AECOM

The TOU times will continue to follow Tianjin's current peak, normal, and valley times. CPP events will last 2 hours at a time, with no more than 15 events per year. Event periods have been set for between 14:00 and 16:00. While CEPRI has suggested CPP events of between 30 minutes to an hour, preliminary consumption data from Honeywell's pilot project suggests that peak demand periods typically last much longer than 30 minutes. Event triggers will be seasonal, with summer and winter high and low temperatures being the main triggers.

Any profit that is derived from the CPP program will be directly funneled to fund the DR program, and will be managed by local government authorities rather than the utility.[13]

3.1.4.2 Alternative or Additional DR Program Incentives

While financial incentives and penalties are the typical model for DR programs, the Chinese context suggests that other alternative incentives may work just as well in promoting customer participation and peak load reduction. The proposed two programs will be modeled based on customer price responsiveness; however, CEPRI may decide that alternative incentives are preferable given the current regulatory environment. In order to model participation levels associated with the suggested incentives, an additional pilot program would need to be developed to generate reliable response rates.

Alternative or additional DR program incentives may include:

- Technical assistance (energy audits)
- Equipment reimbursement via:
  - Tax credits
  - Cash rebates
  - Reduced electricity bills
- A customer award system (e.g., green energy star for participation)
- Protection from blackouts for program participants

[13] Based on feedback from CEPRI, May 2010.

3.1.4.3 Conditions for Successful Implementation

Based on CEPRI and TEDA feedback, it is understood that the DR pricing strategies proposed in this project cannot be implemented as part of the pilot project. This situation is a direct result of the existing policy and regulatory environment that prohibits local utilities from adjusting electricity rates. TEDA has also expressed that it will be unable to implement a DR program with variable pricing for such a small segment of its customer base. Additionally, TEDA has expressed concerns regarding the source and availability of incentive funds.

Despite the implementation challenges of any proposed DR strategies, the potential for peak load reduction was simulated to support future development of DR opportunities in China.

The conditions and characteristics of the simulated approach include:

- A site controller was installed in the participant buildings
- Building owner-approved shed strategies were automated
- Auto-DR events were initiated via the DRAS
- A automated (M2M) reduction of actual kW load at the building level were tested at the building level
- The effect on the building owner's utility bill will be simulated
  - The building owner saw a reduction in kW usage during the test periods.
  - Incentives for DR events (proposal 2) were simulated.
  - Avoided penalties for kW reduction during DR events (proposal 6) were simulated.

The following program assumptions have been proposed as part of any suggested DR strategy. These assumptions reflect norms from international case studies, international best practices, and an understanding of traditional challenges for C+I customers. The program design assumptions must be met to maximize peak load reduction potential.

Program Design Assumptions:

1. Program enrollment will be mandatory for large users, but voluntary for small consumers; select critical national industries may be exempt from participation.
2. Customer participation, once enrolled in the program, will be contractual and mandatory.
3. Convenient incentive payment/reimbursement options will be available to customers (e.g., direct payment, bill credit, rebate for DR system investments, etc.).
4. Technical assistance will be provided to all customers (e.g., building auditing, evaluation of reduction capability, financial support for technical aspects).
5. The event notification process will be reliable and made in a timely manner.
6. Where necessary, metering capabilities (i.e., smart meters) will be installed.
7. Where necessary, building monitoring (and control) systems will be installed (i.e., the Auto-DR system will be connected to relevant systems if building controls are not available).

3.2 Pilot Project Implementation Strategy

3.2.1 System Architecture

The solution offered by Honeywell offers a flexible and scalable architectural system for demonstrating the demand response capability in the TEDA project.

3.2.1.1 Key Characteristics of Honeywell's System Architecture

- A **scalable** architecture that can start small and scale up quickly to meet the peak demand
- Integration of **existing and proven technologies**, which is the most cost-effective method of acquiring robust technologies and ensuring continued upgrades, training, and support
- An architecture for auto DR that can be utilized directly by end users or multiple DSI providers
- An architecture that maximizes **reliability and scalability**
- Provision of services to enhance customer relationship and further their commitment to EE and sustainability
- Fully leverage **open standards** and protocol to maximize interoperability with State Grid's system operations and future requirements.

- OpenADR Gateway
  - Supports multiple industry protocols (i.e., BACnet, MODBUS, OPC, etc.).
  - Great flexibility to connect to popular building management systems (BMS), industrial process control system (e.g., DCS), control devices, and meters
  - Programmable platform
  - Web service ready
- Demand response automation server
  - Proven integration with utility information systems such as:
    - CAISO Automated Dispatch System (ADS)
    - CAISO Open Access Same-time Information System (OASIS)
    - Varolii Envoy
    - UISOL DRBiznet
    - Stonewater Enjoin
    - Itron InterAct
    - APX
    - SCE Energy Analytics
    - Schneider kWickview
    - Bow Networks
    - Hong Kong CLP

3.2.1.2 Demand Response Automation Server System Architecture

The DRAS architecture model (Figure 3-2) is a standard Java 2 Enterprise Edition (J2EE) implementation provided by JBoss application platform. The standard servlet technologies provided by the embedded Tomcat Web container in JBoss application server talks to Stateless Enterprise Java Beans (EJBs), which in turn communicate with a MySQL database via Entity Beans. The Web tier, Service tier, and Persistence tiers are deployed into a single container via an enterprise archive (EAR).

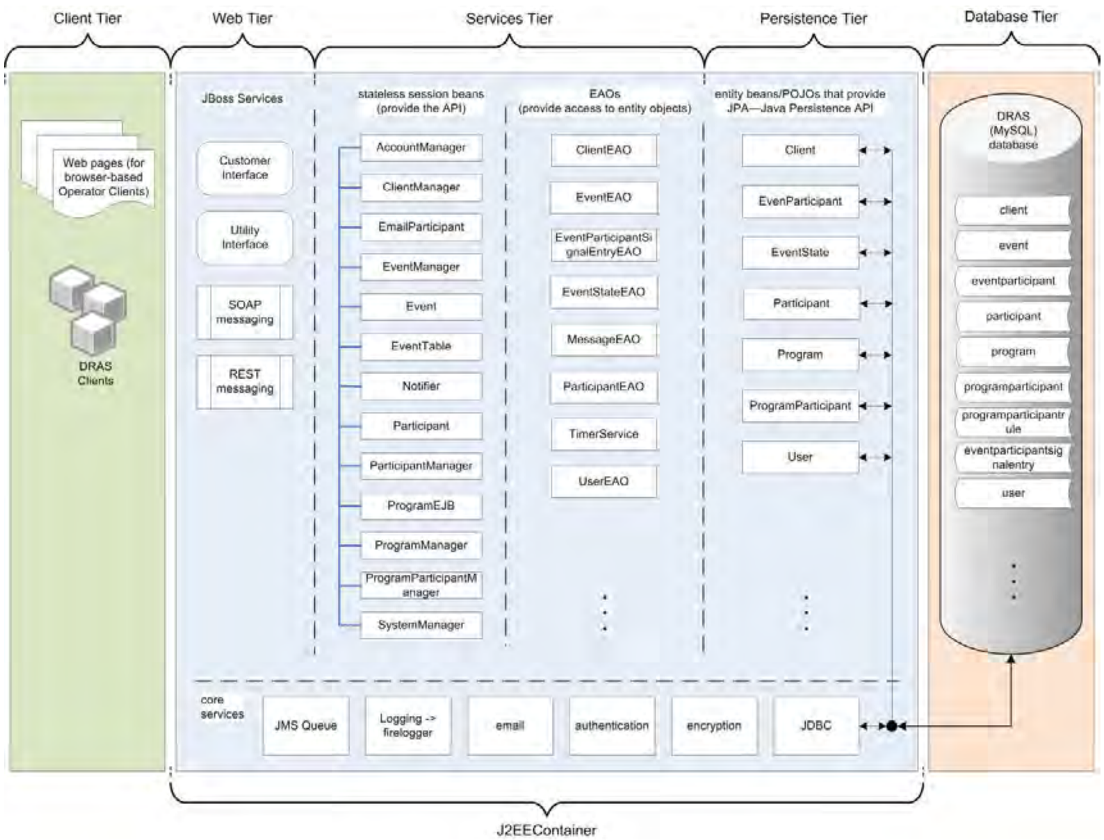


Figure 3-2. DRAS Application Architecture

The advantages of the DRAS application architecture include:

- Portability
  - Platform independent standard Java 2 Enterprise Edition (J2EE)
  - Web-based user interface and web service API
- Scalability
  - Application clustering
  - Hardware virtualization
- Interoperability
  - OpenADR compliant REST/SOAP interaction with client device/software.
  - Single sign on (SSO) and pluggable login architecture
  - Other standard support: SMTP, NTP, oBIX, etc.
- Security
  - Communication security
    - Protected with TLS/SSL through HTTPS protocol.
    - OpenADR compliant REST/SOAP interaction with client device/software.
    - Single Sign On (SSO) to allow session transfer between various application domains
    - Plug-in login modules to simplify the 3rd party application integration
  - Access control
    - Multi-layer client/server infrastructure with firewall and system security control
    - Integrated with the java authentication and authorization service (JAAS)
    - Role-based access control: super admin, utility operator, installer, facility operator, and web service client for device.

3.2.1.3 System Architecture of OpenADR Gateway

An OpenADR Gateway is installed at the customer site. The OpenADR Gateway is based on the NiagaraAX framework and supports widely-used system protocols such as OPC, BACnet IP, Modbus TCP, SNMP, etc. It also provides a graphical environment for the users to develop rich applications. Benefits of the OpenADR Gateway include:

- Java-based machine: It employs Java VM as a common runtime environment across various operating systems and hardware platforms. Programming work can be based on a set of open Java APIs to be accessed by developers writing Java code. At the same, most features are also designed to be used through high-level graphical programming and configuration tools. This approach provides an environment for TEDA Power to develop the add-on functionalities.
- Heterogeneous system integration: OpenADR Gateway is designed to communicate with any network protocol, distributed architecture, or field bus, which ensures its ability to integrate cleanly with all networks and protocols. Hence, it is easy to communicate with any open protocol computer system, such as building management systems, hotel management systems, or energy management systems. This feature is important for the Demand Response System model, as it needs to seamlessly integrate with various building management systems when the system is scaled up. With OpenADR Gateway, it is easy to integrate into the any computing system without a large technical or financial investment.
- Distributed systems: The framework provides scalability to highly distributed systems running the Niagara Framework software. This is important to system stability over the internet when it scales up from pilot to the whole customer base of TEDA Power.

As an industry-leading integration tool, OpenADR Gateway already supports a comprehensive list of drivers for interfacing with different systems (as described). For this pilot project, OpenADR Gateway could interface with the Honeywell EBI, KMC BMS, Johnson Control's BMS, and so on. The integration details for each pilot site are defined together with the site owner. The OpenADR Gateway is compatible with nearly any existing building automation system. No significant integration difficulties are envisioned at the pilot sites.

3.2.2 System Specifications

Our aim is to work with all the participating parties to design demand response programs, implement hardware and network infrastructure in a local hosting data center, audit participating facilities, develop customer shed strategies, install OpenADR gateway, manage demand response resources, initiate and monitor demand response events, and produce reports to demonstrate the demand response capability of the TEDA pilot system.

3.2.2.1 DR Program Specification

DR program specification is defined by a group of participating companies including AECOM, Honeywell, and TEDA Electric and Power Company. The programs can be categorized four ways:

- Demonstration program
- Emergency day-of program
- Curtailment day-ahead program
- Client test program

3.2.2.2 DRAS Hardware and Network Infrastructure Specification

Honeywell worked with TEDA to identify a local hosting data center with the hardware and network component infrastructure shown in Figure 3-3 and Figure 3-4.

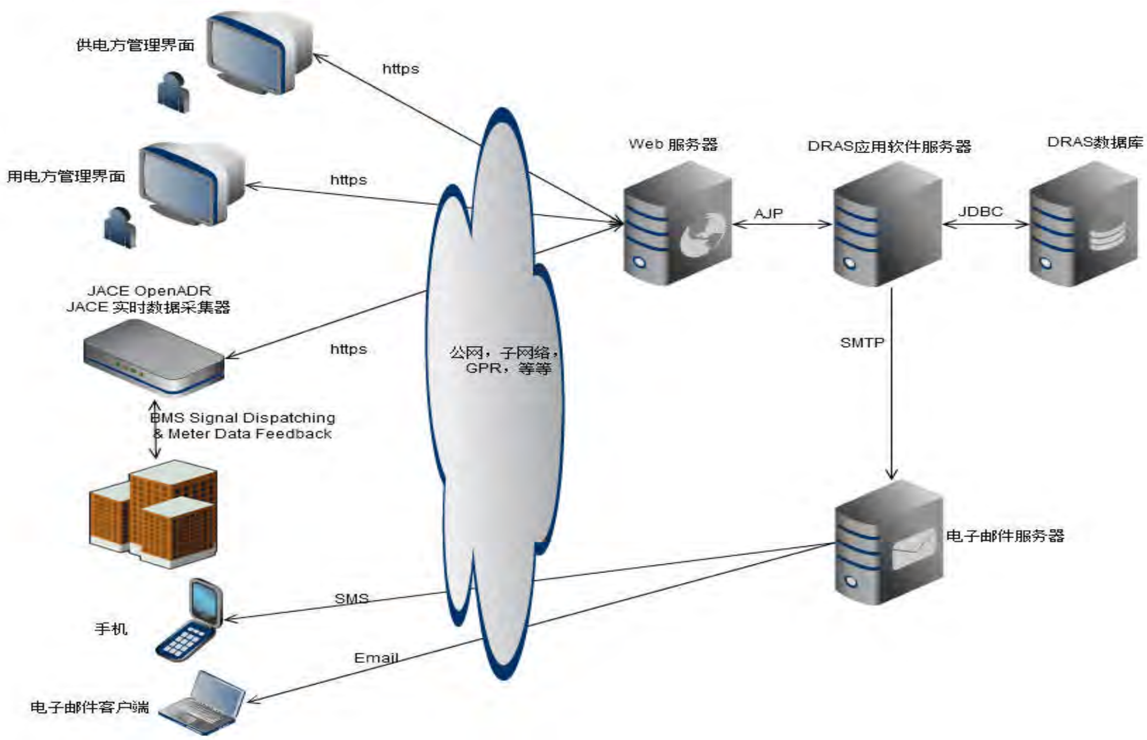


Figure 3-3. DRAS Components

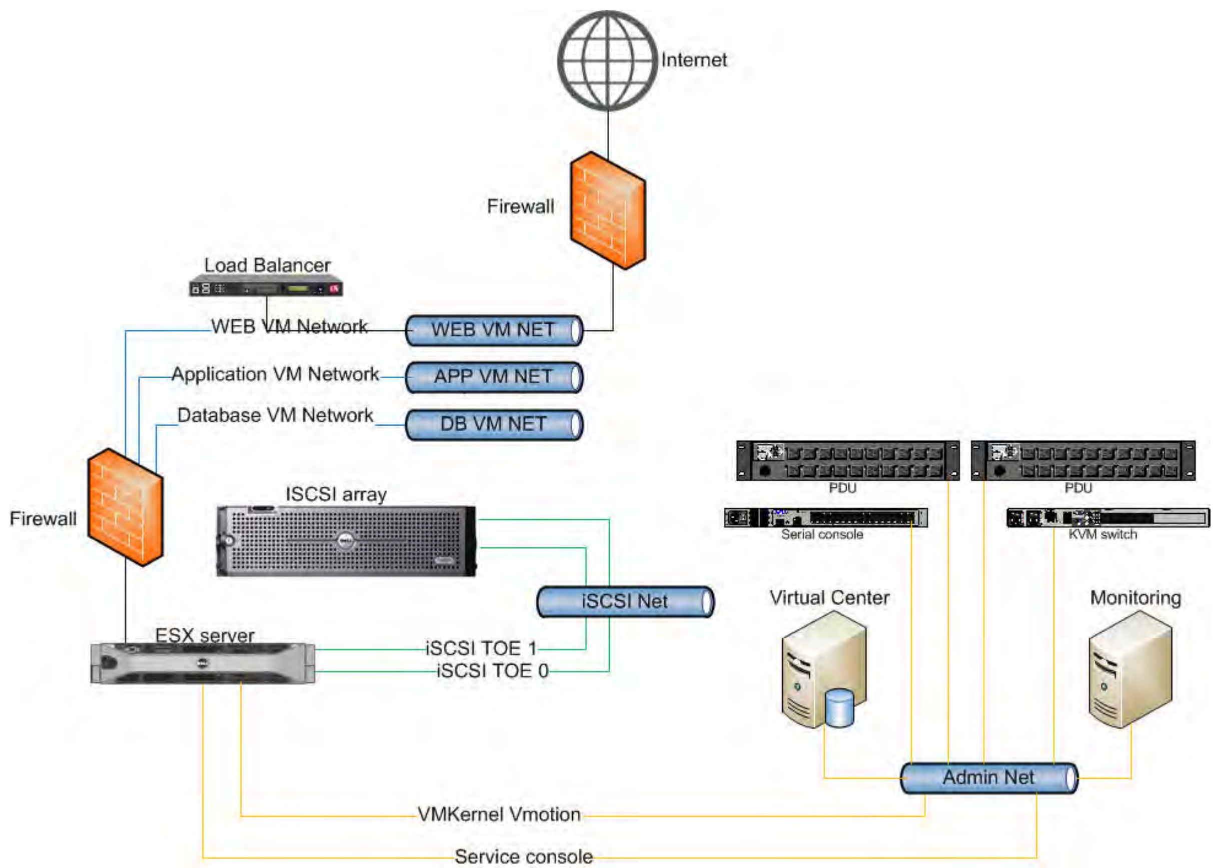


Figure 3-4. DRAS Network

3.2.2.3 Facility Audit Results

The TEDA Administration Building and TEDA Library pilot sites are good examples of typical commercial buildings (i.e., HVAC system design, and major HVAC and lighting equipment types). Geographical differences in commercial buildings across China are not significant for the purposes of this study and are mostly limited to the length and severity of the winter and summer seasons. HVAC system designs and equipment types will be very similar for most large commercial buildings across China.

Appendix D includes the detailed results of auditing the three customer sites: TEDA Administration Building, TEDA Library, and Kumho Tire.

This project's analysis addressed typical DR programs used in the USA: time of use (TOU), critical peak pricing (CPP), and real time pricing (RTP), generically. Details of implementing these types of DR programs in China will differ from USA experience, due to regulatory constraints and other factors.

3.2.2.4 Facility Shed Strategies

After energy auditing and discussions with facility managers, load shed strategies were developed for each site, summarized in the following tables.

Table 3-10. TEDA Administration Building Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - Limit fan variable frequency driver	Automated	5.8	30.9	30.9
Strategy B - Reduce fan quantity	Automated	8.8	17.6	35.2
Strategy C - Shut off elevators	Manual	17.6	35.2	64.8
Strategy D - Lighting switching	Manual	3.6	3.6	3.6
Strategy E - Increase chilled water temperature	Manual	20.8	41.6	62.4
Total kW Reduction =		56.6	128.9	196.9

Table 3-11. TEDA Library Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - Limit AHU fan variable frequency driver	Automated	9.8	23.0	32.1
Strategy B - Switch off exhaust fan	Automated	17.8	28.8	37.8
Strategy C - Reduce PAU fan quantity	Automated	4.4	6.6	11.0
Strategy D - Shut off elevators	Manual	21.0	31.5	39.2
Strategy E - Lighting switching	Automated	54.4	161.8	161.8
Strategy F - Increase chilled water temperature	Manual	9.2	18.3	27.5
Total kW Reduction =		116.6	270.0	309.4

Table 3-12. Kumho Tire Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - AHU Fan Switch Off	Manual		270	557
Strategy B - Shift the Running Time of Rubber Mixers	Manual		1,200	2,400
Strategy C - Shift the Running Time of Semi-finished Rubber Parts Process	Manual		1,195	1,418
Total kW Reduction =			2,665	4,375

3.2.2.5 Install OpenADR Gateway

We installed an OpenADR Gateway installation at each site. The details of the installations are given in Appendix E.

3.2.2.6 Managing DR resources

The DRAS provided by Honeywell Akuacom implements the following function to manage DR resources.

- Program configuration. Figure 3-5 is an example of the DR program configuration page.

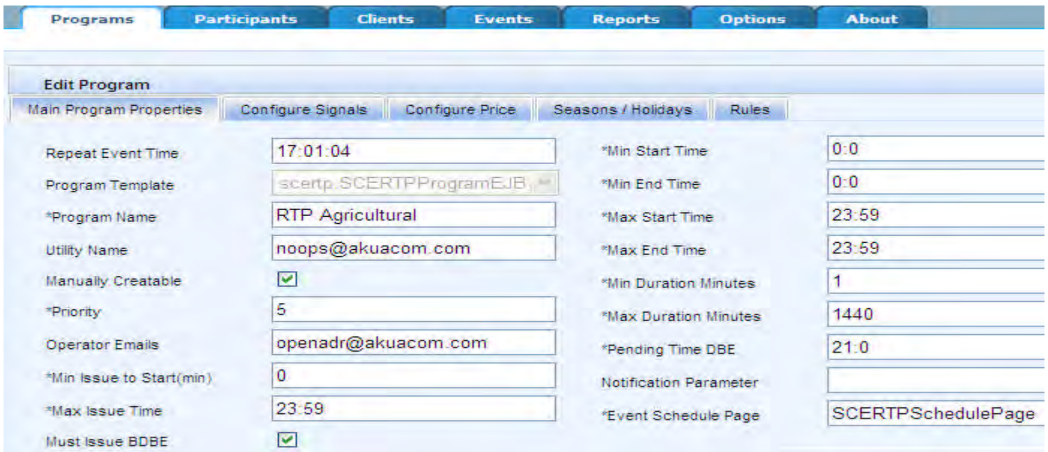


Figure 3-5. DR Program Configuration Page

  - Customizable rules for event time constraints and duration.
  - Intelligent program prioritization to enable multiple program participation
- Resource management. Figure 3-6 illustrates some options on the DRAS customer interface for management of resources.
  - Resource aggregation allows utilities and their facilities to group the resource portfolio by location, shed potential, industry, and facility type.
  - Shed strategy customization and manual control options give facility operators full control of how and when to participate in the various programs.

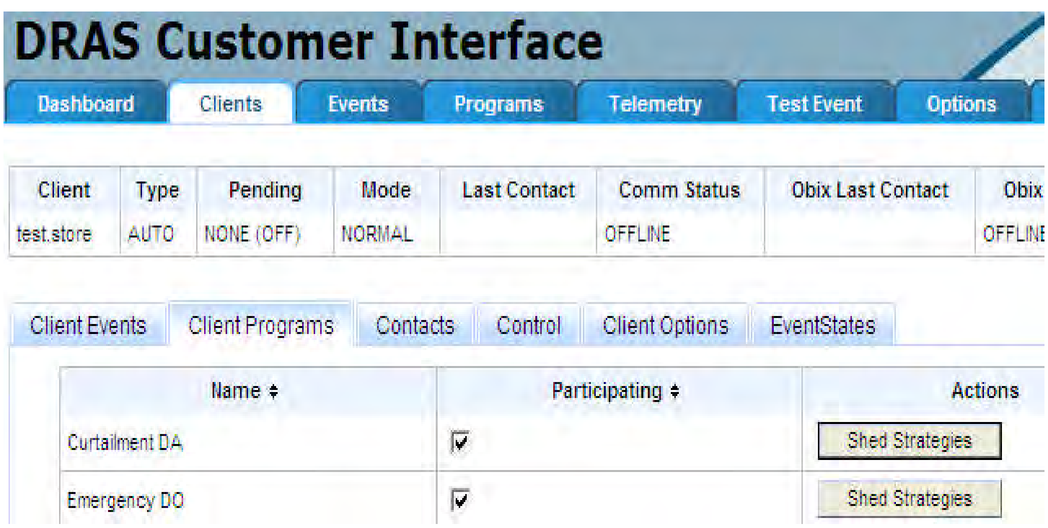


Figure 3-6. DR Client Shed Strategy Configuration

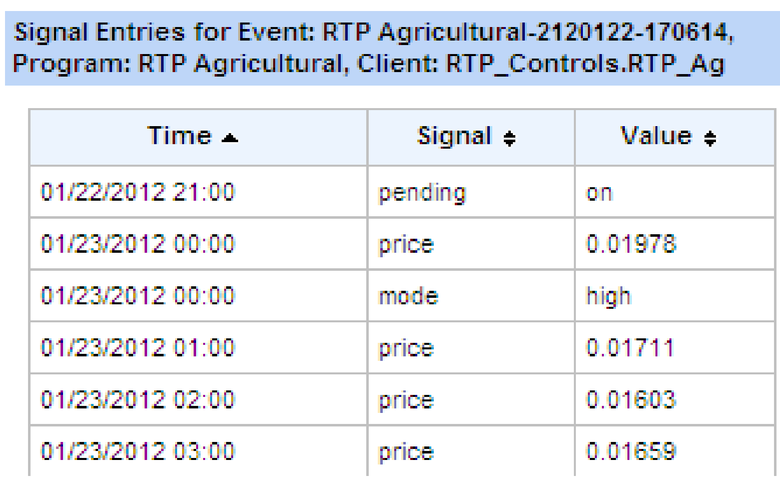
3.2.2.7 Initiating DR Events and Monitor Events and Energy Usage

- Event and signal
  - Intelligent state machine to enable event and dispatch signals in a fool-proof manner.
  - OptIn/OptOut support for utility and facilities at both program and event levels.
  - Two-way messaging infrastructure to communicate price and reliability signals between utilities and facilities.
  - OpenADR compliant WS endpoints to interact with the utilities with facilities over the cloud.
- Event and usage monitoring

Monitor event and signal state in the DRAS (Figure 3-7 and Figure 3-8). The utility implements the following function to issue DR events and monitor events and usage data.

  - Aggregator and facility levels
  - Monitor real time usage and shed information in utility, aggregator (Figure 3-9), and facility levels.

Figure 3-7. Event Summary


Signal Entries for Event: RTP Agricultural-2120122-170614, Program: RTP Agricultural, Client: RTP_Controls.RTP_Ag

Time	Signal	Value
01/22/2012 21:00	pending	on
01/23/2012 00:00	price	0.01978
01/23/2012 00:00	mode	high
01/23/2012 01:00	price	0.01711
01/23/2012 02:00	price	0.01603
01/23/2012 03:00	price	0.01659

Figure 3-8. Client Signal Page

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	67.01	1,591.59	66.44	1,577.90	0.58	13.69
During Event	112.62	450.47	81.12	324.46	31.50	126.01

Figure 3-9. Customer/Aggregator Telemetry Page

3.2.2.8 Producing DR Reports

DRAS provided by Honeywell Akuacom uses the following methodologies to calculate a baseline and generate DR reports.

- Baseline models
  - 3/10 baseline (default)
  - 3/10 baseline with morning adjustment
  - 5/10 baseline
  - 5/10 baseline with morning adjustment
  - 10/10 baseline
  - 10/10 baseline with morning adjustment

- Aggregation
  - Program-based DR resource aggregation
  - Group demand response resources by industry, facility type, location, potential kilowatt (kW) reduction or other common attributes.
  - Load and report aggregation
- Event performance scorecard (Figure 3-10)

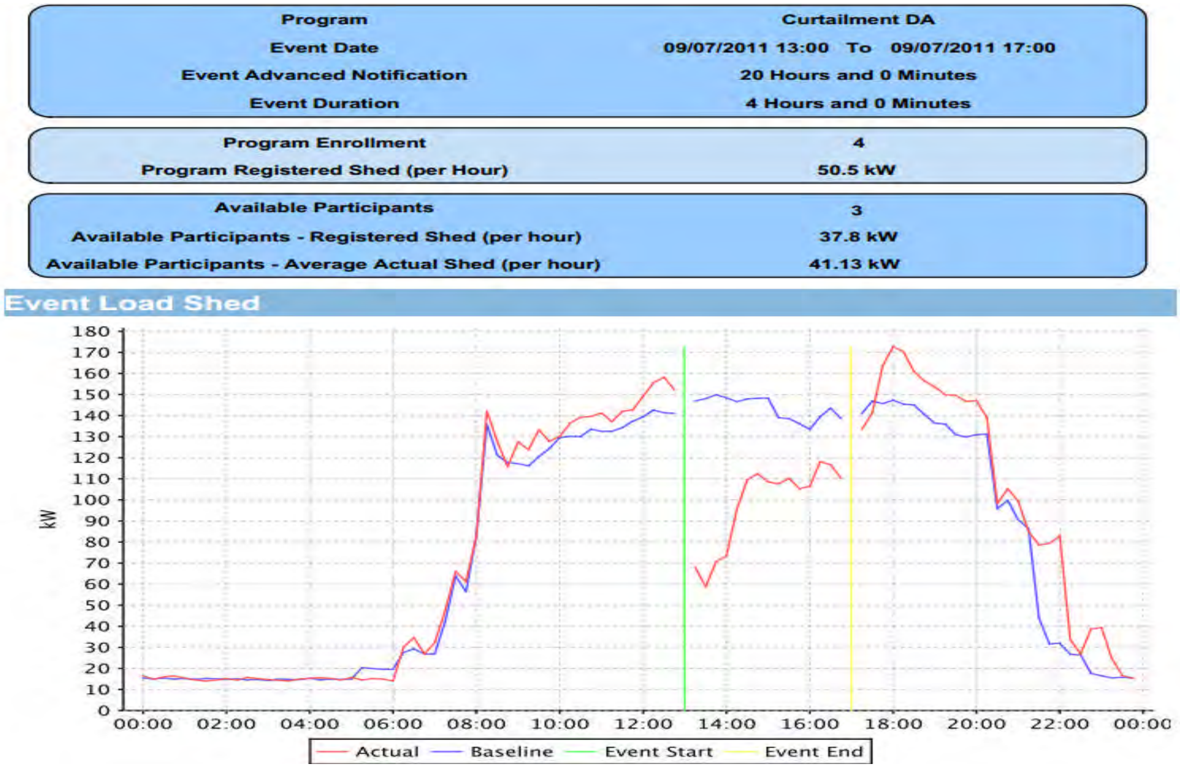


Figure 3-10. Event Scorecard

3.2.3 Pilot Implementation Schedule

Working with facility managers and building site owners, the Honeywell team developed a project schedule to guide the pilot implementation work.

3.3 Automated Demand Response

Automated demand response (AutoDR) technology offers many advantages that help utility and grid operators to balance supply and demand. This technology should have a prominent place in China's smart grid roadmap. The following sections provide a brief high level discussion of some of the features of AutoDR.

3.3.1 Benefits of Automated Demand Response

Today's demand management practices in China rely heavily on manually implemented curtailments of whole facilities. While these methods are effective from a grid stability standpoint, scheduling plants and buildings to shutdown 3 or 4 times per month results in an "all or nothing" situation for the facility owner. The result is that their business is either open and operating, or it is shutdown or severely impacted during an event.

Automated demand response (AutoDR) offers an alternative having significant benefits for both the utility and facility owners. An objective of AutoDR is to keep the end user at or near normal output capacity during a DR event. Shed activities are designed to be relatively non-intrusive to the operation of the facility. Turning off lights, fans, elevators and raising temperatures for short periods does not require a complete shutdown. Utility demand response incentives can be reduced by applying AutoDR, because the impact on the facility owner can be programmed to be much less costly to the owner's operations.

A recent publication by the OpenADR Alliance, a nonprofit corporation created to foster the development, adoption and compliance of a smart grid standard known as Open Automated Demand Response (OpenADR), , [ADR Primer], states that for most effective operation, demand response programs need automation and that "ADR helps system operators reduce the operating costs of DR programs while increasing DR resource reliability. For customers, ADR reduces the resources and effort required to achieve successful results from these DR programs".

OpenADR is gaining momentum as the number deployments around the world increases. Figure 3-11 shows key applications of the technology. [OpenADR]

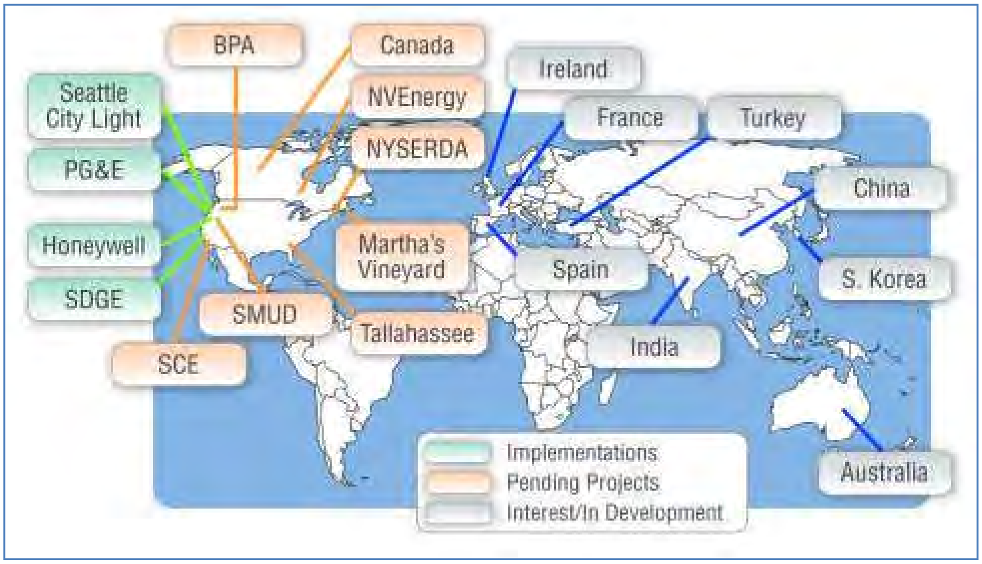


Figure 3-11. Key applications of OpenADR worldwide

An interactive map of ADR deployments can be found on the LBNL website [ADR map].

3.3.2 Demand Response and Energy Efficiency

In support of peak and overall consumption reduction, interest in combining DR programs with energy efficiency programs and technologies is growing. While the two types of programs have slightly different goals (peak load reduction vs. overall consumption reduction), their objectives are complementary and generate greater results when combined, with each offering important benefits to both the utility and the end customer. AutoDR combined with energy efficiency programs can offer even greater benefits.

A recent study by Lawrence Berkeley National Laboratory [LBNL-3044E], states: "Energy efficiency programs yield energy savings, and demand response programs yield reductions in demand at critical times, which usually correspond to times of peak power demand … But the programs have overlapping effects: energy efficiency can permanently reduce demand, and demand response, with proper control strategies, also produces some energy savings … The effect of energy efficiency on electricity demand is clear. Buildings and equipment that use less energy (fewer kilowatt-hours) because they are more efficient impose smaller power loads (lower kilowatts of demand) on the system."

Another study found that "because the majority of technologies that are promoted by energy efficiency programs (e.g., lighting, air conditioning) operate during hours of peak demand— typically hot summer afternoons across most of the United States—they contribute to reductions in system peak." [York and Kushler]

3.3.3 Smart Grid Ready Facilities

AutoDR technology can be easily retrofitted to existing buildings and doesn't have to be "designed in" for new buildings or industrial facilities. This ease of application enables utility AutoDR programs to be successful in both new and retrofit installations. The ability to leverage existing investments in building and process control systems promotes acceptance of AutoDR technology.

A building or industrial facility that is enabled to receive AutoDR signals (rather than using manual DR), can be described as "smart grid-ready." Such a facility is ready to participate in AutoDR programs and automatically shed load when the programs become available from the electric utility. AutoDR enables a facility to dependably reduce load, thereby providing a valuable demand-side resource for the utility and a good economic return for the facility owner. The concept of smart grid-ready facilities is illustrated in Figure 3-12.

The utility can encourage efficiency in a way that encourages development of smart grid-ready facilities. Even before a full DR program is ready, the utility can create strong interest and a capable and willing customer base that is prepared to support future AutoDR programs. An example of properly marketed and incentivized utility programs is one that delivers end-use benefits such as energy efficiency and demand limiting. The goal is to design programs that are cost-justified on their own merits and that also create the capability within facilities to support additional services such as AutoDR.

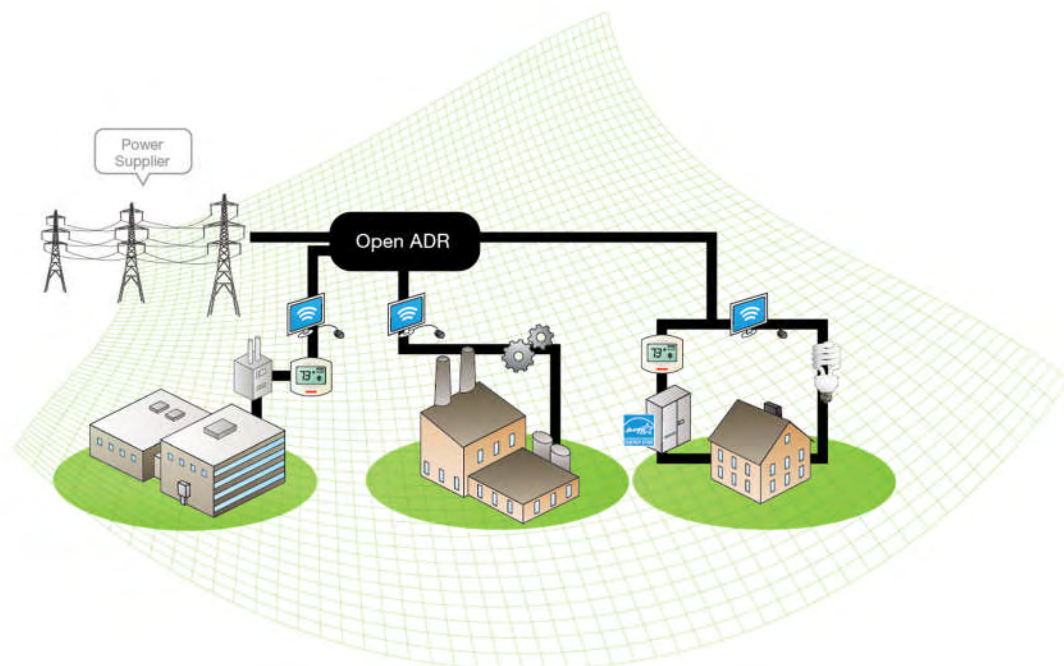


Figure 3-12. Smart Grid-ready facilities concept

4 Pilot Project Implementation

This section presents the results of the demand response implementation at the selected customer sites and the demonstrated benefits of demand side management.

This project installed and operated Honeywell demand-side management technologies in selected commercial and industrial pilot sites to demonstrate the feasibility of adopting automated demand response solutions within China's grid infrastructure. The pilot sites were selected jointly with the pilot city partner for this project (Tianjin Economic Technological Development Area - TEDA) and CEPRI.

The objective of this demonstration was to verify that open standards based automated demand response works in China and can provide valuable benefits for State Grid, electric utilities, and electric customers. Due to the limited scope of this feasibility study project, there was no intent to define a proposed structure (or parameters) for a demand response tariff that meets all of the needs and constraints that exist in the China electric utility sector. Given the limited scope and simulated nature of the demonstration, this effort was very successful, and the measured results provide important validation of OpenADR automated demand response technology in China. Building from this successful demonstration, work to develop appropriate demand response programs in China will require more effort from all stakeholders over the next few years. Honeywell and AECOM are ready to assist SGCC, CEPRI and other stakeholders in taking those next steps.

With the strong assistance and support from TEDA government and help from CEPRI and SGCC Smart Grid Department, Honeywell screened three cities and over 20 potential sites recommended by the TEDA public utility bureau, State Grid Tianjin Power Company as well as TEDA Power, including Vishay Semi-Conductor, Tianjin FAW Toyota, Standard Chartered Bank, Motorola, Novo Nordisk, Ting Yi Holding Corp. After about 5 month of visiting, auditing, and technical discussions, two commercial buildings and one industrial facility were recruited to participate as demonstration sites in this project.

The demonstration was implemented using the Open Automated Demand Response (OpenADR) standard. To meet Chinese energy data storage/transmission safety requirement, a new Demand Response Automation Server (DRAS) was constructed and installed at the eTEDA data center in Tianjin. OpenADR Gateways are installed at the customer site locations. This configuration is shown in is shown in Figure 4-1.

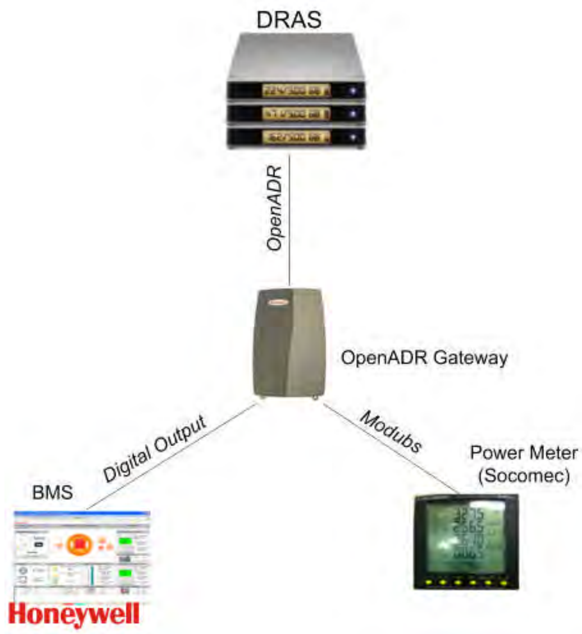


Figure 4-1. Demonstration Implementation Hardware Configuration

For the pilot implementation, two demand response programs were proposed and agreed on with CEPRI—the new critical peak pricing (CPP) and modified time of use pricing (TOU) structure. Implementation of a new tariff in China for a pilot project is very difficult since utility tariffs are heavily regulated. As expected, the implementation of CPP and new TOU were not approved by utility companies for this project; therefore, the pilot project demonstration used a simulated critical peak price signal to trigger the automatic demand events by the affected utility companies. The event "High" is issued using this simulated signal. The DR events issued during the demonstration for the two commercial and one industrial site are shown in Table 4-1.

Table 4-1. DR Events Issued at Demonstration Sites

	Notification Time	Notification Method	Event Day	Start Time	End Time	Participants
Event 1	Day ahead	Email, Manual	Jun 15, 2012	14:00	15:00	TEDA Admin Building, TEDA Library
Event 2	Day ahead	Email, Manual	July 6, 2012	13:30	15:30	TEDA Admin Building, TEDA Library
Event 3	Day ahead	Email, Manual	Aug 8, 2012	14:00	16:00	TEDA Admin Building, TEA Library, Kumho Tire
Event 4	Day ahead	Email, Manual	Aug 23, 2012	9:30	11:00	TEDA Admin Building, TEA Library, Kumho Tire

No major problems were encountered during the demonstration work. The auto DR demonstration at the three field sites was very successful. Other than the simulated nature of the DR events and the work needed to host the DRAS at a data center in China, all aspects of the demonstration were accomplished in the same manner as Honeywell's auto DR pilot programs at other electric utilities around the world. As a result of this demonstration, we believe there are no technical or operational barriers that would prevent wide implementation of auto DR in China.

A number of minor problems were discovered in performing this demonstration. A set of recommended solutions or approaches for addressing these items is included in Section 4.6.

4.1 Demonstration Overview

This section presents an overview of the demonstration work and a high-level description of the individual customer sites.

4.1.1 Testing Roles

Several different roles supported the development of the test plan and pilot implementation for this pilot project. These roles are as follows:

- **TEDA** coordinated development of the test plan between Honeywell, TEDA Power and the customer sites.
- **CEPRI** provided suggestions for the testing plan and monitored some of the testing process.
- **Tianjin Power** and Honeywell worked together in defining demand response events for the pilot site in west TEDA where the power is supplied by Tianjin Power.
- **TEDA Power** and Honeywell worked together in defining the demand response events linked with the two commercial buildings power-supplied by TEDA power.
- **Pilot Site Facility Managers** received demand response requests, to make the decision to participate (opt-in) or not. If yes, they were responsible for ensuring that the DR requests were responded to correctly; they also provided customer feedback. The facility managers helped coordinate with other suppliers for building management system interface programming and interfacing with the OpenADR Gateway.

4.2 Pilot City and Pilot Site

The biggest challenge for the project pilot demonstration was to find a demonstration city and customer sites since there were no initial incentives such as utility tariff changes that could benefit pilot customers or other subsidies planned in the project budget.

With the help of CEPRI and ECP, the team was able to select Tianjin as the pilot city and we signed the pilot site agreement with TEDA, as shown in Source: TEDA

Figure 4-2. The project team then visited and audited over 20 different customer facilities, ultimately selecting two commercial buildings and one industrial site. For the companies/facilities visited, see Table 4-2.

The biggest challenges for the pilot city and pilot site selection are:

- Demand response is a new concept and technology in China; the concept was not easily explainable and understood by customers.
- There were no clear low-level benefits for participation since there were no subsidies planned and no utility tariff changes allowed.
- Piloting demand response involved many parties, government, local utilities, facility owners, etc.—the decision making process was lengthy.
- Short project timing didn't allow many decision making iterations.

The project team had these advantages and solutions:

- Great team together with CEPRI/SGCC
- Multi-proposal, simultaneous engineering
- Comprehensive resource leveraging, ECP, USTDA, SGCC, CEPRI, HON…
- Honeywell top leader's strong support
- Effective global/local resource collaboration, fast growth of local team
- Effective communication

Source: TEDA

Figure 4-2. Tianjin Economic Development Area

Table 4-2. List of Companies Audited or Visited in TEDA

No	Company Visited/Audited	Segment	Initial DR Understanding	Engagement Efforts
1	泰达管委会大楼 TEDA Admin Building	Commercial Bldg	Low	High
2	泰达图书馆及档案馆 TEDA Library	Commercial Bldg	Low	High
3	锦湖轮胎天津公司 Kumho Tire	Mechanical	Low	High
4	维斯塔斯天津公司 Vestas Tianjin	Mechanical	Mid	High
5	三星机电 Samsung Tianjin	Electro Mechanical	Low	High
6	霍尼韦尔天津环境控制工厂 HON ECC Tianjin Plt	Electrical/mechanical	Mid	High
7	威世通用半导体(中国)有限公司 Vishay General Semiconductor Co., Ltd	Electronic	High	High
8	天津一汽丰田汽车有限公司 Tianjin FAW TOYOTA Motor Co., Ltd	Transportation	Medium	High
9	康师傅控股有限公司 Ting Yi (Cayman Islands) Holding Corp.	Food and Beverage	Medium	High
10	摩托罗拉(中国)电子有限公司 Motorola (China) Electronics Ltd	Electronic	Low	Low
11	天津杰士电池有限公司 Tianjin GS Battery Co., Ltd	Chemical	Low	Mid
12	天津富士达电动车 Tianjin Fushida Elec-Bicyle	Transportation	High	High
13	渣打科营中心 Standard Chartered Scope	Commercial	High	High
14	SEW (German Transmission Plant)	Mechanical	Low	Low
15	诺华诺德 Novo Nordisk	Pharmaceutical	Medium	Mid
16	天津联发精密钢铁	Mechanical	Medium	Low
17	天津秉信纸业	Paper	Low	Mid
18	东方电机	Mechanical	Low	Low
19	首都航天机械公司	Mechanical	Medium	Mid
20	西区投资服务中心	Commercial	Medium	High

We learned several key lessons from the selection of the pilot city and the pilot sites:

- US China Energy Cooperation Project (ECP) is a vital platform to make the initial engagement with potential pilot cities, and pilot sites. Without the platform, the selection of pilot city and pilot sites would have not been possible.
- Given the nature of the demonstration, the incentive mechanism must be considered in the project planning phase, such as which subsidy per demand response time or electricity tariff changes can be allowed and implemented.
- It would be very helpful to understand local government's intention and expectation, the demo project has to bring benefits to the local government such as green image enhancement, investment promotion…
- Local government has strong connections with the companies in the area, their support and coordination is vital to project success.

- Brand name and the resourcefulness of a bigger company are also important, especially on high level engagement
- The “trick is in the doing”, strong execution and persistence makes impossible possible

4.3 Selected Demonstration Sites

With assistance from TEDA and CEPRI, the Honeywell team recruited two commercial buildings and one industrial facility to participate as demonstration sites in this project. An overview of these sites is shown in Table 4-3.

Table 4-3. TEDA Power CPP Program

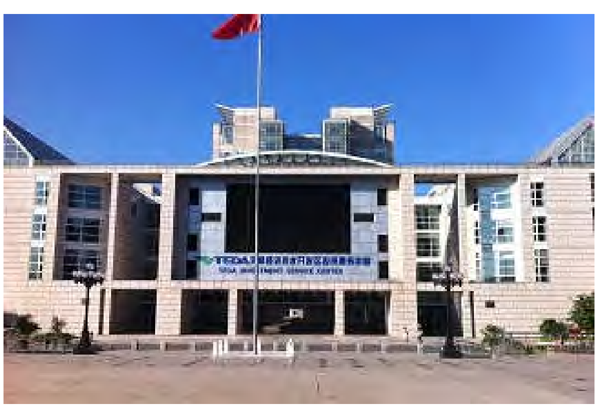
Demonstration Site	Function	Number of Occupants	Building Floor Area	Hours of operation
TEDA Administration Building	Commercial Building	about 1000	52,653 m^2	8:30 to 17:00, Monday to Friday
TEDA Library	Library & Commercial Building	about 3000 (visitors) + 700	66,000 m^2	Library open hours: 9:00am – 8:00pm in winter, 9:00am – 9:00pm in summer, Tues.-Sunday Archives working hours: 8:30am - 5:00pm, Monday - Friday
Kumho Tire	Motor Vehicle Parts / Rubber Products manufacturing	about 2300	310,000 m^2	24 hours x 7 days, 4 shifts

The selected buildings are shown in Source: TEDA

Figure 4-3, Source: TEDA

Figure 4-4, and Source: Kumho Tire

Figure 4-5. Demand response audit results for the three demonstration sites are presented in Section 3.2.2.3.



Source: TEDA

Figure 4-3. TEDA Admin Building

Source: TEDA

Figure 4-4. TEDA Library

Source: Kumho Tire

Figure 4-5. Kumho Tire

4.4 Methodology

This section describes the methodology used in the pilot project, including the Demand Response Automation Server (DRAS), OpenADR Gateway installation and configuration, cyber security, and the peak demand base line model.

4.4.1 DRAS Local Hosting

Based on local policy and customer requirements, it was necessary that the DRAS be physically located in China; therefore, the DRAS was installed at the eTEDA data center in Tianjin.

4.4.2 DRAS Configuration

Figure 4-6 illustrates the DRAS architecture. More details are given in Section 3.2.

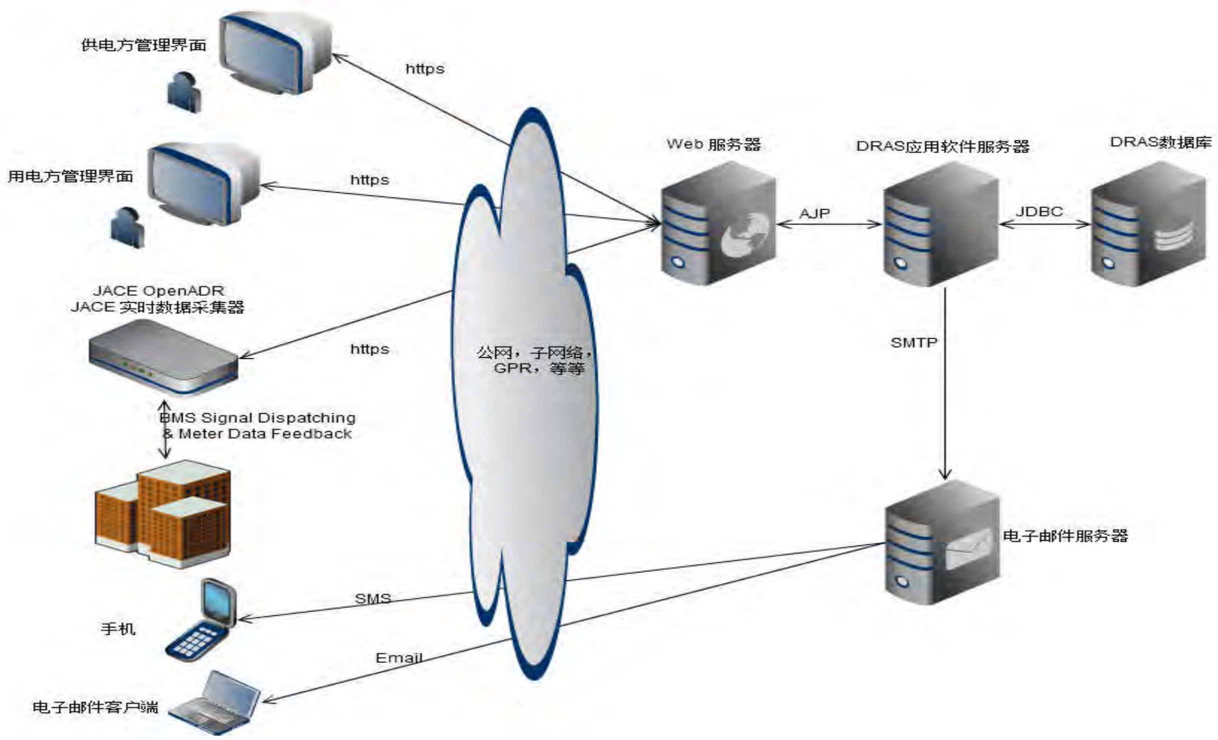
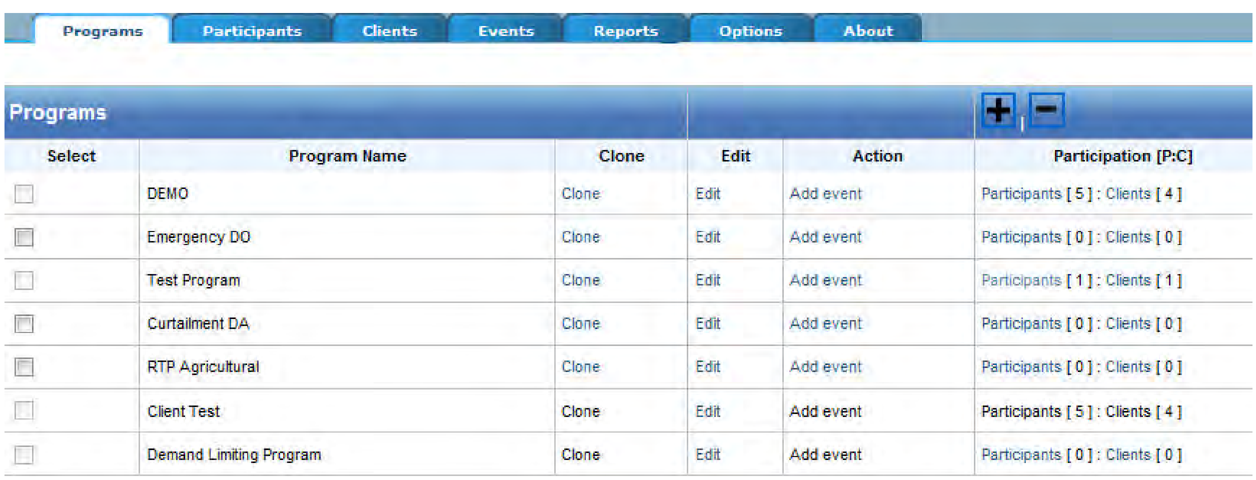


Figure 4-6. DRAS Architecture

Two types of accounts are configured in the system. Both account types use the URL http://teda.openadr.com.

- Utility account. The utility operator uses this account to add programs, participants, clients, events, etc. to the system. Figure 4-7 shows the utility operator web interface.
- Participant account. Participants (usually facility mangers) use this account type to check events, add contacts, opt-out, etc. Figure 4-8 shows the participant web interface.



Select	Program Name	Clone	Edit	Action	Participation [P:C]
	DEMO	Clone	Edit	Add event	Participants [5] : Clients [4]
	Emergency DO	Clone	Edit	Add event	Participants [0] : Clients [0]
	Test Program	Clone	Edit	Add event	Participants [1] : Clients [1]
	Curtailment DA	Clone	Edit	Add event	Participants [0] : Clients [0]
	RTP Agricultural	Clone	Edit	Add event	Participants [0] : Clients [0]
	Client Test	Clone	Edit	Add event	Participants [5] : Clients [4]
	Demand Limiting Program	Clone	Edit	Add event	Participants [0] : Clients [0]

Figure 4-7. Utility Operator Web Interface

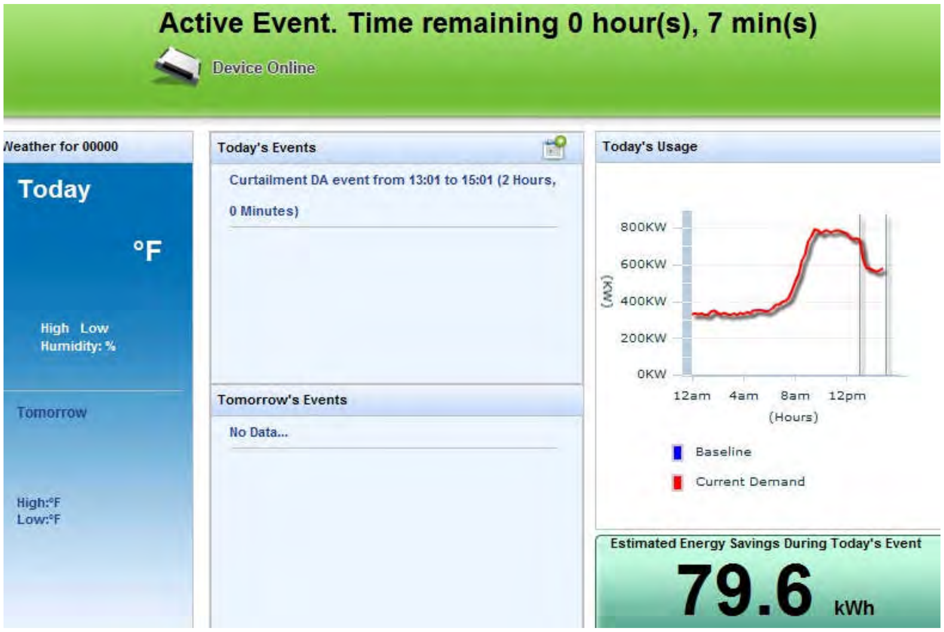


Figure 4-8. Participant Web Interface

4.4.3 DRAS Maintenance

The DRAS is maintained remotely by Honeywell, so the utility doesn't need to maintain the system.

4.4.4 OpenADR Gateway Installation and Configuration

For details of the OpenADR gateway installations, refer to the Appendix G.

4.4.5 Cyber Security

The DRAS was developed from the outset using fundamental security architecture concepts:

- Requirements.
  - Confidentiality
  - Integrity
  - Authentication
- Implementation. Transport Layer Security/Secure Sockets Layer (TLS/SSL).
  - The connection is private. Symmetric cryptography is used for data encryption (e.g., DES [DES], RC4 [SCH], etc.).
  - The connection is reliable. Message transport includes a message integrity check using a keyed MAC. Secure hash functions (e.g., SHA, MD5, etc.) are used for MAC computations.
  - Authentication. Server with client password or client certificates
  - Client/Server architecture with separation of web traffic from the application server and the database layers.

The DRAS presents a server SSL certificate issued by a well-known certificate authority. It is, of course, up to the client facility manager to validate this certificate before proceeding with any transactions.

The OpenADR Gateway implements secure and role-based communication with DRAS. All ports are forbidden except port 25 (time synchronization), 80(http) and 443(https) in OpenADR Gateway. The DRAS not only supports client devices from Honeywell, but also supports third-party devices and provides sample code that demonstrates the proper use of SLL. Honeywell suggests that each client certified for a given project complete a security review to verify the proper use of SLL.

4.4.6 DR Program Design

Based on the CPP program design shown in Table 4-4, the ratio of the CPP event rate to the valley rate falls between 8 and 10. When one CPP event is issued, the signal "High" will be sent from the DRAS to the OpenADR Gateway, which converts “High” to a digital output signal connected to the building energy management system on the customer side.

Table 4-4. TEDA Power CPP Program

	Voltage Category	CPP Peak Event Rate (¥/kWh)	TOU Consumption Rate (D) (¥/kWh)			Ratio of CPP Peak to TOU Valley Rate
			Peak	Normal	Valley	
Ordinary industries, commercial and other power consumption	<1 KV	4.01	1.60	0.86	0.32	12.5:1
	1-10KV	3.93	1.57	0.84	0.31	12.5:1
	35-110KV	3.87	1.55	0.83	0.31	12.5:1
Large-scale industries power consumption	1-10KV	3.62	1.45	0.66	0.29	12.5:1
	35-110KV	3.48	1.39	0.64	0.28	12.5:1
	110-220KV	3.39	1.35	0.63	0.27	12.5:1
	>=220KV	3.36	1.34	0.62	0.27	12.5:1

4.4.7 Peak Demand Baseline Model

Utilities and facilities need baselines for usage data against which they can compare performance when assessing demand shed. Baselines are a simple form of forecast that predict a day's usage using simple calculations based on the usage measured on the previous days. In addition to using historical data from previous days, some baselines are also adjusted based on measurements made in the morning of the same day. These adjustments are called morning adjustments and are explained further below.

The n/m baseline model is the average hourly load shape of the “n” highest consumption days within “m” selected like-days. TEDA DRAS adopts a 3/10 week day model.

Here is the logic for the TEDA 3/10 week day baseline calculation.

1. Establish a 10-day selection pool.

   Choose the last 10 business days, excluding
   - Weekends
   - Holidays
   - Event dates
2. Calculate the average consumption of each day.

   Calculate the average consumption during the possible DR period (TEDA DR potential period is between 12:00 and 20:00)

3. Choose the three highest consumption days.

   Choose the three highest consumption days using the result in Step 2.

4. Calculate the average.

   For each interval, calculate the average consumption of the three highest days. Those average consumption points constitute the baseline.

The morning adjustment is used to make an adjustment to the baseline to accommodate situations in which today's weather or other factors are significantly different from the past few days. In these cases, the calculated n/m baseline might not accurately predict the normal (i.e., non-shedding) usage behavior. For example: Today is going to be extremely hot, but the past two weeks have been rainy. The average high temperature over the last two weeks was about 70 degrees, but the expected high today is 100 degrees. We can expect that our baseline does not accurately predict our usage for today.

The morning adjustment calculation uses that day's actual usage data reported in the morning time or hours before the event starts. The calculation constructs an average offset from the baseline to that day's actual data, and then re-constructs the baseline using that offset. Thus, the new baseline for the day is a better predictor for the rest of the day (especially the usual event periods in the afternoon) than the old baseline.

As an example, Figure 4-9 shows a typical load profile in TEDA Admin Building on a non-event day when the 3/10 baseline approach results consistency between the "forecasted" and the actual load profiles.

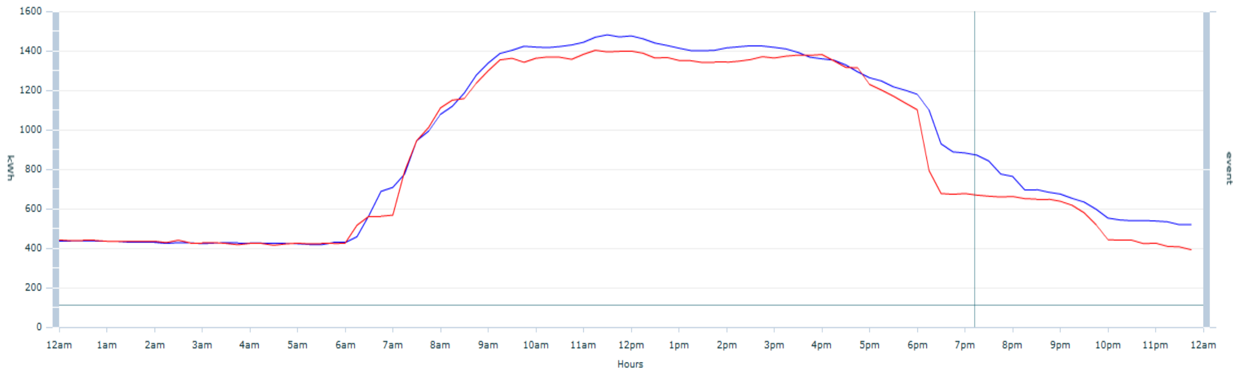


Figure 4-9. Typical Load Profile of TEDA Admin Building

4.5 Demonstration

The following sections present the process followed and the results collected during the demonstration.

Figure 4-10 illustrates the testing process.

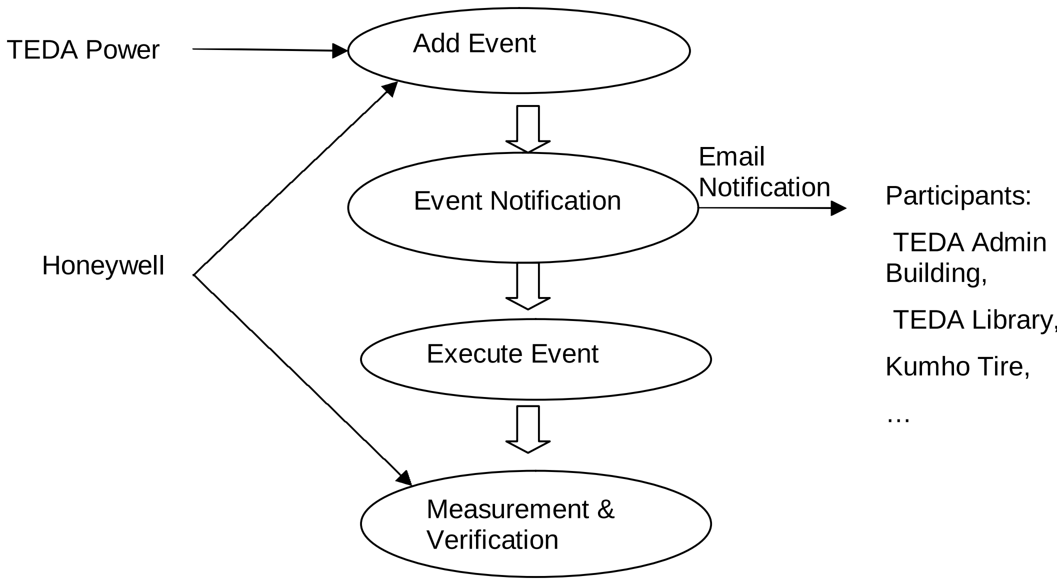


Figure 4-10. DR Pilot Project Test Process

4.5.1 Automatic Demand Response Events

The CPP program proposed in Section 3 is not a tariff approved by TEDA power. Therefore, this pilot project simulated the critical peak price signal. The event "High" was issued using this simulated signal. The events in Table 4-5 were defined and executed for this project.

Table 4-5. ADR Events

	Notification Time	Notification Method	Event Day	Start Time	End Time	Participants
Event 1	Day ahead	Email, Manual	Jun 15, 2012	14:00	15:00	TEDA Admin Building, TEDA Library
Event 2	Day ahead	Email, Manual	July 6, 2012	13:30	15:30	TEDA Admin Building, TEDA Library
Event 3	Day ahead	Email, Manual	Aug 8, 2012	14:00	16:00	TEDA Admin Building, TEA Library, Kumho Tire
Event 4	Day ahead	Email, Manual	Aug 23, 2012	9:30	11:00	TEDA Admin Building, TEA Library, Kumho Tire

4.5.2 Measured Load Reduction

The combined load reduction (for the TEDA Admin building and the TEDA Library) for Event 2, is shown in Figure 4-11. During this event, the demonstration was very successful and the two customer sites responded as follows:

- Because the TEDA Admin Building baseline is much lower than the actual load, its actual load shedding was lower than the estimated load shedding.
- All devices for the TEDA Library responded automatically, so the response speed was very fast.

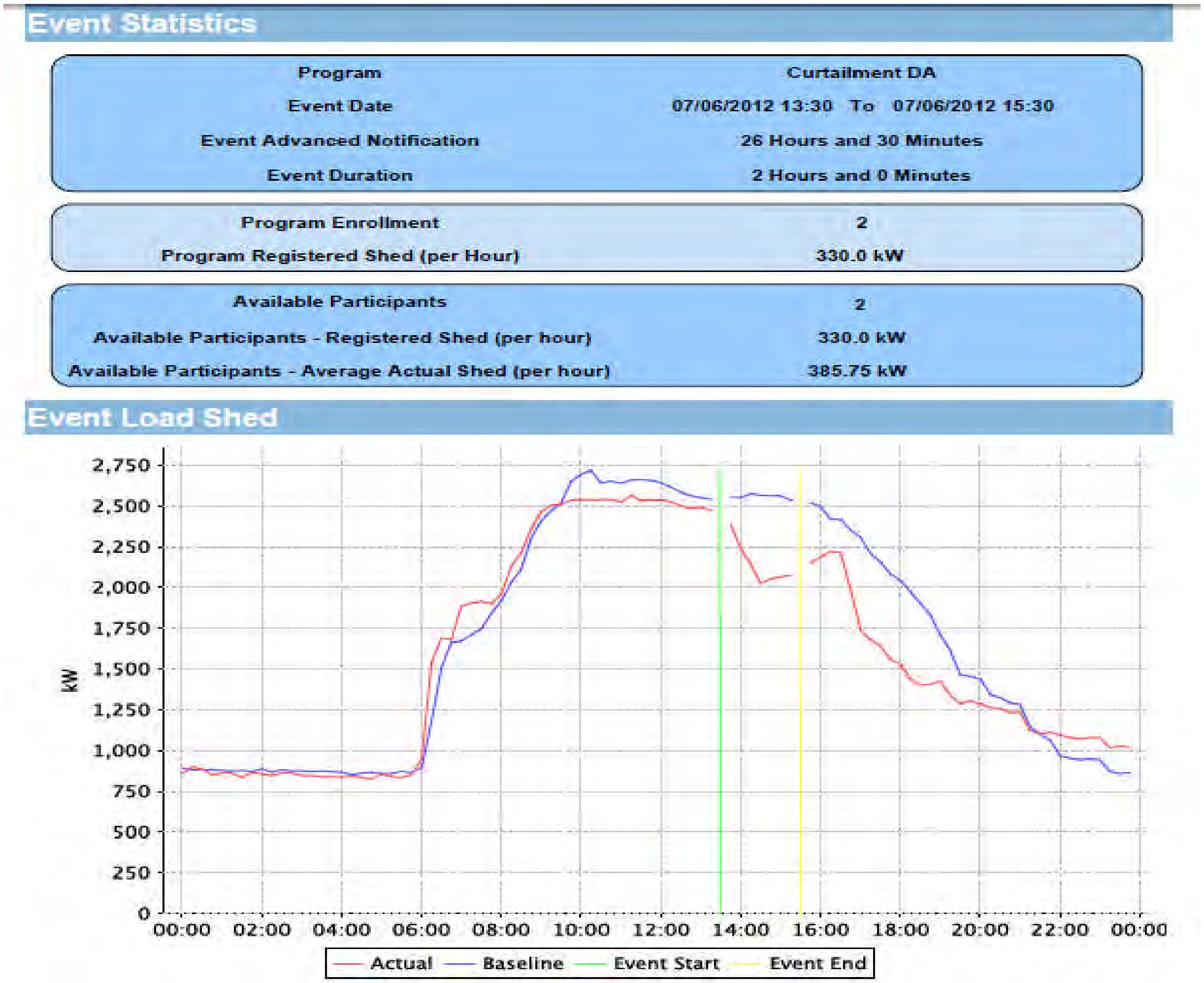


Figure 4-11. Event 2 Score Card

Additional measured results for all demonstration events are included in Appendix H.

Individual building load reductions for Event 2 at the TEDA Admin building and the TEDA Library are shown in Figure 4-12 and Figure 4-13. These results are representative of the measured load reductions for these two sites. Additional measured results for all three demonstration sites are included in Appendix F.

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	1,114.20	26,462.18	1,027.67	24,407.08	86.53	2,055.10
During Event	1,758.53	3,517.07	1,479.16	2,958.31	279.38	558.76

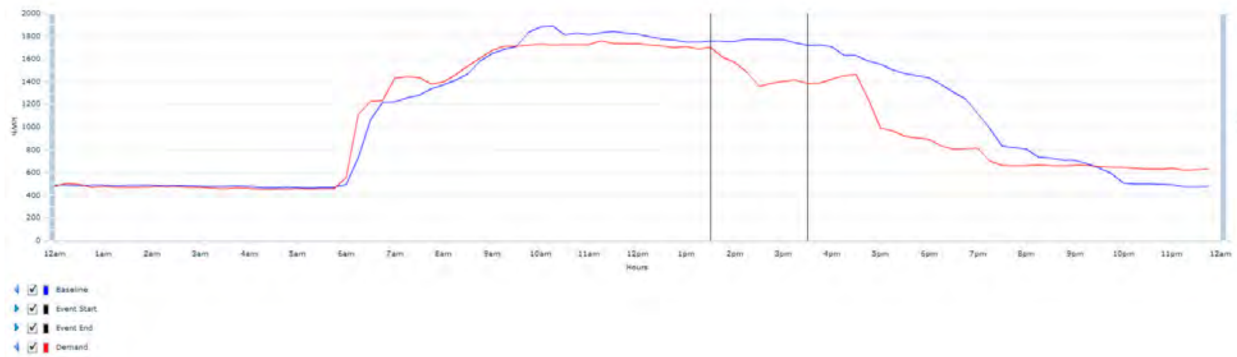


Figure 4-12. TEDA Admin Building Load Curve during Event 2

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	589.75	14,006.56	576.00	13,680.00	13.75	326.56
During Event	793.48	1,586.96	687.11	1,374.22	106.37	212.74

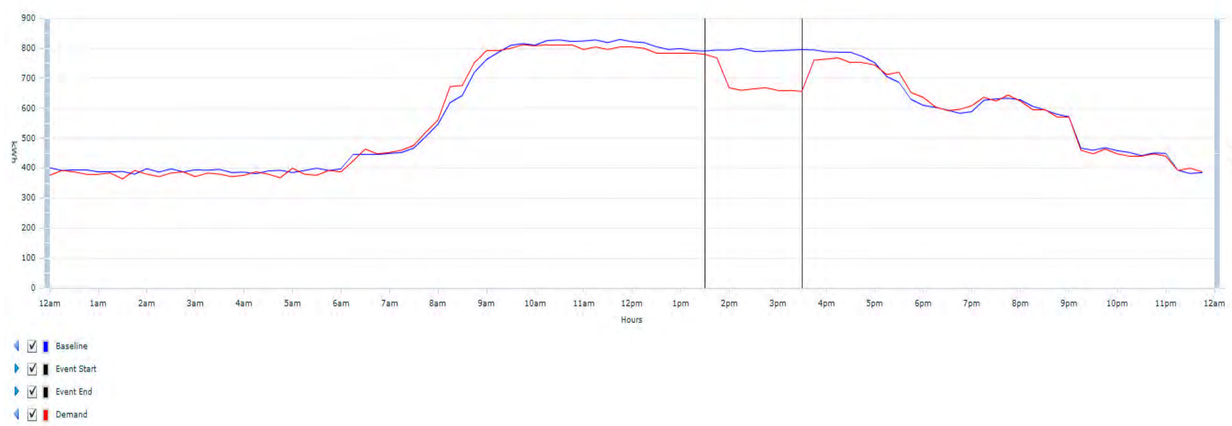


Figure 4-13. TEDA Library Load Curve during Event 2

4.5.3 Benefits and Simulated CPP and TOU Analysis

Using the four ADR event profiles, we presented the benefits to the pilot site owners and potential benefits to utility companies as summarized in Table 4-6.

Table 4-6. ADR event Benefits

<table>
<tr><th>Event</th><th>Parameter</th><th>KumhoTire</th><th>Admin Bldg</th><th>Library Bldg</th><th>Sub-total</th></tr>
<tr><td rowspan="5">Event 1
June 15</td><td>Baseload(Kw)</td><td rowspan="5">Not Ready</td><td>1592.4</td><td>BMS issue</td><td>1592.4</td></tr>
<tr><td>Shed -Expected (Kw)</td><td colspan="3">330</td></tr>
<tr><td>Shed -Actual (Kw)</td><td>253</td><td rowspan="3">BMS issue</td><td>253</td></tr>
<tr><td>Energy Saving(Kwh)</td><td>253</td><td>253</td></tr>
<tr><td>Shed Rate %</td><td>15.9%</td><td>15.9%</td></tr>
<tr><td rowspan="5">Event 2
July 06</td><td>Baseload(Kw)</td><td rowspan="5">Not Ready</td><td>1758.53</td><td>793.48</td><td>2552.01</td></tr>
<tr><td>Shed -Expected (Kw)</td><td colspan="3">330</td></tr>
<tr><td>Shed -Actual (Kw)</td><td>279.38</td><td>106.37</td><td>385.75</td></tr>
<tr><td>Energy Saving(Kwh)</td><td>558.76</td><td>212.74</td><td>771.5</td></tr>
<tr><td>Shed Rate %</td><td>15.9%</td><td>13.4%</td><td>15.1%</td></tr>
<tr><td rowspan="5">Event 3
Aug. 08</td><td>Baseload(Kw)</td><td>8164.09</td><td>1819.9</td><td>822.52</td><td>10806.51</td></tr>
<tr><td>Shed -Expected (Kw)</td><td></td><td colspan="3">2730</td></tr>
<tr><td>Shed -Actual (Kw)</td><td>633.9</td><td>140.79</td><td>136.76</td><td>911.45</td></tr>
<tr><td>Energy Saving(Kwh)</td><td>1267.81</td><td>281.5</td><td>273.48</td><td>1822.79</td></tr>
<tr><td>Shed Rate %</td><td></td><td>7.7%</td><td>16.6%</td><td>8.4%</td></tr>
<tr><td rowspan="5">Event 4
Aug. 23</td><td>Baseload(Kw)</td><td>7273.19</td><td>1768</td><td>810.48</td><td>9851.67</td></tr>
<tr><td>Shed -Expected (Kw)</td><td></td><td colspan="3">2730</td></tr>
<tr><td>Shed -Actual (Kw)</td><td>4040</td><td>414.6</td><td>156.76</td><td>4611.36</td></tr>
<tr><td>Energy Saving(Kwh)</td><td>6060.12</td><td>621.9</td><td>235.14</td><td>6917.16</td></tr>
<tr><td>Shed Rate %</td><td>55.5%</td><td>23.5%</td><td>19.3%</td><td>46.8%</td></tr>
</table>

Our general observations included:

- The load shedding rates for the two commercial buildings are similar, around 15%, which is consistent with the real ADR applications in the U.S. and the rest of the world
- The manufacturing site load shedding capability varied with production load. When the production was in full load, as in the case of Event 3, a load reduction around 7.7% was achieved. When the production was not fully loaded, the demand response shed capability increased significantly, reaching over 50%.
- In comparison with commercial buildings, the manufacturing site had a large load shedding capacity, which is seen in Event 3 and 4. In future, more attention should be given to industrial sites, especially as China supports a large manufacturing industry.
- From the shed stability point of view, the two commercial buildings have more stable and consistent load shedding— between 15~20%

Although the designed CCP/TOU programs were not implemented in real time on the pilot sites, their potential impacts on facility owners can be examined using the data collected during ADR events and the utility's historical data. We used the TEDA administration building only as an example for the analysis and to verify the ADR program design described in Section 3.

Table 4-7 shows the latest electric tariff applied to the TEDA admin building, where the existing TOU rate is used with peak 1.2573 RMB/kwh, normal 0.8193RMB/kwh, and 0.4023RMB for the valley period. Based on this existing TOU, a new modified CPP rate was proposed by increasing the peak/valley ratio to 5:1, as suggested earlier, and increasing the CPP/valley ratio to 12.5:1.0 This modified CPP rate is shown in Figure 4-14 and Figure 4-15.

Table 4-7. East TEDA Electric Tariff -2011

Unit：RMB/KWH						
	Voltage Class	CPP	Peak	Normal	Valley	Demand Charge
Industrial	<1KV	1.3753	1.2503	0.8173	0.4063	17RMB/KVA /Month
	1-10KV	1.0948	0.9953	0.6963	0.4153	
	>35KV	1.0926	0.9933	0.6943	0.4133	
Commercial Building （Transformer Capacity over 100KVA）			1.2573	0.8193	0.4023	

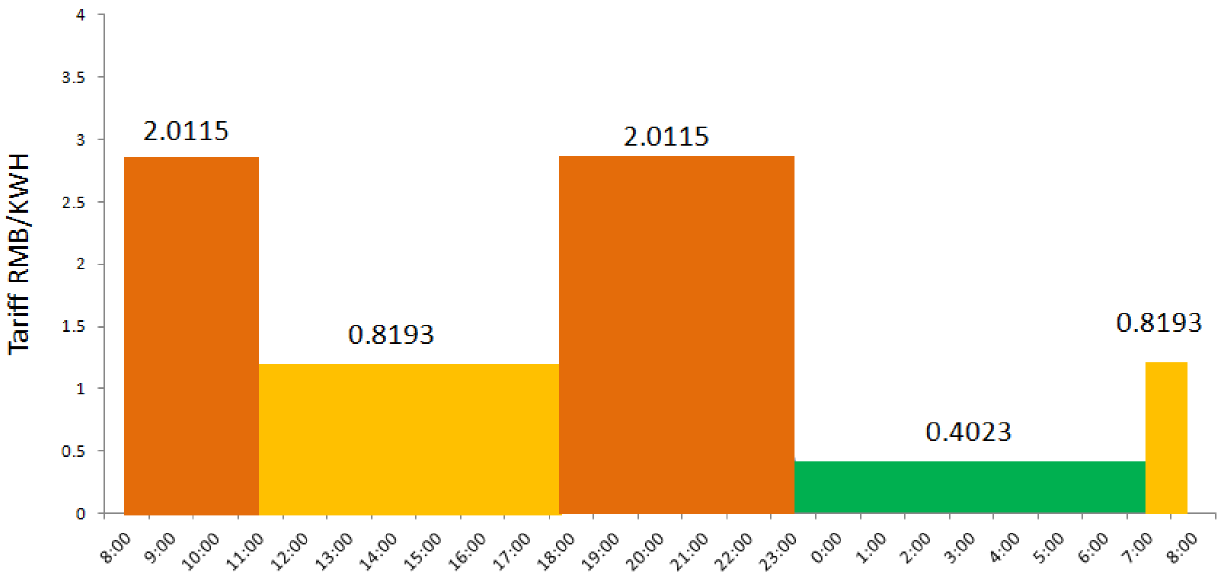


Figure 4-14. Modified TOU Structure

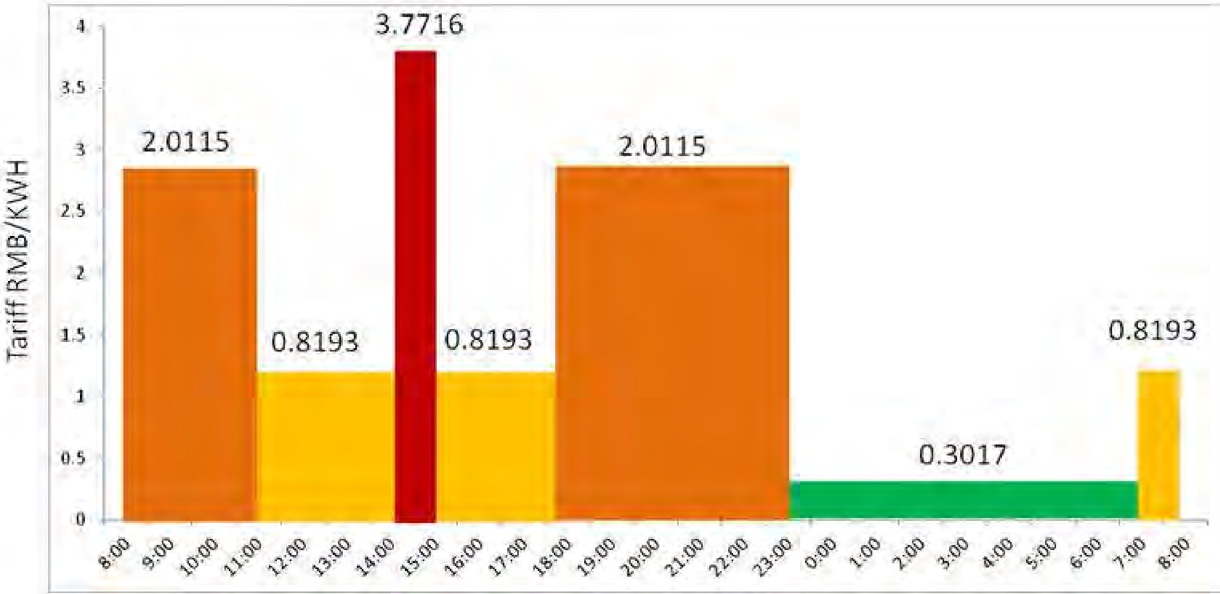


Figure 4-15. One Hour CPP Structure

Next, we calculated the utility fees for event days in a year. We then obtained utility fee differences by using the CPP tariff structure on the event days, which is 23,239 RMB minus 20,483RMB, representing the cost overrun for a one hour CPP program. Assume the pilot sites use the California CPP approach, i.e., normally 10 times DR is required in summer time, and a minimum of 6 response times are mandatory. With this, assume each CPP program lasts 4 hours, so the total minimum is 24hrs of event time in a year, the total CPP event cost overrun in a year would be 66,152RMB as shown in Table 4-8.

To calculate the non-event day utility cost in a year, the past year electricity load profiles with hourly data points are required. Due to data limitations, we used only typical seasonal day load profiles for 2011 to estimate the whole year non-event utility cost. Since the TEDA Admin building has been running stably for over 10 years, we can reasonably assume that 2011 and 2012 load profiles are not dramatically different. As can be seen in Table 4-9, the March 1st, June 1st and September 1st day load profiles are used to do the calculation. With some calculation, by implementing the TOU/CPP Tariff structure shown in Figure 4-14 and Figure 4-15, the TEDA Admin building owner could save 66,607RMB in a year as shown in Table 4-9. The TEDA Library site demonstrated similar characteristics. This verified the methodology applied to the CPP/TOU program design. Since customer benefits are very sensitive to the parameters in the CPP tariff structure, in future demand response scaled-up pilot projects or real implementation, the regulators and utility companies should design an appropriate DR tariff structure for specific regions. In any case, government encouragement and subsidies are required, especially in early stages when the demand response market has not grown to an economic scale.

Table 4-8. Event Day (e.g., June 15) Electricity Fee (RMB) - TEDA Admin Bldg

<table>
<tr><td>Existing TOU</td><td>20,483</td><td rowspan="3">Like California, 10 time ADR is required, minimal 6 must be done, 4hrs/time</td></tr>
<tr><td>Revised TOU</td><td>27,552</td></tr>
<tr><td>CPP</td><td>23,239</td></tr>
<tr><td colspan="3">Fee for all event days(24hours/year) in a year : 66,152 RMB</td></tr>
</table>

Table 4-9. Non-Event Days in the Year (RMB)

Program	1-Mar	1-Jun	1-Sep	Whole Year
Existing TOU	15,890.9	22,200.6	23,016.8	6,929,918.5
Revised TOU	21,262.3	29,844.9	30,671.5	9,273,688.3
New CPP	15,543.9	21,820.9	22,615.4	6,797,160.4
Net Saving for the Whole Year: 66,607 (RMB)				

4.5.4 Customer Feedback and Observations

The experience gained and the feedback received from the customers at these three demonstration sites in China was similar to what we have seen in Honeywell's auto DR programs and pilot projects in other parts of the world. Starting from the pilot site selection, a great deal of interaction occurred between the project team and building owners, TEDA power, Tianjin power, SGCC, CEPRI—to a certain degree they are all our customers. During the ADR event, we purposefully solicited feedback from building owners and the people working at the demo sites. Our general observations and feedback include:

- Understanding DR process/benefits. The team found it difficult to make the demand response understandable for the pilot sites, including the concept, principle, risks and benefits that could result from the DR event. The first thought of all the customers we talked with had to do with energy saving, i.e., the kWh, rather than kW.
- Motivation for customers to participate in a DR pilot. Two key criteria are government support and a proper incentive strategy. Without these two criteria, customers are reluctant to agree to participate in a demand response pilot.
- Access to electric usage data. Interest from facility managers increased when they learned that they would gain access to 15-minute whole-building meter data (available after the installation of the OpenADR Gateway).
- Notification time. Two commercial sites (TEDA Admin Building and TEDA Library) were able to accommodate 4 hours notification time, as the facility managers need time to inform their employees. In an emergency, facility managers could accept 30 minutes notification time. For the industrial site (Kumho Tire), only day-ahead event notification is acceptable, because more time is needed to shift production tasks.
- Customer feedback about the DRAS web portal. Facility managers at all sites were trained to operate the DRAS web portal. As the DRAS web portal does not support Chinese, it was difficult for some personnel to operate.
- Customer feedback during the event. Because facility managers of customer sites notified the employees at the sites and explained possible effects during a DR event, we received no complaints from customers. During the events, project team member and facility personnel walked around the areas that were affected by shedding strategies; they observed no abnormal situations.
- Cyber security in industrial site. Cyber security is more critical for industrial sites than commercial sites. It is difficult to persuade industrial sites to connect their process control systems to the OpenADR Gateway. More time and resources will be necessary to gain the confidence of industrial sites in the use of automated demand response technology.

4.6 Summary Conclusions

The objective of this demonstration was to verify that open standards based automated demand response works in China and can provide valuable benefits for State Grid, electric utilities, and electric customers. Due to the limited scope of this feasibility study project, we could not propose a structure (or parameters for) a demand response tariff that meets all of the needs and constraints that exist in the China electric utility sector. Given the limited scope and simulated nature of the demonstration, this effort was very successful, and the measured results provide important validation of OpenADR automated demand response technology in China.

Building from this successful demonstration, work to develop appropriate demand response programs in China will require more effort from all stakeholders over the next few years. Honeywell and AECOM are ready to assist SGCC, CEPRI, and other stakeholders in taking those next steps.

No major problems were encountered during the demonstration work. Other than the simulated nature of the DR events and the work needed to host the DRAS at a data center in China, all aspects of the demonstration were accomplished in the same manner as Honeywell's auto DR pilot programs at other electric utilities around the world. As a result of this demonstration, we believe there are no technical or operational barriers that would prevent wide implementation of auto DR in China.

A number of minor problems were discovered in performing the demonstration. These issues and our approaches for addressing them are presented in Table 4-10.

Table 4-10. Issues Discovered in Demonstration and Suggested Solutions

Issue	Solution
There were no initial incentives to the demonstration participants, which made it difficult to get customer support for a DR technology demonstration project	In the future, a project like this should consider including a pilot participation subsidy budget in the overall project funding. A demonstration at a similar scale is hard to implement without such incentives.
Requirement to host the DRAS server at a data center in China	The DRAS was hosted at the eTEDA data center in Tianjin. This DRAS implementation has sufficient capability to support numerous auto DR programs at other locations in China. When additional capability is needed in the future, a suitable strategy for expanding this DRAS or replicating it at another site can be developed.
The user interface for the DRAS is available only in English. An alternative user interface in Mandarin is needed.	A user interface displayed in Mandarin can be developed as a part of an expanded set of demonstrations or pilot DR programs in China.
The TEDA Library site required manual intervention to accomplish the response to the DR events.	With the willing support of the TEDA Library building operators, we were able to accomplish this demonstration and measure the load shed results. In the future, a fully automated DR capability can be implemented in a fashion similar to that for the TEDA Admin building.
Due to management's concern about risk to production processes and production schedules at the Kumho Tire site, there was no direct control interface from the OpenADR Gateway to the industrial automation system.	In the future, as customers and utility operators in China gain more experience with auto DR, it will be shown that automated DR programs can be successfully employed in industrial applications.

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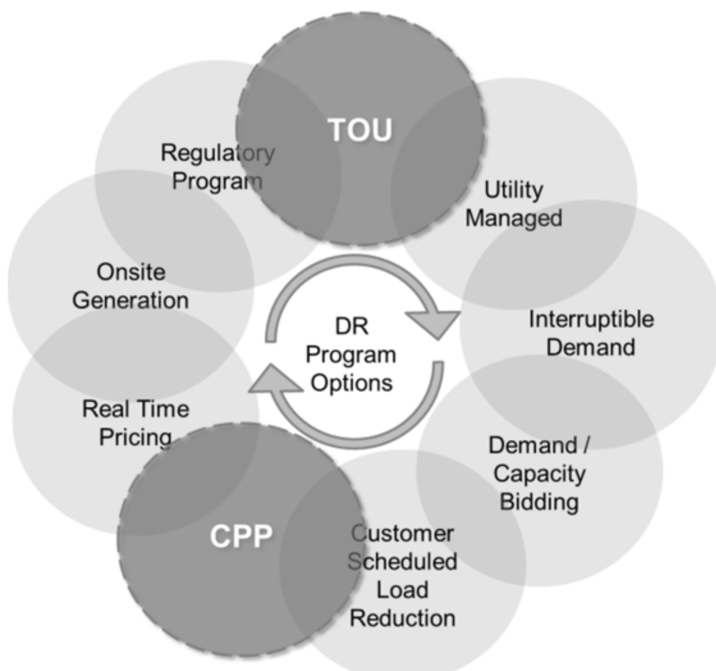
5 Regulations, Market Demand, and Cost Estimates

This section presents a review of existing laws and regulations in China that could impact the project implementation and a market forecast for demand response technologies. Also included is an estimate of the total cost for implementation of the demand response program in the pilot project city as well as across China.

The DR strategy proposed is intended to serve as a starting point for a larger discussion about more detailed approaches. Because proper data on electricity use, energy consumption, and projections of electricity use were not available from State Grid for Tianjin or China, a number of informed assumptions have been made regarding these inputs. Without more accurate information it is difficult to compare and contrast various program approaches precisely. *As such, the results presented here and in Sections 6 and 7 are intended to provide an estimate of the level of magnitude for the potential of such programs, rather than an exact result.*

Utilities typically provide a range of DR program options to meet various energy goals as well as to fit different customer needs. For the purpose of this study, two initial programs have been selected to evaluate gross potential of DR programs in Tianjin and China: a revised TOU program and a CPP program. These programs were selected based on CEPRI feedback, as well ease of implementation in China's regulatory and energy environment. The programs are intended to serve as a starting point for development of a larger DR portfolio. As such, our results are intended to provide a sense of the scale of impact, and do not explore the full range of DR potential in China. Figure 5-1 illustrates various DR options and tariff types explored earlier and highlights the two selected for initial evaluation.



Source: AECOM

Figure 5-1 Range of DR Program Options

This section summarizes information pertaining to:

- Existing laws and regulations impacting project viability.
- Demand reduction potential (MW and MWh) for Tianjin and China.
- Market demand forecast for demand response technologies in Tianjin and China.
- Cost estimate and annual investment plan.

5.1 Review of Existing Laws and Regulations Impacting Project Viability

As described in detail in Section 2, a number of laws and regulations in China directly affect DR program implementation in the pilot project and Tianjin as well as throughout China. Through its recent legislation, it is clear that China is working to develop a regulatory environment that supports smart grid and related technologies. Since 1996, China has implemented laws mandating energy conservation, renewable energy incorporation, energy consumption measurement, and supported various monitoring and control technologies. Some of the most notable laws are:

- **2007 Energy Conservation Law of China –** Identifies energy conservation and efficiency as a major goal of both state and local governments, as well as public institutions and utilities.
- **2011 Work Plan for Energy Conservation and Emission Reduction in the Twelfth-Five-Year-Plan Period** – Includes substantial targets for clean energy integration and carbon emission reductions.
- **2010 DSM Implementation Measures**[14] – Requires integrated resource planning, creates energy efficiency and energy savings targets for utilities, allows for utility surcharges, variable pricing, and government funding for Demand Side Management (DSM) implementation.

In addition to the laws above, in July of 2012, China's National Development and Reform Commission (NDRC) together with the Ministry of Finance (MOF) passed the *Interim Measure of Fiscal Incentives to the Demand Side Management Comprehensive Pilots in Cities*. The measure indicates that the NDRC and MOF will select a number of key cities to implement DSM pilot projects. Cities will receive financial support ranging from ¥100-¥550 for each temporary and permanent kW of peak load shed. Per the measure, the incentives will continue to be regulated by the central government.

While such laws encourage the development of energy saving programs, such as DR, the implementation of these programs is still largely possible only at a pilot project level. Significant barriers still exist to the development of localized pricing and profit systems, as well as to funding DR program implementation on a large scale. Given China's commitment to pursuing DR as a viable reduction strategy, existing barriers to successful implementation may be removed easily in the near future.

In a review of laws and regulations related to the power sector, six recurring topics emerged related to smart grid and demand response development.

1. **Energy conservation** – The State has emphasized the importance of energy conservation, investment in conservation strategies, and a greater awareness of consumption.
2. **Energy efficiency** – The State has placed a heavy emphasis on increasing energy efficiency through regulation of technology, investment in technology, and mandates on consumption.
3. **Pricing regulations** – Energy pricing and profit distribution in China continues to be regulated at the State level, which limits the ability of local utilities to develop unique demand response pricing strategies.
4. **Renewable energy promotion** – The State has repeatedly emphasized the importance of integrating renewable energy resources into the grid, and has allowed for supportive pricing policies for renewable energies.
5. **Energy measurement promotion –** Since the mid-1990s, the State has required energy consumers to install metering devices. In Tianjin, the local State Grid has also been actively involved in replacing any old meters with smart meters.
6. **Energy use to support economic and social development –** The State requires governments to consider economic and social development, as well as environmental protection, in the planning of their energy systems.

For greater detail, please see Section 2.4.6 and Appendix C.

[14] "Taking Action to Meet its Climate Pledge - China Enacts National Energy Efficiency DSM Regulations to Dramatically Scale Up Investments in Energy Efficiency," NRDC, November 29, 2010. http://switchboard.nrdc.org/blogs/bfinamore/taking_action_to_meet_its_clim.html

5.2 Energy Reduction Estimates

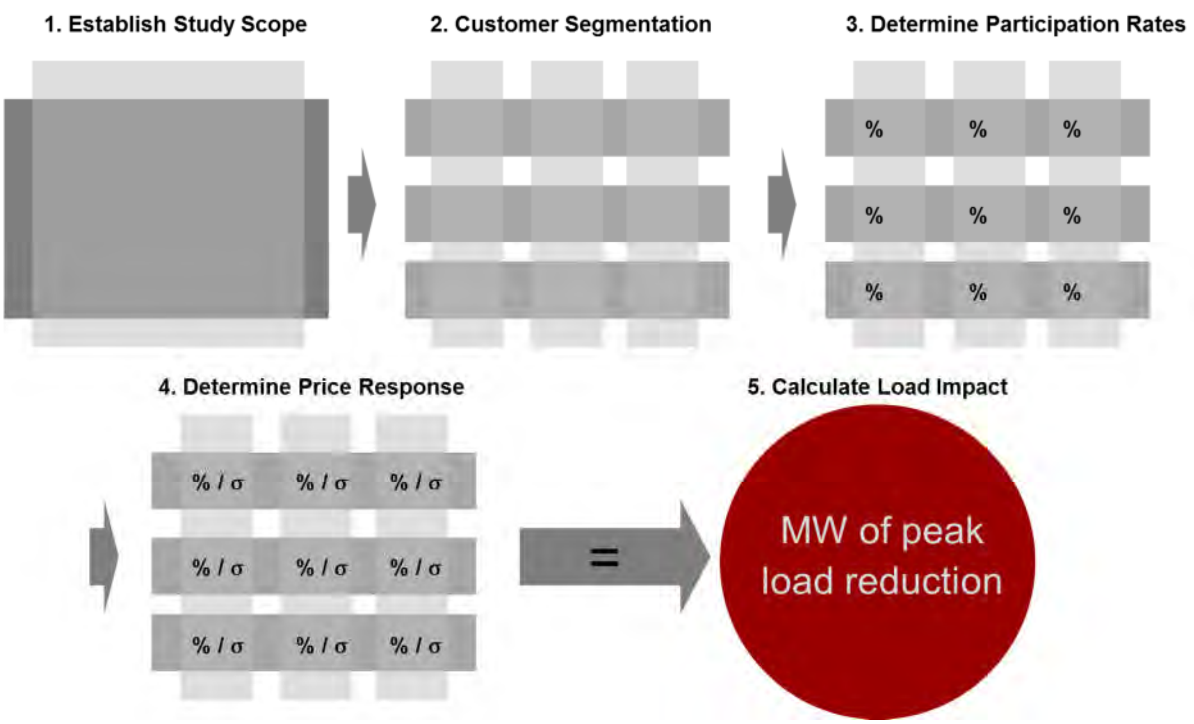
While both the TOU and CPP programs help manage demand and consumption through variations in electricity rates, the two programs serve different purposes. The TOU program helps shift consumption (kWh) away from daily peaks towards less congested times, and simultaneously allows for generation and T&D costs to be more accurately represented. The price patterns (valley, normal, and peak) are consistent throughout the year. By comparison, the CPP program primarily aims to reduce peak demand (kW) on the 10 to 15 highest demand days in the year, typically during the summer months. Together, these two programs complement each other to result in shifted and reduced consumption (kWh) and reduced peak demand (kW).

This section reviews the potential electricity reduction associated with the proposed programs. The first portion of this section is on peak demand reduction (kW). These estimates are then translated into gross estimates for consumption (kWh) reduction based on experiences from international benchmarks.

It is important to note that with more DR program options targeting commercial, industrial *and* residential sectors, the potential for peak demand and overall demand reduction could be even greater than what is estimated in this report.

5.2.1 Peak Demand Reduction (kW)

The methodology for estimating the total peak load reduction impacts of the proposed critical peak pricing program is based on the approach outlined by the Lawrence Berkeley National Laboratory (LBNL) in its 2007 report, *Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study*. A similar approach was used in the United States Federal Energy Regulatory Commission's (FERC) 2009 report, *A National Assessment of Demand Response Potential*. LBNL's methodology consists of five primary pieces, outlined in Figure 5-2.



Source: Graphic by AECOM; Methodology based on Goldman, *et al.*, "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study," LBNL Environmental Energy Technologies Division, Jan 2007.

Figure 5-2. Methodology for Estimating Demand Response Potential for Peak Load Reduction

5.2.1.1 Study Scope and Customer Segmentation

The study scope for this project was defined as commercial and industrial customers in Tianjin City. Due to limited data, all commercial customers have been grouped together, while the industrial sector has been broken down into two sub-categories: Mining and Quarrying, and Manufacturing. Each of these three industry sectors are expected to behave differently within the DR programs based on their operational patterns.

For commercial customers, we assumed that only larger commercial buildings (office buildings, shopping centers, large hotels, large government administration buildings, etc.) would be initially targeted to participate in the DR program. Given this criterion, and based on a review of Tianjin's current commercial space, only 30 percent of existing commercial space is considered to be part of the addressable commercial market. For this 30 percent, the average building size is estimated at 10,000 square meters. In 2012, the total commercial GFA (gross floor area) for Tianjin is estimated around 40 million square meters. Assuming 30 percent of this area is addressable commercial market, which results in just over 12 million square meters. At an average of 10,000 square meters for the large, addressable buildings, this results in just over 1,200 commercial buildings in Tianjin that would be eligible for DR program.

For industrial customers, all enterprises are included as potential program participants. Based on data from the National Statistical Yearbook, the average industrial enterprise generates roughly 150 to 200 million ¥ of gross industrial output per year. In 2012, Tianjin's manufacturing enterprises are estimated to generate 1.7 trillion ¥ of gross industrial output. This is based on the most recent 2010 data, as well as historic growth trends. The annual average growth rate from 2010 onwards has been estimated at a conservative 10 percent. With each manufacturing enterprise estimated to generate 200 million ¥ in gross industrial output, this results in an assumed 8,400 manufacturing enterprises in Tianjin.

For the purposes of this study, growth in existing commercial area and gross industrial output are based on historic growth trends, and have been adjusted to reflect a more conservative growth estimate in the next 10 years. Electricity consumption growth by industry is similarly based on historic trends, revised based on studies by the LBNL. Given these assumptions, Table 5-1 summarizes the program's estimated available customer base.

Table 5-1 Estimated Industrial Enterprises and Addressable Commercial Buildings

	2012	2022	Historic CAGR* 2000-2010	Estimated CAGR* 2011-2015	Estimated CAGR* 2016-2022
Tianjin					
Industrial Enterprises					
Mining and Quarrying	1,500	5,200	30%	20%	10%
Manufacturing	8,400	21,900	19%	10%	10%
Commercial Buildings	1,200	1,600	11%	3%	3%
China					
Industrial Enterprises					
Mining and Quarrying	43,000	145,000	27%	20%	10%
Manufacturing	492,000	1,275,000	25%	10%	10%
Commercial Buildings	347,000	572,000	7%	3%	3%

Source: Various Statistical Yearbooks, AECOM.
* *CAGR* = Compound Annual Growth Rate

Based on client feedback, we identified two programs, a revised TOU and AutoDR critical peak pricing (CPP) program as test cases to understand the scale of impact from DR implementation. Together, these programs have been found to be effective in decreasing peak demand as well as reducing overall electricity consumption.

For the CPP program, it should be noted that given the length of the peak demand period, which typically ranges from 2 to 6 hours, the two hour limit of the CPP event is not expected to address the entire peak period. However, for the purposes of this study, it is assumed that reductions during the 2 hour peak result in an overall peak reduction.

The proposed DR programs are described in greater detail in Section 3.3.

Benchmarks and assumptions for Tianjin have been applied at the National level as well to develop estimates at the potential for peak demand reduction throughout China.

5.2.1.2 Participation Rates

International case studies from various utilities and national agencies have been referenced to develop penetration, or participation rates[15]. Benchmark penetration rates tend to vary between 0 and10 percent per sector. In very rare cases, penetration rates of up to 30 percent have been experienced.

Based on these studies, as well as on an understanding of participation trends in China, participation rate for the addressable commercial sector is estimated to begin at 5 percent in the starting year (2013), increasing up to 20 percent in 5 years (2018). The original, aggressive estimate of 30 percent participation rate of addressable commercial buildings was revised down to 20 percent to reflect the constraints of an automated DR program, which often requires either a building energy management system or a programmable logic controller (PLC).

For industrial enterprises, the participation rate is estimated to begin at 2 percent in the starting year, increasing up to 12 percent in 5 years. The 2 percent first year participation is chosen as a modest start, as many manufacturing enterprises may be hesitant to participate until they have seen the program proven. The 12 percent is based on a weighted participation rate of 30 percent for medium and large enterprises, and 10 percent for smaller enterprises.

Given the large percentage of state owned enterprises (SOE) and strong administrative and regulatory control, a shift in policy and incentives could result in significantly higher penetration rates in China, than what is typically seen in other international cases.

The growth of participation rates over the first five years is based on a 2009 FERC study which noted that programs to reach maximum penetration within 5 years.

While a participation rate of 20 percent for the commercial sector and 12 percent for industrial sectors have been presented as a current achievable penetration, it is very likely that, given China's regulatory environment, penetration rates may far exceed current experiences in other countries– particularly as newer commercial and industrial buildings are constructed.

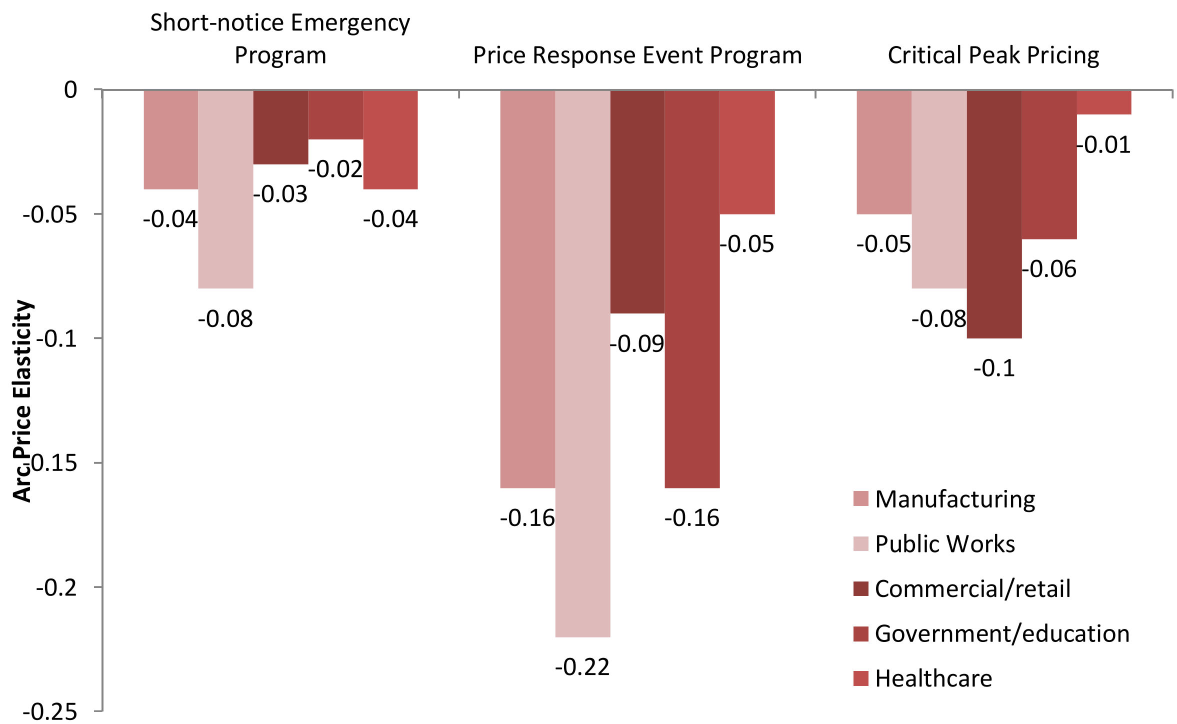
5.2.1.3 Price Response

The key issue of most DR strategies is how well companies respond to changes in electricity price during a DR event. Sensitivity to price changes is known as *price elasticity*. There are three main types of elasticity: (1) price elasticity of demand, (2) elasticity of substitution, (3) arc price elasticity. Each elasticity has its own set of statistical strengths and weaknesses. For the purposes of this study, arc price elasticity is used as the basic measure of price responsiveness. This elasticity was selected due to its frequent use in the DR literature as well as because, methodologically, it relies on fewer data inputs.

To understand how commercial and industrial sectors in China might be expected to respond to electricity price changes, a survey of current research on price elasticity was undertaken. Due to maturity of western DR programs, international research on electricity price elasticity is primarily focused on western case studies. However, there have been a few limited studies on price responsiveness in China. Those studies in particular have helped to inform how western price elasticities might be adjusted for the Chinese context.

[15] PG&E Auto-DR Programs, SCE Demand Response Programs reviewed in Task 2; "A National Assessment of Demand Response Potential," FERC, June 2009.

Figure 5-3 presents arc price elasticities for DR programs in the United States as a benchmark for China. Customers enrolled in short-notice programs have shown to be least responsive, with customers with critical peak pricing and other price responsive events showing greater response to changes in electricity prices.[16] Healthcare and commercial industries tend to be less responsive than manufacturing or public works industries, which have greater control of when and how they consume electricity.



Source: Goodman, Charles, et al. "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study," LBNL, January 2007. Table ES-2. Average Elasticity Values.

Figure 5-3 Arc Price Elasticities for Demand Response Programs in the United States

Data from China indicate similar patterns among industry sectors, with mining industries being significantly more responsive than traditional commercial industries. While China's residential customers tend to be much more price sensitive than their western counterparts, commercial and industrial industries appear to be less so.

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[16] Goodman, Charles, et al. "Estimating Demand Response Market Potential among Large commercial and Industrial Customers: A Scoping Study," LBNL, January 2007.

"2010 California Statewide Non-Residential Critical Peak Pricing Evaluation," Freeman and, Sullivan & Co, April 2011.

Ryan, Lisa, et. al.,"Energy Efficiency Policy and Carbon Pricing," International Energy Agency, August 2011.

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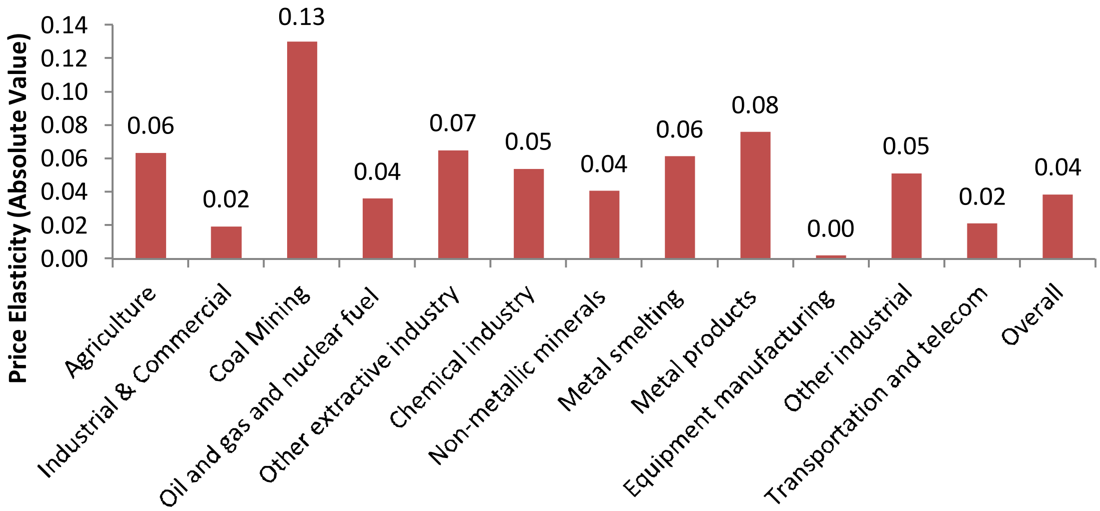

Source: He, Y.X. et al, "Electricity Demand Price Elasticity in China Base on Computable General Equilibrium Model Analysis," School of Economics and Management, North China Electricity Power University, Energy Journal - November 2010. Table 3, 4.

Figure 5-4 Price Elasticity (Absolute Values) of Electricity Demand in China by Industry

Based on these data and a number of additional benchmark studies, the following arc price elasticities were developed for the three study sectors in China. These elasticities are expected to remain constant over time.

Table 5-2 Estimated Arc Price Elasticities for TOU and CPP Programs

Sector	TOU Program		CPP Program	
	Elasticity	Basis for TOU Elasticities	Elasticity	Basis for CPP Elasticities
Industrial				
Mining and Quarrying	-0.10	Based on U.S. TOU event – Industrial (-0.04 to -0.09) Increased to reflect China's higher elasticity for Mining sector (-0.13), Other Extractive Industry (-0.07), Non-metallic Minerals (-0.04)	-0.07	Based U.S. CPP event - Manufacturing (-0.05). Increased to reflect China's higher elasticity for Mining sector (-0.13), Other Extractive Industry (-0.07), Non-metallic Minerals (-0.04)
Manufacturing	-0.04	Based on U.S. TOU event – Industrial (-0.04 to -0.09) Decreased to reflect China's lower for elasticity for Industrial and Commercial (-0.02)	-0.02	Based U.S. CPP event - Manufacturing (-0.05). Decreased to reflect China's lower for elasticity for Industrial and Commercial (-0.02)
Commercial	-0.03	Based on U.S. TOU event – Commercial (-0.03 to -0.04) Lower end used to reflect China's lower elasticity for Industrial and Commercial sector (-0.02)	-0.05	Based on U.S. CPP event - Commercial (-0.1). Reduced by half to reflect China's lower elasticity for Industrial and Commercial sector (-0.02)

Source: AECOM.

5.2.1.4 Load Impact

Based on preliminary results of the pilot project in Tianjin, as well as additional industry data from additional Tianjin and United States energy studies[17], Table 5-3 summarizes the estimated average peak demand per commercial building or enterprise in 2012. To estimate industrial enterprise energy usage, an average building size of 9000 square meters was used. This number was selected based on reported peak consumption levels for Tianjin and China in 2012. For commercial buildings, an average building size of 10,000 square meters was used. Peak demand is estimated to grow 2 percent per year to reflect the increase in energy intensity per building or enterprise.[18]

Table 5-3 Average Peak Demand per Building or Enterprise (2012/2013)

	Industrial Enterprises		Commercial Building
	Mining and Quarrying	Manufacturing	
Average Peak Demand per Customer Unit	1,440 /1,469 kW	855 / 872 kW	400 / 408 kW

Source: AECOM Building Engineering, based on data from the National Statistical Yearbook, International DR Program Benchmarks, Various Sources.

Building on these assumptions, Sections 5.2.3 and 5.2.4 outline the expected potential reduction in peak energy demand. It is important to note that, because no real electricity consumption data was made available, this model assumes that all sector peaks occur at the same time of the day, resulting in a stacked peak demand rather than a more realistic staggered peak. This model also does not take the timing of the residential peak demand into consideration.

While residential customers are not being considered as part of the overall peak event, it is assumed that their peak, which occurs much later in the day than industrial or commercial peaks, is not large enough to shift the overall system peak from midday. Residential electricity demand accounts for only 10 percent of the total electricity demand for this level of study.

Based on LBNL's methodology, the peak demand reduction per enterprise or building calculation is:

$$DR = (-1) * Q_{CBL} * \sigma_{Arc} * \left[\frac{(P - P_B)}{P_B}\right]¶$$

Figure 5-5 Demand Response Peak Load Reduction Equation

Where:

DR = Demand response (peak demand reduction)

Q_{CBL} = Level of load during an event (kW or MW)

σ_{Arc} = Arc elasticity value (Price response)

P = CPP event electricity fee

P_B =Non-event electricity fee

Source: Goodman, Charles, et al. "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study," LBNL, January 2007.

Table 5-4 summarizes the estimated peak load reduction for individual industrial enterprises and commercial buildings expected during a peak event. These results are derived using the DR formula.

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[17] Energy consumption curves for commercial, manufacturing and general industrial enterprises based on estimates from AECOM Building Engineering.

[18] Faruqui, Ahmad, et al, "The Power of Five Percent: How Dynamic Pricing Can Save $35 Billion in Electricity Costs," The Brattle Group, May 16, 2007, p10.

Table 5-4 Estimated Peak Load Reduction during CPP Event per Enterprise or Building (2013)

	Industrial Enterprises		Commercial Building
	Mining and Quarrying	Manufacturing	
Estimated % Load Impact	31	9	18
Estimated Reduced Peak Demand (kW)	461	78	75
Estimated Resulting Peak Demand During CPP Event (kW)	1,008	794	333

Source: AECOM

5.2.2 Annual Electricity Load Savings (kWh)

Annual electricity savings (kWh) for the CPP and TOU programs have been calculated separately.

In 2008, the U.S. Electric Power Research Institute (EPRI) conducted a study of AutoDR CPP program impacts among primarily commercial customers in California.[19] One of the findings of EPRI's extensive report was that each kW of CPP peak load reduction results in approximately 65 kWh of annual electricity savings. This number has been applied in this report for consumption savings associated with the CPP program.

For the TOU program, a separate calculation was conducted applying average consumption curves developed by AECOM Building Engineering, based on data from the National Statistical Yearbook and international DR program benchmarks. The elasticities presented in Table 5-2 for the TOU program were applied to the revised TOU pricing model using the equation in Figure 5-5.

Given that the revised TOU pricing strategy only adjusted prices for the peak times, reduction is limited to seven peak hours per day. Mining and Quarrying enterprises are estimated to reduce overall consumption by approximately 3 percent on average per day (just under 800 kWh), with manufacturing enterprises saving roughly 1.2 percent per day (just under 200 kWh) and commercial customers reducing consumption by approximately 0.6 percent (just over 20 kWh) per day.

5.2.3 Tianjin Peak Demand and Total Load Savings

Using these assumptions, Tianjin's peak load reduction demand response potential associated with the proposed CPP program is estimated to be roughly 36 MW in 2013, the first year of operation. This represents an estimated 0.3 percent in peak load savings. This savings is expected to grow to 616 MW, or 1.8 percent, in peak load savings by 2022.

By 2022, these peak savings could result in not having to build and additional smaller scale coal or nuclear power plant.

Combined, the TOU and CPP programs are estimated to result in1,180 GWh of electricity savings in 2013, climbing to 2,674 GWh by 2022. This represents a total savings of 1.4 to 1.6 percent of the annual electricity consumption in Tianjin.

It is important to note that due to lack of proper electricity usage data and projection estimates, the contribution estimates of the DR programs to overall energy reduction are only approximate.

5.2.4 China Peak Demand and Total Load Savings

Based on the methodology used for Tianjin's peak demand savings, China's national peak load reduction demand response potential associated with the proposed CPP program is estimated to be roughly 2,700 MW in 2013, the first year of operation, representing an estimated 0.2 percent in peak load savings. This is expected to grow to 39,200 MW, or 1.5 percent in peak load savings by 2022.

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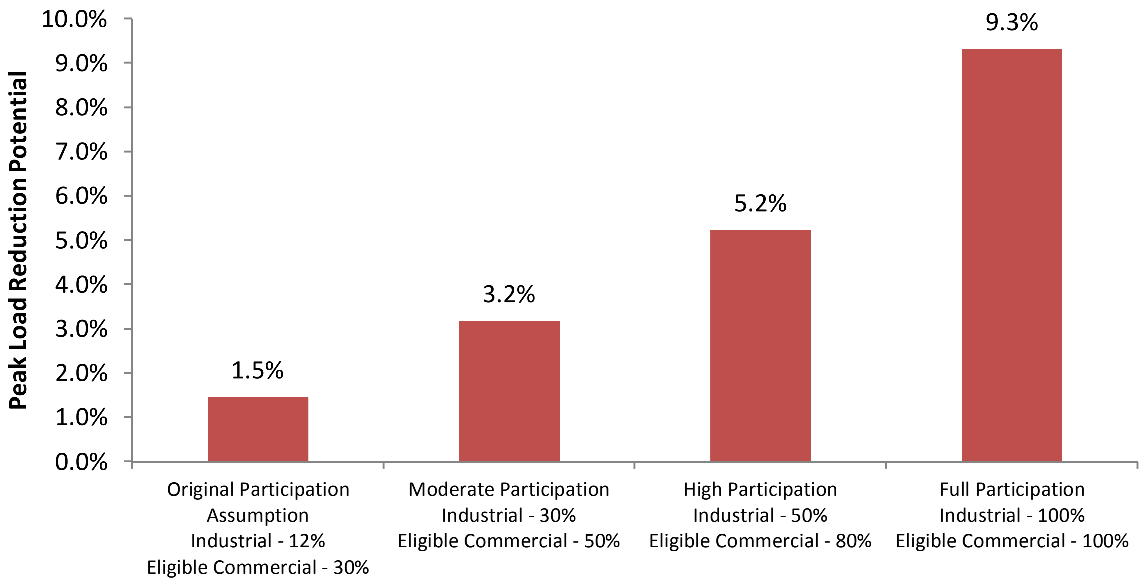
[19] "The Green Grid: Energy Savings and Carbon Emissions Reductions Enabled by a Smart Grid," Electric Power Research Institute, June 2008. www.my.epri.com

By 2022, this peak savings would be equivalent to reducing China's generation demand by twenty 2 GW coal power plants.

The 1.5 percent peak load reduction estimate is based on somewhat conservative participation assumptions of a single program. It is clear that with more aggressive participation rates or with a larger suite of DR programs, the potential for peak load reduction in China would be significantly greater. Figure 5-6 shows the potential for peak load reduction of the CPP program with varying participation rates. A full-participation scenario in China, involving 100 percent of industrial customers and 100 percent of eligible, large-scale commercial customers could result in peak load reduction of up to 9.3 percent. It is clear that coupled with energy efficiency programs and additional DR options, the results could be even greater.



Source: AECOM

Figure 5-6 National Peak Load Reduction Potential by Participation Scenario – CPP Only (2022)

Combined, the TOU and CPP programs are estimated to result 64 TWh of electricity savings in 2013, climbing to 113 TWh by 2022. This represents a total savings of 1 to 1.2 percent of the annual electricity consumption in China.

5.3 Hardware and Software Demand

Implementation of the proposed DR program within a utility and at participating customer locations requires relatively little hardware and software investment. Honeywell's proposed system, which has been implemented in the TEDA pilot buildings (*illustrated in greater detail in Section 3.2.2 and Appendix D*), relies on off-site hosting of AutoDR application. The purchased hardware and software requirements include:

- Utility:
  - Non-production Test Server.
- Customer:
  - DR Gateway – OpenADR Gateways are used in the TEDA project.

The hardware and software demands assume that non-revenue grade pulse data at 15 minute intervals is available. If this is not present, customers would also require sub-metering hardware.

Equipment demand is directly tied to customer participation, with one type of device necessary for each participating utility or customer. It is assumed that purchasing and installation occurs the year before a customer begins participation in the DR program. Table 5-5 and Table 5-6 summarize the expected demand of DR hardware and software in Tianjin and throughout China. In Tianjin, equipment demand is estimated range from 155 to 885 units per year. Total hardware and software demand is estimate at roughly 3,900 by 2022.

Table 5-5 Estimated Hardware and Software Demand - Tianjin

	Unit	2012	2013	2017	2022	Total 2012-2022
Utility-Based						
Non-Production Test Server	1/ Utility	1				
Customer-Based						
DR Gateway	1/customer	285	155	885	335	3,908

Source: AECOM, Inputs from Honeywell.

In China, equipment demand is estimated to range from 16,150 to 89,570 units per year. Total hardware and software demand is estimated to be just under 368,000 by 2022.

For China, the utility demand for test servers is based on an expected utility participation growth rate of 5 percent per year, starting in 2012 and reaching full participation by 2021. *Given the uneven distribution of customers throughout utility service areas, the participation rate of local utilities is not expected to affect overall customer participation rate.*

Table 5-6 Estimated Hardware and Software Demand - China

	Unit	2012	2013	2017	2022	Total 2012-2022
Utility-Based						
Non-Production Test Server	1/ Utility	5	10	10	5	100
Customer-Based						
DR Gateway	1/customer	30,093	16,151	89,570	25,842	367,923

Source: AECOM, Inputs from Honeywell.

5.4 Cost Estimate and Investment Plan (2012 – 2022)

To develop the cost estimate and investment plan, costs and benefits of the proposed demand response system were considered. Annual inflation of 2 percent has been assumed over the course of implementation.

Additional program costs and benefits, including social and environmental, are presented in greater detail in Section 7.3.

5.4.1 DR Program Cost Estimate

Three primary types of costs have been included[20]:

1. Utility-based capital costs (materials, hardware and software).
2. Customer-based capital costs (materials, hardware and software).
3. Operations and maintenance costs.

The utility-based capital costs are estimated around ¥2.78 million (US$427,000) per utility, and include:

1. Non-production test server.
2. Annual software licensing fee – Typically only Year 1 license costs may be capitalized. Subsequent years' fees are included in O&M costs.
3. Annual hosting and maintenance fee – Typically only Year 1 license costs may be capitalized. Subsequent years' fees are included in O&M costs.
4. Training manuals.
5. Staff training fee.

Customer-based capital costs are estimated at an average of roughly ¥200,000 (US$30,600) per industrial enterprise, and roughly ¥125,000 (US$18,300) per commercial building. For this analysis, it is assumed that metering hardware and software based at the customer site will be paid for by the utility. Tianjin State Grid has already indicated that it will pay for the replacement of existing meters with smart meters. Such incentives help to encourage participation. The customer-based capital costs include:

1. Customer outreach.
2. Physical facility audit (and shed strategy development).
3. Site engineering / installation / commission.
4. Shed strategy programming.
5. Project management.
6. DR gateway.
7. Sub-metering, where necessary.

Ongoing operations and maintenance (O&M) costs include:

1. O&M – Utility
    a. Licensing and Server Maintenance Fees (¥2.3 million or US$360,000 per utility annually) – the annual fee may vary.
    b. Insurance (5% of all capital costs spent to date).
    c. Taxes – 15% of all capital costs spent to date).
2. O&M – Customer
    a. Labor (¥1,350 or US$200 per customer annually).
    b. Replacement and repair (10% of all capital costs spent to date).

O&M costs of customers and buildings will be borne by the participating customer.

In addition to the O&M costs included above, some DR programs may include the costs of participation incentives, or event participation rebates for customers. However, the proposed CPP pricing strategy does not include these payments, and as such, they are omitted from the overall cost estimate.

[20] All cost categories and cost ranges provided by Honeywell. Exchange rate of ¥6.5 to US$1 used.

5.4.2 DR Program Benefit Estimate

A number of cost-saving benefits are traditionally associated with DR programs. The savings associated with these various benefits are based on a 2007 study by the Brattle Group, and include:[21]

1. Meter operations – fewer field operations calls, visits, maintenance (50% of total customer hardware installation)
2. Avoided costs of supplying electricity:
    a. Avoided generation capacity costs (¥335 per kW of avoided generation).
    b. Avoided energy costs (12% of avoided generation costs).
    c. Avoided transmission and distribution costs (10% of savings in generation capacity and energy costs).
3. Net increase in revenue from proposed DR strategy.
4. Government Incentive Payment – Only assumed to benefit Tianjin, not that National estimates.

In July of 2012, China's National Development and Reform Commission (NDRC) together with the Ministry of Finance (MOF) passed the *Interim Measure of Fiscal Incentives to the Demand Side Management Comprehensive Pilots in Cities*. The measure indicates that the NDRC and MOF will select a number of key cities to implement DSM pilot projects. Cities will receive financial support ranging from ¥100-¥550 for each temporary and permanent kW of peak load shed. Per the measure, the incentives will continue to be regulated by the central government.

While the Chinese electricity system is structured in such a way that the savings in generation costs do not necessarily benefit the distribution utility, in this model, these savings have been included in the overall estimate to provide a system-wide, complete view of the costs and benefits.

5.4.2.1 Net Revenue Change

While estimates for savings associated with avoided generation, energy, and T&D are based on previously done work, the net revenue increase for the DR strategy was calculated separately.

The net increase in revenue associated with the DR strategy was calculated based on Tianjin's electricity fee calculation (C = B*M +D*T), *which is described in greater detail in Section 2.1.3*.

As described in Section 3, the basic demand charge (B) was not revised from Tianjin's current rates.

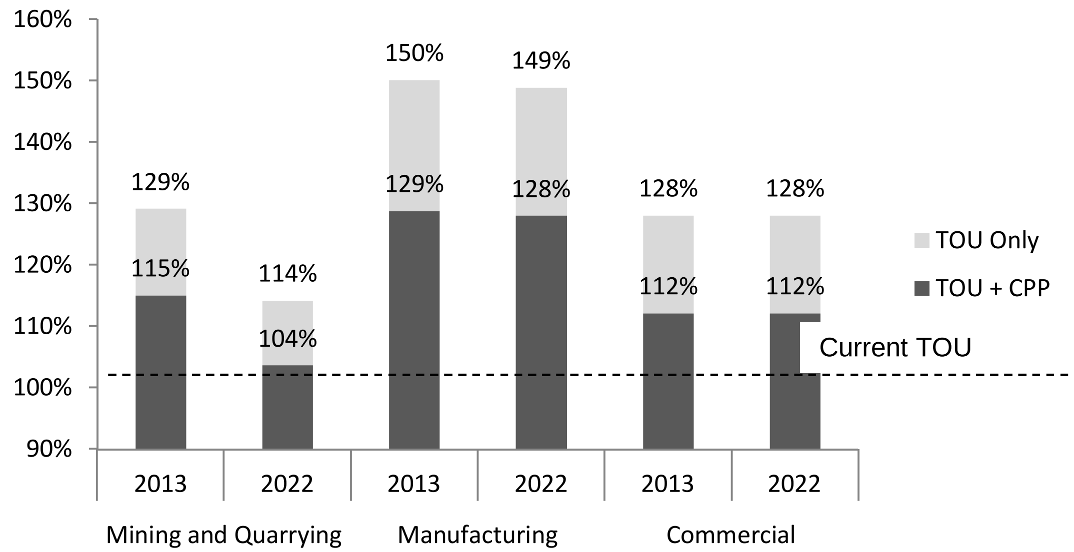
Three sets of electricity revenue numbers were calculated. First, an estimate of electricity fee revenue generated by Tianjin's current TOU structure was developed. Second, an estimate of the electricity fee revenue expected based on the revised TOU structure, which sets Tianjin's peak price to 5 times that of the off-peak price. Third, an estimate of the electricity fee revenue expected based on the revised TOU structure in conjunction with the CPP pricing (*presented in Section 3*).

In comparison to the current TOU pricing structure, in 2013, the first year of CPP operation, industrial and commercial customers enrolled in the revised TOU program could expect to pay between 29 and 50 percent more on their annual electricity charges. This is due to the increase in peak price. Such rate increases encourage customers to be aware of their consumption patterns, and shift consumption to off-peak hours.

In contrast, CPP program participants could expect to pay only between 12 and 29 percent more on their annual electricity charges. This would result in savings of 14 percent for CPP mining and quarrying customers, 21 percent for CPP manufacturing customers, and 16 percent for CPP commercial customers. Such savings provide significant incentives to participate in the CPP program and help reduce overall peak demand. Source: AECOM.

Figure 5-7 illustrates the increase in annual cost over the current TOU baseline, and the savings for customers associated with CPP participation.

[21] Faruqui, Ahmad, et al, "The Power of Five Percent: How Dynamic Pricing Can Save $35 Billion in Electricity Costs," The Brattle Group, May 16, 2007, p2



Source: AECOM.

Figure 5-7 Difference in Average Annual Cost per Participating Customer over Baseline (Tianjin)

5.4.3 Tianjin Investment Plan

Based on the above assumptions, Tianjin's capital and operating costs for the proposed CPP program are estimated to range from ¥0.07 billion in year 0 (2012), to ¥0.35 billion in year 5 (2017), and ¥0.34 billion by year 10 (2022). Because Tianjin already has a TOU program in place, it is assumed that there are no additional costs associated with revising the TOU tariffs.

Table 5-7 presents the estimated capital costs for Tianjin's CPP program. These estimates represent a roughly 40 percent annual increase in costs in the first five years of implementation, tapering off to a steady level over the next five years of implementation.

Compared with Tianjin's current TOU pricing structure, both the revised TOU and the CPP program result in a positive net revenue, able to support the costs associated with implementation.

The anticipated benefits associated with implementing the CPP program are estimated to range from ¥0 in year 0 (2012), to ¥ 1.58 billion in year 5 (2017), and ¥ 3.52 billion by year 10 (2022). Of the expected benefits, 1 to 2 percent are derived from the government incentive program.

In addition to the benefits associated with the CPP program, the expected increase in tariff revenue compared with the Tianjin's current TOU structure has also been considered within the DR program benefits. Considering the benefits associated with both DR programs, expected revenue is estimated to range from ¥0 in year 0 (2012), to ¥ 30.9 billion in year 5 (2017), and ¥ 46.6 billion by year 10 (2022).

Table 5-8 presents the estimated economic benefits associated with the proposed CPP and TOU programs.

Additional implications of the relationship between costs and benefits of implementation are reviewed in Section 6.

Table 5-7 Estimated Capital and Operating Costs of Tianjin's CPP Program (2012-2022)

Utility Costs	Utility / Customer Expense	One time / Annually Recurring	Unit	Unit Cost	% Covered by Utility	2012 Year 0	2013 Year 1	2017 Year 5	2022 Year 10	2012-2022
Assumptions										
Inflation Factor				2%		1.00	1.02	1.10	1.22	
DR Program Participation						**-**	**285**	**1,622**	**3,574**	**3,574**
Industrial			Enterprise			-	223	1,409	3,247	**3,247**
Mining and Quarrying			Enterprise			-	37	269	621	**621**
Manufacturing			Enterprise			-	186	1,140	2,627	**2,627**
Commercial			Building			-	62	213	326	**326**
Avoided Peak Demand (kW)			kW			-	36,125	247,822	615,950	**615,950**
COST ESTIMATE										
Utility Based Capital Costs – Materials, Hardware & Software	Utility	One time	¥/utility	2,778,750,000		**2,778,750**	**-**	**-**	**-**	**2,778,750**
Customer Based Capital Costs – Materials, Hardware & Software		One time	¥/customer		100%	**51,671,739**	**29,715,985**	**187,802,072**	**80,241,735**	**832,901,540**
Operations and Maintenance (Building Site Activity)						**16,335,147**	**28,014,260**	**158,511,372**	**259,219,583**	**1,486,190,710**
O&M - Utility										
Licensing /Maintenance Fees		Recurring/ Customer	¥/year	2,340,000		-	2,386,800	2,583,549	2,852,447	26,134,794
Insurance		Recurring	% of Capital Costs	5%	100%	2,722,524	4,208,324	25,600,025	41,784,014	238,546,120
Taxes				15%	100%	8,167,573	12,624,971	76,800,075	125,352,043	715,638,361
O&M - Customer										
Labor		Recurring/ Customer		1,300		-	377,518	2,327,673	5,663,049	28,779,195
Replacement and Repair		Recurring	% of Capital Costs	10%	100%	5,445,049	8,416,647	51,200,050	83,568,029	477,092,240
Total Costs (¥)						**70,785,635**	**57,730,245**	**346,313,444**	**339,461,318**	**2,321,871,000**
Total Costs (¥ billion)						**0.07**	**0.06**	**0.35**	**0.34**	**2.3**

Source: AECOM, Honeywell Input on Costing Organization

Table 5-8 Estimated Benefits of Tianjin's DR Program (2012-2022)

	Unit	Unit Cost	2012	2013	2017	2022	2012-2022
Meter Operations (fewer field operations calls, visits, maintenance)	% of AMI Investment	50%	2,775,866	4,321,292	26,147,362	42,218,861	239,817,169
Avoided Costs of Supplying Electricity			-	15,207,564	112,926,665	309,886,727	1,478,197,731
Avoided Generation Capacity Costs	¥/kW of avoided generation	335	-	12,343,802	91,661,254	251,531,434	1,199,835,821
Avoided Energy Costs	% of avoided generation costs	12%	-	1,481,256	10,999,351	30,183,772	143,980,298
Avoided T&D Costs	% of savings in generation capacity and energy costs	10%	-	1,382,506	10,266,060	28,171,521	134,381,612
Net Change in Revenue for CPP Program over Current TOU Program			0	232,638,390	1,416,643,080	3,088,072,989	16,641,983,894
Government Incentive Payment			-	3,684,717	27,361,568	75,084,010	358,159,946
Total Benefits of CPP Program				255,851,962	1,583,078,675	3,515,262,588	18,718,158,741
Total Benefits of CPP Program (¥ billion)			0.00	0.26	1.58	3.52	18.7
Net Change in Revenue for Revised TOU Program over Current TOU Program				21,065,839,946	29,344,327,791	43,094,318,033	310,665,685,660
Total Benefits from Revised TOU and CPP Program (¥)			0	21,321,691,908	30,927,406,465	46,609,580,620	329,383,844,401
Total Benefits of TOU and CPP Program (¥ billion)			0.0	21.3	30.9	46.6	329.4

Source: AECOM

5.4.4 China Investment Plan

Following the same approach as used for Tianjin, both the CPP and TOU programs implemented across China would result in a similar positive net increase in revenue for national utilities.

Capital costs for the implementation of a nationwide DR program are estimated to range from ¥5.9billion in year 0 (2012), to ¥28.5 in year 5 (2017), and ¥25.3 by year 10 (2022). While the costs grow steadily during the initial years of implementation, they level off once the program reaches its achievable participation. Table 5-9 presents the estimated capital and operating costs for China's DR program.

As in Tianjin, the anticipated benefits associated with implementing the proposed CPP and TOU program are similarly expected to more than cover the costs associated with DR implementation.

Benefits for the CPP program alone are estimated to range from ¥0 in year 0 (2012), to ¥ 95.6billion in year 5 (2017), and ¥ 235.6 billion by year 10 (2022). Revenue associated with the increase in TOU tariff is expected to grow to ¥3.1 trillion by year 10 (2022). Table 5-10 presents the estimated economic benefits associated with China's DR program.

Additional implications of the relationship between costs and benefits of implementation are reviewed in Section 6.

Table 5-9 Estimated Capital and Operating Costs of China National CPP Program Implementation (2012-2022)

Utility Costs	Utility / Customer Expense	One time / Annually Recurring	Unit	Unit Cost	% Covered by Utility	2012 Year 0	2013 Year 1	2017 Year 5	2022 Year 10	2012-2022
Assumptions										
Inflation Factor				2%		1.00	1.02	1.10	1.22	
Local Utility Participation						**5**	**15**	**55**	**100**	
DR Program Participation						**-**	**30,093**	**167,377**	**342,080**	**342,080**
Industrial			Enterprise			-	11,853	73,975	170,482	**170,482**
Mining and Quarrying			Enterprise			-	1,036	7,566	17,437	**17,437**
Manufacturing			Enterprise			-	10,818	66,409	153,044	**153,044**
Commercial			Building			-	18,240	93,402	171,598	**171,598**
Avoided Peak Demand (kW)			kW			-	2,684,288	16,938,312	39,202,373	**39,202,373**
COST ESTIMATE										
Utility Based Capital Costs – Materials, Hardware & Software	Utility	One time	¥/utility			**13,893,750**	**28,422,810**	**31,127,808**	**17,456,962**	**312,035,436**
Customer Based Capital Costs – Materials, Hardware & Software		One time	¥/customer		100%	**4,523,219,016**	**2,524,687,766**	**15,502,490,741**	**5,408,498,856**	**64,827,644,278**
Operations and Maintenance (Building Site Activity)						**1,361,140,330**	**2,162,888,893**	**12,977,428,948**	**19,827,307,078**	**117,575,463,095**
O&M - Utility										
Licensing /Maintenance Fees		Recurring/ Customer	¥/year	2,340,000		-	35,802,000	142,095,199	285,244,694	1,596,494,103
Insurance		Recurring	% of Capital Costs	5%	100%	226,855,638	354,511,167	2,139,209,134	3,256,983,986	19,329,679,258
Taxes				15%	100%	680,566,915	1,063,533,501	6,417,627,403	9,770,951,957	57,989,037,775
O&M - Customer										
Labor		Recurring/ Customer		1,300		6,500	19,890	78,942	158,469	893,441
Replacement and Repair		Recurring	% of Capital Costs	10%	100%	453,711,276	709,022,334	4,278,418,268	6,513,967,971	38,659,358,517
Total Costs (¥)						**5,898,253,096**	**4,715,999,469**	**28,511,047,497**	**25,253,262,896**	**182,715,142,809**
Total Costs (¥ billion)						**5.9**	**4.7**	**28.5**	**25.3**	**182.7**

Source: AECOM, Honeywell Input on Costing Organization

Table 5-10 Estimated Benefits of National DR Program Implementation (2012-2022)

	Unit	Unit Cost	2012	2013	2017	2022	2012-2022
Meter Operations (fewer field operations calls, visits, maintenance)	% of AMI Investment	50%	-	454,028,076	2,678,576,281	3,950,784,498	23,611,884,368
Avoided Costs of Supplying Electricity				1,130,016,590	7,718,385,996	19,722,846,288	97,680,259,351
Avoided Generation Capacity Costs	¥/kW of avoided generation	335	-	917,221,258	6,264,923,698	16,008,803,805	79,285,924,798
Avoided Energy Costs	% of avoided generation costs	12%	-	110,066,551	751,790,844	1,921,056,457	9,514,310,976
Avoided T&D Costs	% of savings in generation capacity and energy costs	10%	-	102,728,781	701,671,454	1,792,986,026	8,880,023,577
Net Change in Revenue for CPP Program over Current TOU Program			0	13,017,231,579	85,197,550,747	211,951,628,560	1,065,303,281,499
Total Benefits of CPP Program			**-**	**14,601,276,245**	**95,594,513,025**	**235,625,259,346**	**1,186,595,425,218**
Total Benefits of CPP Program (¥ billion)			**-**	**14.6**	**95.6**	**235.6**	**1,186.6**
Net Change in Revenue for Revised TOU Program over Current TOU Program				1,178,428,401,551	1,712,163,900,391	2,821,725,022,381	18,724,511,605,677
Total Benefits from Revised TOU and CPP Program (¥)				**1,193,029,677,796**	**1,807,758,413,416**	**3,057,350,281,727**	**19,911,107,030,895**
Total Benefits of TOU and CPP Program (¥ billion)				**1,193.0**	**1,807.8**	**3,057.4**	**19,911.1**

Source: AECOM.

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6 Economic Analysis and Financing Mechanisms

This section presents an economic analysis of the proposed implementation strategy and a review of financing mechanisms. The proposed framework provides a robust model, resilient to reasonable swings in the economy and cost of goods. The review of financing mechanisms indicates that there are a number of ways for State Grid to fund the program, although the combination of TOU and CPP programs explored in Sections 3 and 5 suggest that upfront investment will quickly be returned.

6.1 Economic Analysis

The section presents the net present value (NPV) of the proposed implementation strategy (2012-2022), the estimated benefit-cost ratio, the program's internal rate of return (IRR), and an estimate of the payback period from the utility's perspective. Additionally, the section includes a sensitivity analysis of various project cost components.

Because the TOU program is not expected to come with significant additional costs to the implementing utility, we mainly address the economics and sensitivity around only the CPP program, which does have implementation costs.

6.1.1 Summary of Broad Capital Estimate

Both the CPP and the revised TOU programs are expected to result in significant positive net returns when compared with Tianjin's current TOU program. In Tianjin, the CPP program alone is expected to result in an NPV gain of ¥10.7 billion by 2022.

Results from the implementation costs and benefits estimates presented in Section 5.4 are summarized in Table 6-1 below.

Table 6-1 Summary of Benefits and Costs of DR Program Implementation[22]

(Billion ¥)	2012 Year 0	2013 Year 1	2017 Year 5	2022 Year 10	Total 2012-2022
Tianjin					
CPP Program					
Total Benefits	-	0.26	1.58	3.52	
Total Costs	(0.07)	(0.06)	(0.35)	(0.34)	
Net Revenue (Benefits-Cost)	(0.07)	0.20	1.24	3.18	
Net Present Value of Revenue					10.74
Cumulative NPV Cash Flow	(0.07)	0.12	2.39	10.74	
TOU and CPP Program					
Total Benefits	-	21.3	30.9	46.6	
Total Costs	(0.1)	(0.1)	(0.3)	(0.3)	
Net Revenue (Benefits-Cost)	(0.1)	21.3	30.6	46.3	
Net Present Value of Revenue					231.3
Cumulative NPV Cash Flow	(0.1)	20.0	108.7	231.3	
China					
CPP Program					
Total Benefits	-	14.6	95.6	235.6	
Total Costs	(5.9)	(4.7)	(28.5)	(25.3)	
Net Revenue (Benefits-Cost)	(5.9)	9.9	67.1	210.4	
Net Present Value of Revenue					650.2
Cumulative NPV Cash Flow	(5.9)	3.4	122.6	650.2	
TOU and CPP Program					
Total Benefits	-	1,193.0	1,807.8	3,057.4	
Total Costs	(5.9)	(4.7)	(28.5)	(25.3)	
Net Revenue (Benefits-Cost)	(5.9)	1,188.3	1,779.2	3,032.1	
Net Present Value of Revenue					13,820.3
Cumulative NPV Cash Flow	(5.9)	1,115.2	6,142.2	13,820.3	

Source: AECOM.

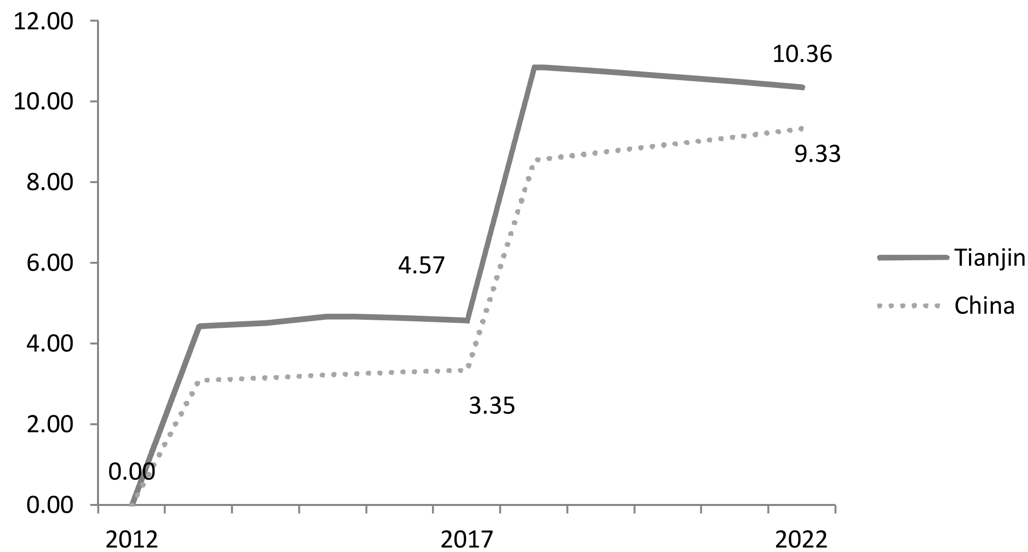
[22] Numbers in "( )", reflect negative numbers; Net Present Value represented in 2012¥.

6.1.1.1 NPV and Benefit-Cost Ratio

Using a discount rate of 6 percent, the Tianjin CPP program alone is expected to result in net increase of ¥10.7 billion in revenue (present ¥) in the first ten years of operation. Similarly, a nationwide DR program is also expected to result in a net revenue increase of over just over ¥650 billion in the first ten years of operation.

After the first year of operation, the benefit-cost ratios for the two scales of implementation over the first 10 years of operation fluctuate between 3:1 and 10:1. In the United States, DR programs have typically been found to result in benefit-cost ratios ranging from 2:1 to 6:1.[23] The results for the proposed DR program in Tianjin and China show healthy returns on the utilities' investment at both the local Tianjin and national level.

The benefit-cost ratios for CPP program implementation is illustrated in Figure 6-1. The ratios fluctuate based in part on the rate of new participation.



Source: AECOM.

Figure 6-1. Benefit-Cost Ratio of CPP Program Implementation

6.1.1.2 IRR

Because of the nature of the system that Honeywell has proposed for the pilot project, very little upfront capital investment is required for the proposed AutoDR CPP program. As such, the utility's internal rate of return (IRR) for Tianjin's DR program implementation is estimated around 340 percent.

In China, the IRR of the AutoDR CPP program implementation is estimated around 230 percent. The scale of China's implementation, coupled with the number of utilities decreases the IRR as compared to Tianjin's implementation.

6.1.1.3 Payback Period

Currently, both the Tianjin and nationwide implementation programs are expected to break even after just one year of operation. See Table 6-1 and Section 5.4 for more detailed information on the investment plans and payback period.

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[23] Faruqui, Ahmad, et al, "The Power of Five Percent: How Dynamic Pricing Can Save $35 Billion in Electricity Costs," The Brattle Group, May 16, 2007.

6.1.1.4 Profit Targets

No currency targets have been set for the CPP and TOU programs. It will be important for CEPRI and State Grid to decide how much risk and what sorts of returns they expect from investing in these programs.

6.1.2 Sensitivity Analyses

As part of the economic analysis of DR program implementation, sensitivity analyses for Tianjin's CPP strategy implementation were conducted on key economic inputs to understand the effects of positive or negative changes in the inflation rate, peak to off-peak price ratio, CPP ratio, hardware and software costs, tax rate, and assumed discount factor. Typical ranges for the sensitivity analyses are +/- 20 percent of the base variable.

Each of these analyses indicates the extent to which external factors may affect the viability of the DR program. Only one variable's impact has been evaluated in each analysis. Simultaneous changes in multiple variables will result in un-modeled results.

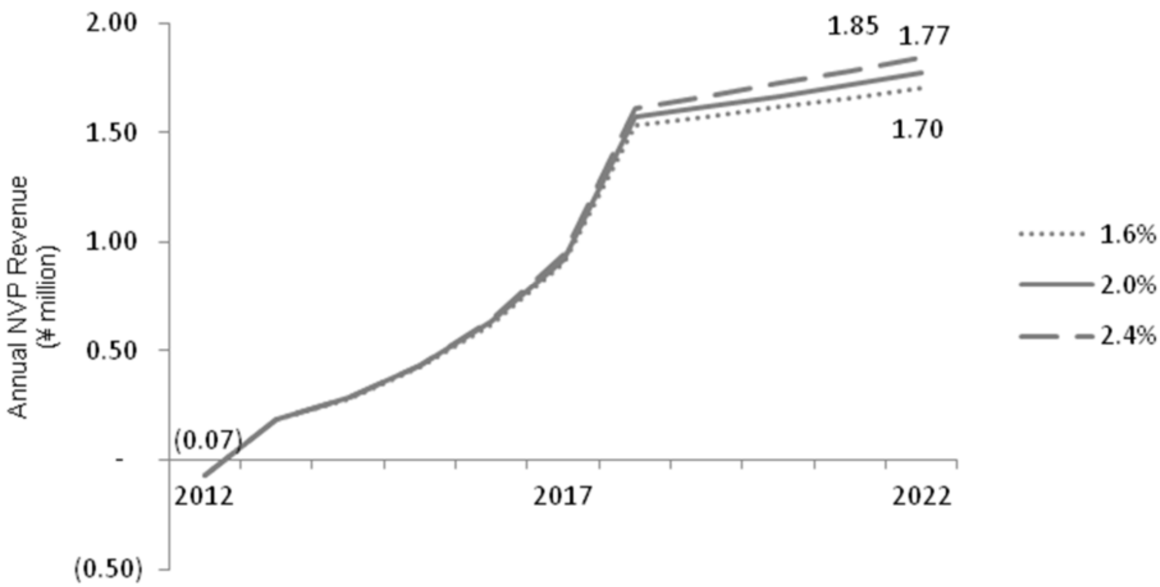
The peak to off-peak pricing ratio, the CPP ratio, and the discount rate are found to have the largest impacts on overall project viability. However, even for these variables, changes of +/- 20% still do not result in revenue loss, reinforcing the CPP program's feasibility.

As noted above, because the TOU program is not expected to come with significant additional costs and is expected to result in net revenue gains, the sensitivity analyses have been conducted around the CPP program, which does have implementation costs.

6.1.2.1 Inflation Rate

In the current model, a fixed inflation rate of 2 percent between 2012 and 2022 has been assumed. Adjustments to the inflation rate, either up or down, are expected to have limited impact on the overall project.

If the inflation rate is increased to 1.85%, the annual revenue from the TOU program in 2022 is expected to increase from ¥1.77 million to ¥1.85 million. A decrease to 1.6% inflation would result in annual revenue of ¥1.70 million in 2022. Cumulative revenue (2012¥) from 2012 to 2022 would only vary by +/- 3 percent.



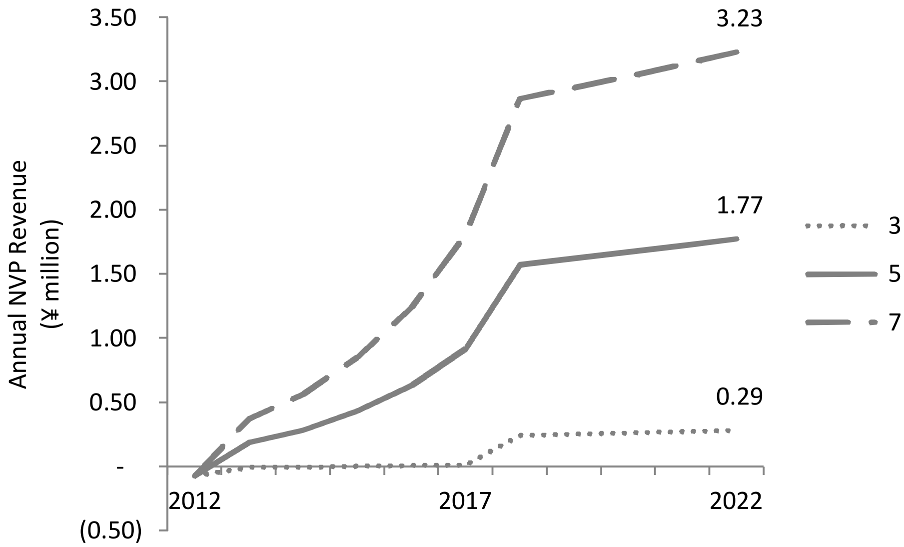
Source: AECOM.

Figure 6-2 Sensitivity Analysis of Inflation Rate on Net Annual Revenue (NPV)

6.1.2.2 Electricity Tariffs – Peak to Off-Peak Ratio

Currently, the model applies a peak to off-peak pricing ratio of 5:1. Increasing this ratio to 7:1 is expected to result to double revenue by 2022, while reducing it to 3:1, just above the current TOU rate, would result in a barely feasible CPP program in Tianjin.

Changing the peak to off-peak ratio would have significant impacts on program feasibility. If the peak to off-peak ratio is increased to 7:1 the annual revenue from the TOU program in 2022 is expected to increase from ¥1.77 million to ¥3.23 million. A decrease to a ratio of 3:1 would result in annual revenue of ¥0.29 million in 2022. Cumulative revenue (2012¥) from 2012 to 2022 would vary by +/- 86 to 88 percent.



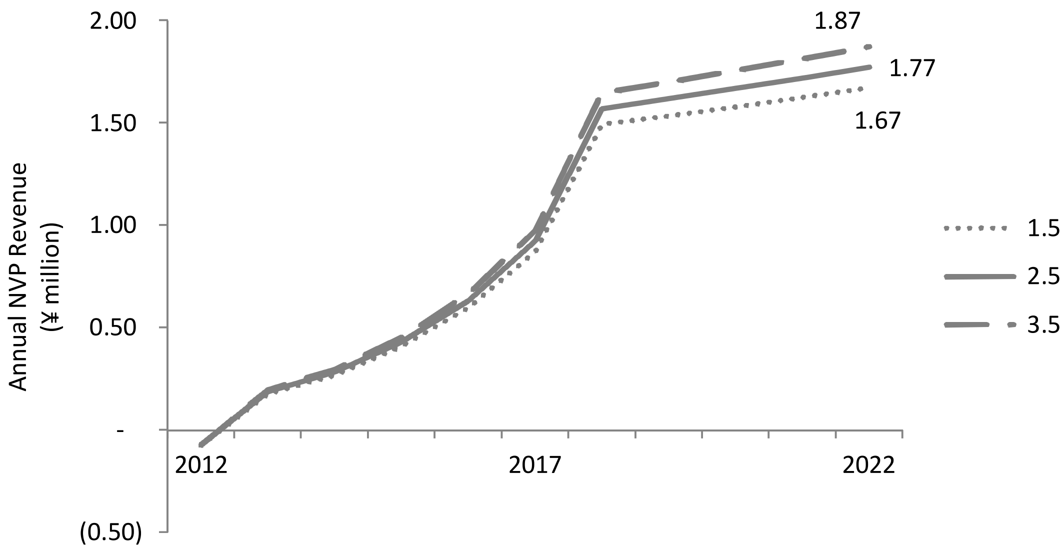
Source: AECOM.

Figure 6-3 Sensitivity Analysis of Peak to Off-Peak Ratio on Net Annual Revenue (NPV)

6.1.2.3 Electricity Tariffs – CPP Ratio

The CPP event price to peak pricing ratio applied was 2.5:1. While increasing or decreasing the ratio will certainly have impacts on project viability, the effects are less dramatic than changing the peak to off-peak ratio.

If the CPP ratio is increased to 3.5:1, the annual revenue from the TOU program in 2022 is expected to increase from ¥1.77 million to ¥1.87 million. A decrease to a ratio of 1.5:1 would result in annual revenue of ¥1.67 million in 2022. Cumulative revenue (2012¥) from 2012 to 2022 would only vary by +/- 3 to 5 percent.



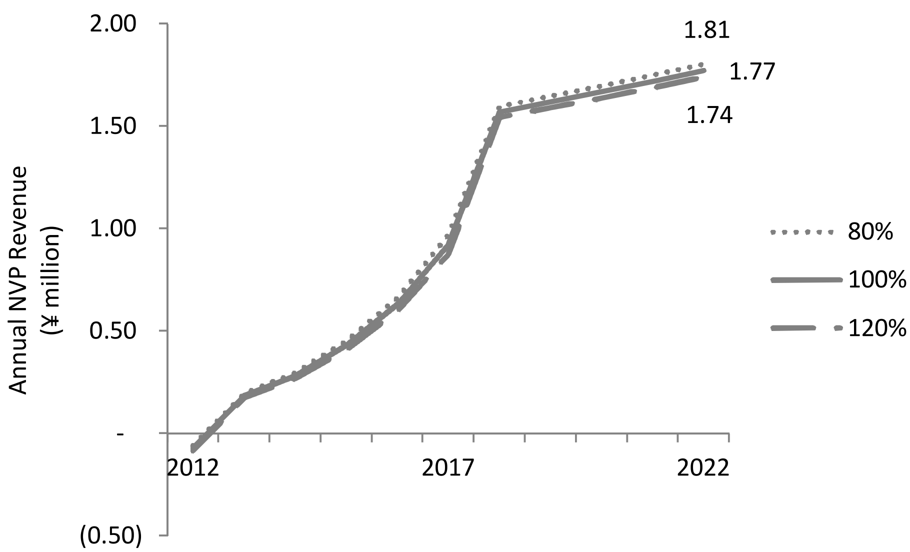
Source: AECOM

Figure 6-4 Sensitivity Analysis of CPP Ratio on Net Annual Revenue (NPV)

6.1.2.4 Equipment Costs

As expected, increasing or decreasing equipment costs will affect project viability, however, the impact is not expected to be significant.

If the equipment costs are increased to 120 percent of currently estimated costs, the annual revenue from the TOU program in 2022 is expected to decrease from ¥1.77 million to ¥1.74 million. If the cost of equipment decreased to 80% of the estimated costs, the 2022 revenue would increase to ¥1.81 million. Cumulative revenue (2012¥) from 2012 to 2022 would only vary by +/- 3 percent.



Source: AECOM.

Figure 6-5 Sensitivity Analysis of Hardware and Software Expense on Net Annual Revenue (NPV)

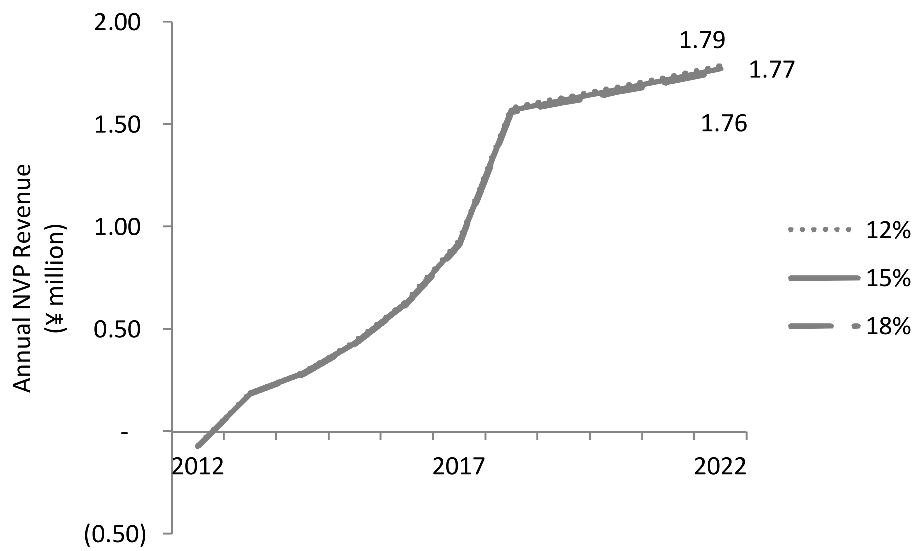
6.1.2.5 International Oil Price

Due to lack of data as well as the division within the electricity industry between generation and distribution, the impacts of rising international oil prices on the project feasibility cannot be evaluated. In China, the prices and profit of electricity generation are fixed by law. If international oil prices increase, the State might allow for a change in the price allowed for generated electricity. While this may result in a necessary increase in electricity tariffs, it is no possible to evaluate that link at this moment without additional information.

6.1.2.6 Tax Rates

The current tax rate for the local Tianjin State Grid is estimated at 15 percent of capital expenditures. As the analysis shows, varying the tax rate by +/- 20 percent only minimally impacts the 10 year forecast.

If the tax rate is increased from 15 percent to 18 percent, the annual revenue from the TOU program in 2022 is expected to decrease from ¥1.77 million to ¥1.76 million. A decrease to 12 percent would result in annual revenue of ¥1.79 million for 2022. Cumulative revenue (2012¥) from 2012 to 2022 would only vary by +/- 1 percent, a very insignificant change.



Source: AECOM.

Figure 6-6 Sensitivity Analysis of Tax Rate on Net Annual Revenue (NPV)

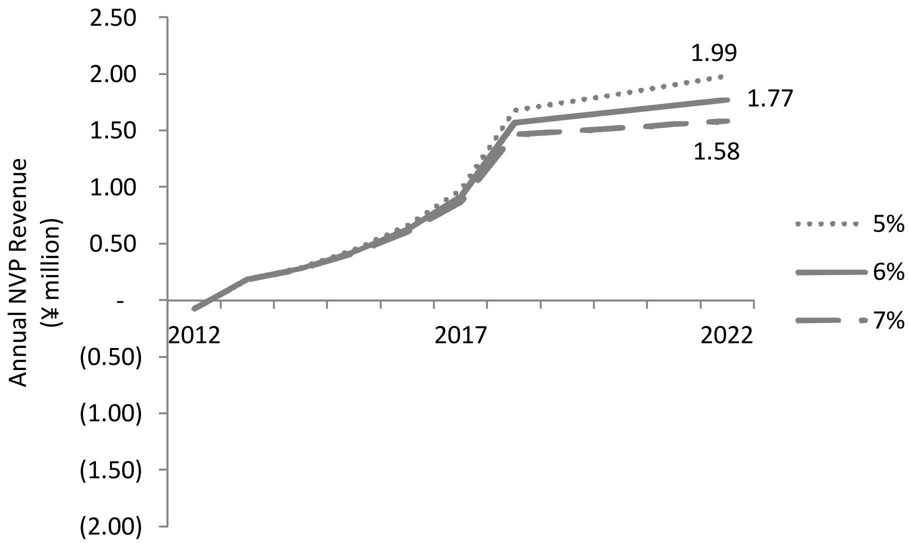
6.1.2.7 Currency Fluctuation

As with international oil prices, changes in currency values may affect electricity generation costs, depending on the source of the electricity. Due to the nature of the project and availability of data, the impacts of currency fluctuation are not able to be evaluated at this time.

6.1.2.8 Discount / Factor

An adjustment of the assumed 6 percent discount rate would result in an increase or decrease of the tapering off of revenue growth. However, the change in discount rates is not expected to affect overall CPP program viability.

If the discount rate is increased from 6 to 7 percent, the annual revenue from the TOU program in 2022 is expected to decrease from ¥1.77 million to ¥1.58 million. A decrease to 5 percent would result in a 2022 annual revenue of ¥1.99 million. Cumulative revenue (2012¥) from 2012 to 2022 would only vary by +/- 8 percent.



Source: AECOM.

Figure 6-7 Sensitivity Analysis of Discount Factor on Net Annual Revenue (NPV)

6.1.3 Analysis of Expected Customer Cost

For the purposes of this study, it is assumed that primary metering hardware and software based at the customer site required for CPP program participation will be paid for by the utility as a participation incentive. *As described earlier, participating customers are already assumed to have the required building energy management systems, and sub-metering hardware with the necessary communication capabilities.* Program participation rates have been revised down to reflect this required condition. Additional customer costs will be limited to small amounts of staff training and onsite operations and maintenance of the energy management systems. Customers participating in the revised TOU program are not expected to have additional costs.

As an incentive, customers participating in the CPP program stand to benefit from a reduction in their electricity fee compared with the revised TOU tariffs. Mining and quarrying customers could expect to enjoy14 percent savings over the revised TOU price, with a 21 percent savings for manufacturing customers, and 16 percent for commercial customers.

While customers participating in the revised TOU tariff structure will not incur hardware or software installation costs, their overall electricity payments are expected to increase. *Mining and quarrying customers could expect increases of up to 29 percent over the current tariff structure (see Section 5.2).* Manufacturing customers might experience increases of 50 percent, and commercial customers could expect annual payment increases of up to 28 percent. Such increases would begin to reflect the true costs, financial and otherwise, associated with energy consumption.

6.2 Analysis of Financing Mechanisms

This section presents a range of financing mechanisms available for consideration *for the TOU and CPP programs.* Each of the financing mechanisms involves a different level of customer support, and relies on varying levels of financial risk. *Due to the nature of the proposed TOU and AutoDR programs, and the limited upfront capital expenses, the application of these financing mechanisms is less necessary than with more traditionally capital-intensive infrastructure projects. Because the upfront investment is expected to be covered by increases in revenue and other financial benefits by the second year of operation, the utility is expected to cover all costs themselves without relying on the mechanisms explored below.* However, while program investments and operating costs are expected to be covered by the financial benefits, four financing mechanisms are still reviewed in compliance with the project Terms of Reference.

The four primary financing mechanisms reviewed are:

1. Full customer expense.
2. Partially subsidized installation.
3. Special purpose funds (bonds).
4. Concessionary financing via international banks.

Given that the agency does not plan to rely on external funding sources such as international banks, State Grid would likely consider full customer expense, partially subsidized installation, or special purpose bonds in order to cover initial implementation costs. A review of concessionary financing from international banks is included to provide a review of an alternative approach to financing.

In program development, most utilities rely on a combination of funding sources and financing mechanisms for their DR program implementation.

6.2.1 Full Customer Expense

The full customer expense approach allows a utility to pass on the cost of implementation directly to its customers. This approach is typically applied when the program's implementation can be shown to have significant external benefits that customers and society would value over potential increases to electricity rates or surcharges. However, while costs of DR programs are often passed on to customers, it is more often the case that customers only bear a portion of the cost burden. Passing the full cost of implementation on to customers is less common.

Both of the California utilities, PG&E and SCE, have relied in part on an increase in customer rates or surcharges to recover a portion of the costs of their DR programs. Similarly, the Russian national electricity utility, IDGC, has relied on such ratepayer expenses as connection fees, unused profit, and borrowed funds[24] in order to cover its US$120 million investment in energy efficient technologies within its service region.

6.2.2 Partially Subsidized Installations

Often, DR and other smart grid related investments are financed through a series of government, or other agency, subsidies. Again, both PG&E and SCE relied on some level of federal and state subsidies to implement their DR programs. In 2012, a US$2.9 million smart grid pilot project in the Stockholm Royal Seaport in Sweden received almost 70 percent of its funding via subsidies from various national level government agencies, with additional funding support from technologies suppliers.

6.2.3 Special Purpose Fund (bonds)

Special purpose funds, or bonds, are a third form of financing for DR implementation. Typically, public agencies may issue bonds, which allow them to borrow money in advance to pay for necessary upfront capital investment. The utility must then pay back the value of the bond plus interest after investment. Such measures allow utilities to cover what may be significant capital investment in order to invest in a project that has potential long term returns.

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[24] IDGC of the Urals 2011 Annual Report. http://report2011.mrsk-ural.ru/reports/mrskural/annual/2011/gb/English/201050/investments.html?search_hit_no=1&search_keywords=investment

6.2.4 Concessionary Financing via International Banks or Agencies

Concessionary financing, originating either domestically or through partnerships with national and international organizations, provides an alternative source of funding that can put less of a burden on either the utility or the customer. While such funds have obvious upfront benefits, one of the disadvantages of such funds is the substantial administrative burden that such funds require in order to comply with program, loan, and grant terms. This is especially difficult when funding comes from multiple sources.

In 2012, the Indian Ministry of Power and the Ministry of New and Renewable Energy began a 5 year program to implement DR technologies and programs for its residential and commercial customers. The program is receiving financial support from the U.S- India Partnership to Advance Clean Energy, which is in turn supported by various U.S. agencies such as USAID, USTDA, the U.S Department of Energy and State, the Overseas Private Investment Corporation, and the Export-Import Bank, among others. The guaranteed funding for the implementation of DR programs significantly reduces the level of risk associated with such projects.

6.2.4.1 Bank and Agency Discussion

While State Grid and the Chinese Government are expecting to fully finance any demand response program implementation themselves, two potential external funding sources were interviewed in order to gauge the international community's capacity and interest in funding DR and energy related projects in China. State Grid did not have additional banks or funding sources that it was interested in contacting.

World Bank

The World Bank is significantly involved in the energy sector, and has particular interest in energy efficiency and climate change. With an office in Beijing, the World Bank invests in infrastructure projects throughout the Mainland. As a result of working exclusively with government partners, the World Bank recognizes that China usually has the capacity to finance its own large infrastructure projects. However, unique cases have shown that the Chinese Government does look to the World Bank for financial support on new or untested projects that carry higher levels of risk.[25]

Energy loans must typically be guaranteed by government partners. Only 60% to 70% may be funded by the World Bank, with the partnering governments expected to fund 30% to 40%.

In addition to financial commitments, the World Bank also stresses environmental and social impact evaluation of all of its projects, as well as technical assistance reviews. Once projects are implemented, they are evaluated based on pre-set targets.

Asian Development Bank

According to the Director of Energy for the East Asia Department of the Asian Development Bank (ADB), there is significant interest in large energy and energy efficiency related projects in China. The ADB is already involved in energy efficiency projects in Guangdong, Shandong, and Hebei. In Guangdong, the ADB currently helps fund a demand response energy project focused on the industrial sector.[26]

The ADB sets aside between US$300-$400 million for energy sector loans every year. China's State Grid has already received a US$900,000 technical assistance grant for its smart grid initiatives. Typically, the ADB will fund or provide loans for between 40-70% of project costs. The ADB tends to avoid funding anything for more than US$250-$350 million. Typical ADB loans are accompanied by 12 months of preparatory technical assistance to determine the project's viability.

After projects are funded or provided a loan, the ADB will follow up on the success and implementation of the project.

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[25] Interview with Mr. Victor Dato, Infrastructure Specialist, World Bank, Manila, July 2012.

[26] Interview with Mr. Shaman Bhargava, the Director of Energy for the East Asia Department, Asian Development Bank, July 2012.

7 Development Impact

This section presents an assessment of the environmental, social, and developmental impact of implementing demand response programs in China.

7.1 Overall Impacts of DR Program Implementation

As with most energy systems, the impacts, costs, and benefits of implementing DR programs in China will not be evenly distributed. Without regulatory support, utilities and generators may bear an uneven share of program implementation costs and reap few financial benefits to justify the burden. Meanwhile, customers, the government, and society will tend to enjoy net gains from DR program implementation. Because of this, it is important that the Chinese government take a holistic, system-wide view of the impacts of implementing DR programs and policies so that it can support utilities and generators in rolling out such programs.

Program impacts, both positive and negative are distributed among many stakeholders, including utilities, energy generators, the government, customers and general society.

7.2 Environmental Review of Implementation

Despite the program's size, the DR program will require minimal infrastructure development, which will result in very few negative environmental impacts. The largest change would be an accrual of significant environmental benefits. With an annual electricity savings of 113.3 TWh nationwide by 2022, greenhouse gases associated with the TOU and CPP programs would be greatly reduced. Furthermore, general findings from similar programs indicate that reduced energy consumption, increased customer awareness and engagement, resulting in positive program impacts.

7.3 Additional Social and Development Impact Review

The project is also expected to have positive impacts as it relates to development in infrastructure and technology transfer, market-oriented reform within the energy sector, and human capacity building and productivity enhancement.

7.4 Overall Impacts of DR Program Implementation

As with most energy systems, the impacts, costs, and benefits of implementing DR programs in China are not evenly distributed. Without regulatory support, utilities and generators may bear an uneven share of program implementation costs and reap few financial benefits to justify the burden. Meanwhile, customers, the government, and society tend to enjoy net gains from DR program implementation. Because of this, it is important that the Chinese government take a holistic, system-wide view of the impacts of implementing DR programs and policies so that it can support utilities and generators in rolling out such programs.

As Table 7-1 shows, when viewed system-wide, the social and environmental benefits from implementing DR programs often far outnumber the initial costs.

Table 7-1 DR Program Costs and Benefits

Sector	Costs / Impacts (-)	Benefits (+)
Utilities	• DR program management and administration • Incentive payments • Potential lost revenue due to reduction in peak demand	• Increased system efficiency • Reduction in new T&D infrastructure / postponement of system upgrade investment • Electricity prices that reflect true cost of generation • Fewer energy shortages; higher system reliability • Support for integration of renewable energies / optimize resource allocation • Better data availability • Operational efficiency from associated smart meter installation
Generators	• Lost operating revenue due to reduction in peak demand	• Reduction in new generation infrastructure with low utilization over the long term • Renewable energy generators have greater access to system
Government	• Substantial policy revision to support DR programs • Potential financial support for utilities for program development and implementation	• Reduces greenhouse gas emissions, supporting regulatory goals • Increased incorporation of renewable energy, support for current renewable policies • Increased energy independence and security • Increased sophistication of energy system • Increased energy reliability; fewer blackouts / brownouts • Increased GDP output due to energy reliability
Customers	• DR hardware and installation costs • Adjustment of consumption patterns • Potential financial penalties	• Potential electricity savings • Increased energy reliability; fewer blackouts / brownouts • Financial savings / incentives • Technical assistance • Better data availability • Increased energy awareness • Good corporate citizenship
Society	• Substituted capital investment in other economic development or infrastructure projects/goals	• Potential for reduced carbon emissions and air pollution • Reduced impacts to environment from mining and transportation • Increased system reliability • Increased energy efficiency • Increased potential for energy independence and security • Lower total electricity costs

Source: AECOM.

7.5 Environmental Review of Implementation

This section reviews the primary environmental impacts of the proposed DR program implementation. Despite the program's size, the DR program requires minimal infrastructure development, and thus, results in very few negative environmental impacts. The largest known impacts are reviewed here. With an annual electricity savings of 113.3 TWh nationwide by 2022, the reduction in greenhouse gases associated with the TOU and CPP programs would generate significant environmental benefits.

7.5.1 Existing Meter Disposal and Recycling

As one of the world's largest disposal sites for electronic waste, China is slowly learning how to manage enormous amounts of electronic waste. In recent years, China has become increasingly active in recycling and environmentally appropriate disposal of its electronic waste. Both state and local agencies have developed programs to encourage the responsible management of electronic waste, a category that includes electricity meters. With the growth of demand response programs and the associated installation of new smart meters, millions of outdated electricity meters will be removed and will require proper disposal.

To support the proper disposal of electronic waste, the Ministry of Finance introduced a tariff in 2011 on the sale of electronic goods. This tariff is intended to subsidize electronic waste (e-waste) collection and recycling. Such policies provide much-needed support to China's e-waste recycling industry.

While this policy increases e-waste recycling capacity, the responsibility to bring e-waste to the proper disposal site falls primarily on customers. Tianjin is one of the municipalities that has shown success in changing behavior through its e-waste education. The municipality has reported that 90 percent of its residential electronic waste now ends up in proper disposal facilities.[27]

In its push to replace traditional residential electricity meters with smart meters, Tianjin State Grid has also assumed responsibility for removal and disposal of existing meters.[28] Measures like this help ensure proper disposal of electricity meters and shift the burden off of electricity customers and onto the utility. While this initiative was specifically targeted at residential customers, it is anticipated that commercial and industrial customers will receive similar treatment.

7.5.2 Societal Environmental Review

As presented in Table 7-1, society in general can expect to benefit from reduced energy demand in the form of reduced carbon emissions and air pollution as well as an increase in system reliability associated with DR programs. The potential environmental and public health benefits associated with these programs would deliver a positive impact to the country.

7.5.3 Environmental Risk Assessment

Implementation of smart grid and demand response programs have net positive environmental effects, as they both encourage less energy generation. In China, where fossil fuels account for over 80% of power generation, reduced demand is expected to result in less energy-production related pollution and improved air quality. Reduced fossil fuel usage also results in less water and soil pollution.

In addition to reduced air and water pollution associated with a decreased energy demand, a fully integrated smart grid system also allows better integration of renewable energy resources and other technologies, such as electric vehicles. Facilitating access to wind and solar energy sources will also help reduce demand on fossil fuel energy generation.

7.5.4 Occupational Health and Safety

Reduced pollution and better air quality associated with decreased energy generation demand has been shown to have significant positive effects on public health. Less coal and fossil fuel related pollution results in reduced rates of asthma, lung disease, and various cancers overall, with particular benefits to

[27] Mitch, Moxley, "E-Waste Hits China," IPS News Agency, July 21, 2011. http://www.ipsnews.net/2011/07/e-waste-hits-china/

[28] http://news.022china.com/2010/07-12/299933_0.html

children and the elderly. Workers engaged in energy generation also receive benefits from cleaner air and fewer pollutants.

7.6 Additional Social and Development Impacts

This section briefly outlines some of the key social and development impacts associated with DR program implementation in China.

7.6.1 Infrastructure

With high growth rates of social and economic activities in China, the electrical demand requirements are also increasing rapidly. In many cases, new generation cannot keep up with demand. Power shortages are more common in the summer periods. The generation deficit was about 30GW in 2011 and is forecasted between 30-40GW in 2012. Today, utilities with support from the Government cut off power supply to customers to keep the power grid stable and reliable during critical times. This AutoDR project provides one alternate solution for utilities to reduce summer peak load. Compared with the prospect of losing all power supply, customers are more comfortable with solutions that require only temporary reduction in power usage.

Like other countries, China is investing in smart grid solutions. One important aspect of the smart grid is to encourage customer participation in its development. Near-real time, two-way communication is often deployed to improve communication between utilities and customers. This smart grid project successfully incorporated two-way communication way between the utility and electricity customers. Although the purpose of the communication channel is to transmit demand response signals (price, reliability), it is also a good reference for transmitting other information (like EV charging, distributed generation) between utility and customers.

The project used the public Internet for data communication, which is different from the existing private network based data acquisition and control system of State Grid. The successful implementation of an Internet-based demand response system with high cyber security demonstrates the potential of leveraging the Internet, which is low-cost and reliable, to transmit information between utility and customers.

The “Service Provider” concept derived from the project gives a new view to Chinese government and utilities about power industry infrastructure reforming and how to supply electrical power to customers better.

7.6.2 Market-Oriented Reform

One potential source of market-oriented reform associated with DR programs is market-based pricing of electricity. Currently in China, as throughout much of the world, electricity rates are rarely tied to electricity generation costs. Mismatched pricing sends mistaken signals to customers, resulting in inefficient electricity generation and use. By promoting a stronger market connection between generation and electricity rates, utilities, generators, and customers can all benefit.

Besides electricity pricing reform, additional market reform potential lies in revising the connection between electricity sales and revenue. Because of inherent conflicts of interest between electricity reduction efforts and utilities, which are compensated through kWh sales, DR and energy efficiency initiatives are often not promoted by the market. New policies and reorganized revenue incentives are needed to help ensure maximum participation.

7.6.3 Human Capacity Building

While a number of DR pilot projects have occurred throughout China, the potential for human capacity building, at both the individual and societal level, associated with large-scale program implementation is great.

At the individual level, an increase in access to energy information can educate customers to be more aware of their consumption. Smart grid and DR systems allow consumers to participate in energy reduction and savings plans and increase awareness about energy availability. This information helps to create a more informed consumer and engaged public citizen.

At the societal level, the implementation of DR programs has been shown to spur energy efficient technology development within the market. Creating a market for DR programs can have lasting impacts on the technology sector. Additionally, instituting DR programs encourages complementary policy and regulatory development, which may open up the market to innovation. In this way, DR is a valuable stepping stone to further energy awareness and energy efficiency improvements.

7.6.4 Technology Transfer and Productivity Enhancement

This project, which adopts the latest IT technology, is the first automated demand response pilot in China. The standards-based communication protocol used by this pilot is OpenADR. Globally, OpenADR is used in a number of demand response programs and is in the formal standards-making process in several countries. This project promotes the application of OpenADR in China.

The total power industry is regulated in China, which is different from the US and other countries. For better application in China, the technology used in this project can be revised to meet specific local requirements as follows.

- DRAS Local Hosting. According to government and utility policy, user power consumption data is not allowed outside China; therefore, the DRAS is hosted locally. [Off-line status of Gateway has nothing to do with the hosting environment.]
- Chinese language support. All systems in Chinese utilities have Chinese language interfaces. Chinese language support is a prerequisite for deployment in China.
- Integration with other utility information and control systems. In the pilot project, events are issued manually by operators through Internet Explorer. To make the system fully “automatic,” it is more convenient for operators for events to be issued by the existing EMS/DMS system in utilities; this system will need integration DRAS and other information and control system. [NOTE: the DRAS automatically implements the DR event. The initiation of a DR event can be automated via a web-services interface.]
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8 U.S. Sources of Supply for Automated Demand Response Technology

This section presents information about U.S. sources of supply for automated demand response technology and a prominent industry organization that is promoting the technology.

8.1 OpenADR Alliance

Over the past few years, demand-side management standards activity has centered on promoting increased use of automated demand response (DR). The most prominent demand response standard in the United States and internationally is the OpenADR 1.0 standard, led by Lawrence Berkeley National Laboratory (LBNL) since 2002. More recently, an effort is underway to enhance and extend the original OpenADR capability. This new effort, OpenADR 2.0, is driven by a large group of utility, customer, and vendor stakeholders. Section 2 of this report presents an overview of the progress of the key demand response standards.

The OpenADR Alliance is a nonprofit corporation created to foster the development, adoption, and compliance of the OpenADR 2.0 standard (based on the EI specification) through collaboration, education, training, testing, and certification. The Alliance is promoting the worldwide acceptance of OpenADR 2.0 for price- and reliability-based demand response.

8.2 U. S. Sources of Supply for Automated Demand Response Technology

The OpenADR Alliance currently includes more than 30 utility, nonprofit, government, and corporate organizations. The work of the Alliance can be followed by visiting its website [OpenADR Alliance]. Members of this organization are the best source of technology solutions for automated demand response.

8.2.1 U.S. Sources of Supply

Information about U.S. suppliers for OpenADR products and services is included in a recent whitepaper report published by the Electric Power Research Institute (EPRI). EPRI's "Automated Demand Response Today" whitepaper lists these suppliers on page 9 of that report [EPRI 1025008]. Information about OpenADR suppliers can be found at the OpenADR Alliance website.

The project team has compiled a list of U.S. Sources of Supply, which is presented in Table 8-1.

8.2.2 China Requirements and U.S. Sources Level of Service

To implement an identical system in China, the use of OpenADR in the enterprise software application (e.g., the DRAS) is essential. As reported by the OpenADR Alliance as of 31 October 2012, two U.S. suppliers have received 3rd Party certification that their automated demand response servers are OpenADR compliant. These companies are: (i) IP Keys Technology and (ii) Honeywell.

This compliance is managed by the Open ADR Alliance which "was formed in 2010 by industry stakeholders to build on the foundation of technical activities to support the development, testing, and deployment of commercial OpenADR and facilitate its acceleration and widespread adoption." (http://www.openadr.org/overview) The 3rd Party testing services are provided by Intertek.

Contact details for Intertek are:

Intertek Testing Services NA, Inc.
1365 Adams Court
Menlo Park, CA 94025
T: +1 650 463 2900
F: +1 650 463 2910

Table 8-1. U.S. Sources of Supply

Company Name	Address	Website	Contact	DR Software Application Provider	DR Hardware Provider Commercial / Industrial	DR Hardware Provider Residential
Comverge	Comverge Georgia (Headquarters) 5390 Triangle Parkway, Suite 300 Norcross, GA 30092 (888) 565-5525 Fax: (770) 696-7665	http://www.comverge.com	R. Blake Young, President and CEO	Yes	No	Yes
ECS	Energy Curtailment Specialists, Inc. 4455 Genesee St, Building 6 Buffalo, NY 14225 Toll free phone: 877.711.5453 Toll free fax: 877.711.0506 Email: info@ecsgrid.com	http://www.ecsgrid.com	Jim Korczykowski, President and CEO	Yes	Yes	No
EnerNOC	EnerNOC 101 Federal Street, Suite 1100 Boston, MA 02110 Office 617.224.9900 Fax 617.224.9910	http://www.enernoc.com	Tim Healy CEO and Chairman	Yes	Yes	No
IPKeys	IPKeys 1 Industrial Way West Building E, Suites G & H Eatontown, New Jersey 07724 Main: 855-475-3970 Local: 732-389-8112 Fax: 732-389-8149 Email: info@ipkeys.com	http://www.ipkeys.com	Lanfen C. Nawy CEO	Yes	Yes	No

Company Name	Address	Website	Contact	DR Software Application Provider	DR Hardware Provider Commercial / Industrial	DR Hardware Provider Residential
Honeywell	Honeywell 1985 Douglas Drive Golden Valley, MN 55422 (415) 256-2582 General Information: https://buildingsolutions.honeywell.com/hbscdms/smartgrid/Contact.aspx	https://buildingsolutions.honeywell.com/hbscdms/smartgrid	Justin McCurnin Marketing, Director	Yes	Yes	Yes
Viridity Energy	Viridity Energy, Inc. 1801 Market Street Suite 2701 Philadelphia PA 19103 Phone: 484.534.2222 Fax: 215.564.3842 General Info: info@viridityenergy.com	http://viridityenergy.com	Audrey Zibelman Chair, President and CEO	Yes	No	No
Universal Devices	Universal Devices, Inc. 5353 Yarmouth Ave. #209 Encino, CA 91316 Phone 818.631.0333 Fax 818.436.0702	http://sales.universal-devices.com	Don Yarush, President	No	Yes	Yes

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Appendix A. Initial Project Planning Detail

This appendix presents more detail of preliminary site selection, initial milestones, schedules, manpower plan, and data requirements.

A.1 Preliminary Site Selection

The candidate demonstration sites are listed below. An overview of the commercial building sites is presented in Table App-1. The locations of the commercial building sites are shown in Source: HON/TEDA

Figure App- 1. An overview of the industrial sites is presented in Table App-2. The TEDA electric utility tariffs are shown in Table App-3.

Note: The TEDA Administration Building and the TEDA Library were selected as commercial building field sites for the ADR demonstration, as described in Section 4. A different industrial site (Kumho Tire) was ultimately selected for the demonstration, as described in the Section 4.

Candidate Commercial Sites	Candidate Industrial Sites
• TEDA West Financial Building • TEDA Administration Building • TEDA Library	• Holding Corp.Tianjin Faw Toyota Motor Co., Ltd. • Vishay General Semiconductor (China) Co., Ltd. • Tingyi (Cayman Islands)

Table App-1. Commercial Building Sites Overview

I. Builing Related Info				
1	Building Name	**Administration Bldg**	**Library +Document Bldg**	**West Financial Bldg**
2	Total Fl Space	60k sq. meters	66k sq. meters	120k sq. meters
3	Building Floors	3 buildings block	2 buildings, 5 floor/12 floor	11 floor
5	Year of Completion	1997	2003	2003~2005
6	Occupency Rate	100%	98%	95%
	HAVC coverage	100%	100%	100%
7	Number of people working at the site	1000	3000 (visitors)+700	3000
II. Power Utilization Info				
8	High/Low peak load in 2011	High: 1.8MW Low: 1.1Mw	high: 1.5MW, Low 0.8kw	Peak total 5 MW, but we will take a small portion of it, less than 1.0MW
9	transformer capacity utilization rate	60% peak time	70% peak time	80% peak time
10	Number of main utility meters	2 Main Meters	3 Main Meters	4 Main Meters
11	If there is over one year utility/tariff data	Yes	Yes	Yes
12	Submeters?	Yes, around 60	No	Phase I: 100, Phase II: 200
III. Building Related Systems				
13	Centralized or de-centralized HAVC?	Central HAVC	Central HAVC	Central HAVC
14	Chillers & Capacities	3 York Chillers, 700 RT*2, 400RT*1	4 York Chillers 500RT*4	7 Chillers 750RT*4，350RT*3
15	AHU controls	Central Controlled	Central Controlled	Central Controlled, VSD
16	Heating approach	Steam supplied outside	Steam supplied outside	Steam supplied outside
17	BA System	Yes, Honeywell EBI	Yes, Honeywell EBI	Yes, Honeywell EBI
18	If BA controls A/C?	EBI Controls A/C	EBI Controls A/C	EBI Controls A/C
19	Central controlled lighting areas	Public Area Centralized	Public area, centralized	Public area, centralized
20	Number of Elevators	14	10	18

Source: HON/TEDA

Figure App- 1. Commercial Building Sites

Table App-2. Industrial Sites Overview

Automated Demand Response - Site Survey for Industrial Customers 智能电网需求侧自动响应系统 - 工业用户现场调查表			
调查企业 Company / 调查项目 Site Survey Item	天津一汽丰田汽车有限公司 TIANJIN FAW TOYOTA MOTOR CO., LTD	威世通用半导体(中国)有限公司 VISHAY GENERAL SEMICONDUCTOR (CHINA) CO., LTD	康师傅控股有限公司 TINGYI (CAYMAN ISLANDS) HOLDING CORP.
现场地址 Site Survey Address	天津经济技术开发区 第九大街81号	天津经济技术开发区 第六大街88号	天津经济技术开发区 第三大街15号
工业领域/产品 Industrial Sector	6款丰田汽车 6 Types Of Cars	半导体行业，半导体，塑封二极管，桥式整流器及表面贴装功率整流器，Semi-conductor industry; plastic diodes, bridge rectifiers and surface mount power rectifiers	食品加工行业，各种方便面 Various kinds of Instant noodles
主要生产设备 Primary Production Equipment	汽车生产，冲压、焊装、油漆、总装 stamping, welding, painting, assembling equipment	烧结、加热炉，铸膜，电镀等 Heating furnances, casting, electro-plating	全自动方便面生产线 Instant noodle production
企业人数 # of Employees	8000多人 more than 8000	2300人左右 About 2300	6000多人 more than 6000
生产时间和班制 Hours of Operation # of Shifts	24小时/days，2班制 17:30-20:30是换班停歇时间 two shifts in 24hrs, shift change time: 17:30-20:30 each day	24小时/7days，2班制 7/24, 2 shifts	24小时，2班制 7/24, 2shifts
用电量百分比 Approximate Breakdown of kW % load	电费占整个能源费用50%-60%，其中生产设备占总电费的70%；原动力(空压机制冷机等)占15%；照明及办公占15%。平均每月电费约为1000多万元 Electricity occupies 50~60% of total energy consumed, among which 70% is from production, HAVC 15%, lighting 15%; everage monthly electricity utility bill over 1.5m USD	电费约为2500-2600万元/年。生产设备：45% 辅助动力、照明及办公：55%（其中主要为空压机、空调、照明用电）Electric utility bill is around 4million USD; among which 45% is from production, 55% from auxillary power supply, lighting & office usage (mainly are for A/C, air compressors, lighting)	生产设备：50% 辅助设备、照明及办公：50% Production: 50% Auxilary equipment, lighting & office: 50%
全年负荷情况 Annual Load	负荷容量：80KVA，实际使用约50%; 7-8月是办公空调用电高峰 生产用电与产量有关 10月到来年2月为用电低谷	生产设备全年负荷相对比较均匀，负荷容量比较大，没有拉负荷的情况	最高在冬季(~11000kVA)，最低在夏季(~6000kVA)
变压器 Transformer	二路 35KVA, two 35KVA circuits	三路 35KVA three 35KVA circuits 夏季负载在40%左右 in summar time, 40% of loading	二路 10KVA two 35KVA circuits
生产设备 Process Equipment	38kW以上的用电生产设备都加了变频 Have VSD added above 38KW motors	用电量多的生产设备为：加热炉、电镀线、覆膜机，老化试验设备 High electricity consumption: heating furnance, electro-plating, laminating machines, fatigue test equipment	用电生产设备都是变频的, all electric motors have VSD.
压缩机 Compressors	压缩机9台，其中640kW/台 9 units, each 640kW	7台，有一台可以中央调节 7 units, one of them can be centrally controlled	75kW压缩机5-6台，可联机控制，控制系统为英格索兰 75KW*5~6, centrally controlled, the control systems are from EngersollRand
制冷机 Chillers	8台溴化锂机组 8 sets of Lithium Bromide Sets	制冷机组5台，分别为1300冷吨1台,1250冷吨1台,420冷吨2台,270冷吨1台。品牌:特灵Trane。只监不控，现场手动操作。冬季有Free Cooling。5 Trane Chillers, 1300RT*1, 1250RT*1, 420RT*2, 270RT*1.	105~260冷吨制冷机组11台。品牌：开利Carrier 11 units of 105-260 RT Chillers, supplier: Carrier
空气处理机组 Air Handling Units	50kW 空气处理机组90多台 用于车间环境温度控制，可以适当调节，电机都配有VFD，平均运行在35HZ Over 90 units of 50kw AHUs used for workshop temp. control, can be modulated, the motors all have VSD, on average running at 35HZ	5.5kW空气处理机组50-60台 75kW带新风的机组8台(配有VSD) 空调温度可以调节，与工艺没有特别大的影响 50-60 units of 5.5kw AHU, 8 units of 75kw AHU (VSD), A/C temp can be adjusted, not much impact for mfg	AHU及PHU不是变频的 AHU/PHU not VSDed
泵 Pumps	都是变频泵 All Pumps use VSD	都是变频泵，可以通过中央控制系统调节, 变频60%~80%范围 All VSD, can be controlled centrally, VSD range: 60%~80%	39台各式泵，大的全部变频 39 various pumps, major ones are all VSDed
照明 Lighting	灯光都是本地开关控制，无灯控系统 local lighting controls	灯光都是本地开关控制，无灯控系统，7000-8000只灯管 Local lighting controls, not centralized, 7000~8000 tubes	灯光都是本地开关控制，无灯控系统，准备更换为LED灯 Local lighting controls, not centralized, plan to use LED
分电表安装情况 Sub-Meter Installed	没有None	已安装很多分电表 Installed many submeters	已安装400-500块电表 每台压缩机，空调机，泵都有自己的表 Installed 400~500 submeters to every chillers, compressosr, pumps, key motors

Table App-3. TEDA Electricity Tariff Data

Electric Power Sales Prices - TEDA East Area						
Unit：RMB/KW.h						
Power Factor	>0.90	0.89-0.80	0.79-0.70	0.69-0.60	<0.60	Transformer Capacity Price
380V , 3 shifts	0.7603	0.7653	0.7703	0.7753	0.7803	
380V, 1 shift	0.7703	0.7753	0.7803	0.7853	0.7903	
10kV,35kV, 3 shifts	0.6643	0.6693	0.6743	0.6993	0.7243	17Rmb/KVA/ Month
10kV,35kV, 1 shift	0.6843	0.6893	0.6943	0.7193	0.7443	
Construction Power Usage			0.9003			
Big Commercial Bldg, office Lighting			0.7683			
Small Commercial Bldg , Office, Lighting				0.7883		
Families				0.49		

Peak-Valley Electric Power Prices						
Unit：RMB/KW.h						
Industrial Tariff	Voltage Level	Critical Peak price	Peak Price	Peak Flat Price	Peak Valley Price	Transformer Capacity Price
	< 1k Volts	1.2978	1.1798	0.7703	0.3828	
	1 to 10k Volts	1.0173	0.9248	0.6493	0.3918	
	>=35k Volts	1.0151	0.9228	0.6473	0.3898	17Rmb/KVA/ Month
Large commercial/office building Lighting If transformer capacity is equial or larger than 100KVA			1.1808	0.7683	0.3768	

A.2 Timeline for ADR Demonstration

The project team worked closely with TEDA and CEPRI to define the timeline for the ADR demonstration at the selected TEDA sites. The key elements of the pilot implementation timeline are shown in Table App-4.

Table App-4. Field Demonstration Implementation Timeline

T4 Pilot Project Implementation	**试点项目实施**	**Key Timing**
Site Survey/Building Selection	现场调查/楼宇选择	
Long Lead Items Purchasing (JACE)	长周期项目采购	**Dec. 20, 2011**
Selected Building Auditing	楼宇需求响应审核	
Shed Strategy Formation/SOW	楼宇需求响应策略形成/工作内容	
Building Owner Discussions/agreements	业主讨论与协议签署	
Admin Bldg Install (Jace, cable, interfaces…)	管委会大楼安装	
U.S. DRAS Config	美国加州服务器设置	
Commissioning, Testing Verification-Adm. Bldg -U.S. DRAS	管委会大楼调试、相应策略验证	**March 15, 2012**
China ADR Kit Preparation	中国ADR 服务器系统准备	
BOM list generation	*清单准备*	
Purchasing/install	*采购/安装*	
DRAS Configration	*服务器配置*	
Shipment to China	*运输到中国*	
China ADR Kit Installation/commissioning	*系统在中国的安装调试*	
Other building installations	其他建筑的系统安装	
Commissioning, Testing Verification- Other Buldings	系统调试	
3 commercial bldgs start to run	商用建筑需求响应系统开始运行	**June 06, 2012**
Commercial Bldgs in ADR operation & data collection	商用建筑需求响应系统运行与数据采集	
Industrial plant Demo	工业企业需求响应示范	
plant selection	*生产企业选择*	
Plant Survery Audit	*现场调研与审计*	
Plant Shed stragegy formation	*企业用电需求响应策略制定*	
Plant ADR system installation	*企业需求响应系统安装*	
Plant ADR commissioning, testing verrfication	*企业需求响应系统调试*	
Plant ADR start to run	*企业需求响应系统开始运行*	**June 06, 2012**
Plant ADR in operation and data collection	*企业需求响应系统运行与数据采集*	
Solicit feedback from SG EPRI	获得国网电科院的反馈与同意	
Submit Task 4	提交任务4	**July 31, 2012**

A.3 Key Milestones

The key milestones of the project are shown in Table App-5.

Table App-5. Project Milestones

Milestone	Date
Project Kick-off Meeting with TEDA	January 5, 2012
Task 1 completion	January 30, 2012
Task 2 completion	February 28, 2012
Task 2 Roundtable Meeting	March 15, 2012
Task 3 completion	March 15, 2012
Task 4 completion	July 31, 2012
Task 5 completion	July 31, 2012
Task 6 completion	July 31, 2012
Task 7 completion	July 31, 2012
Task 8 completion	April 5, 2012
Task 9 completion	August 25, 2012
Draft Report Presentation	August 30, 2012
Task 10 completion	September 21, 2012
Final Roundtable Meeting	September 21, 2012

A.4 Detailed Project Schedule

A detailed project schedule is shown in Figure App- 2 (next page). This schedule shows the key elements of the various project tasks.

A.5 Manpower Plan

The time commitments for the key personnel on the project are shown in Table App-6. Time commitments include both USTDA funding and project team cost share funding.

Table App-6. Manpower Plan

Team Member	Key Technical Resources	man days
Honeywell	Jack Wu	180
	Jason Lo	40
	Kathy Jiang Jianming	60
	Wenxiao Ma	176
	Jay Sparling	25
	Steve Gabel	95
AECOM	Chris Yoshii	15
	Donald Johnson	23
	Anita Roth	136
	Other non-USA staff	62
Akuacom	Paul Lipkin	30
	Lin Wang	75
	Thorsten Bach	45

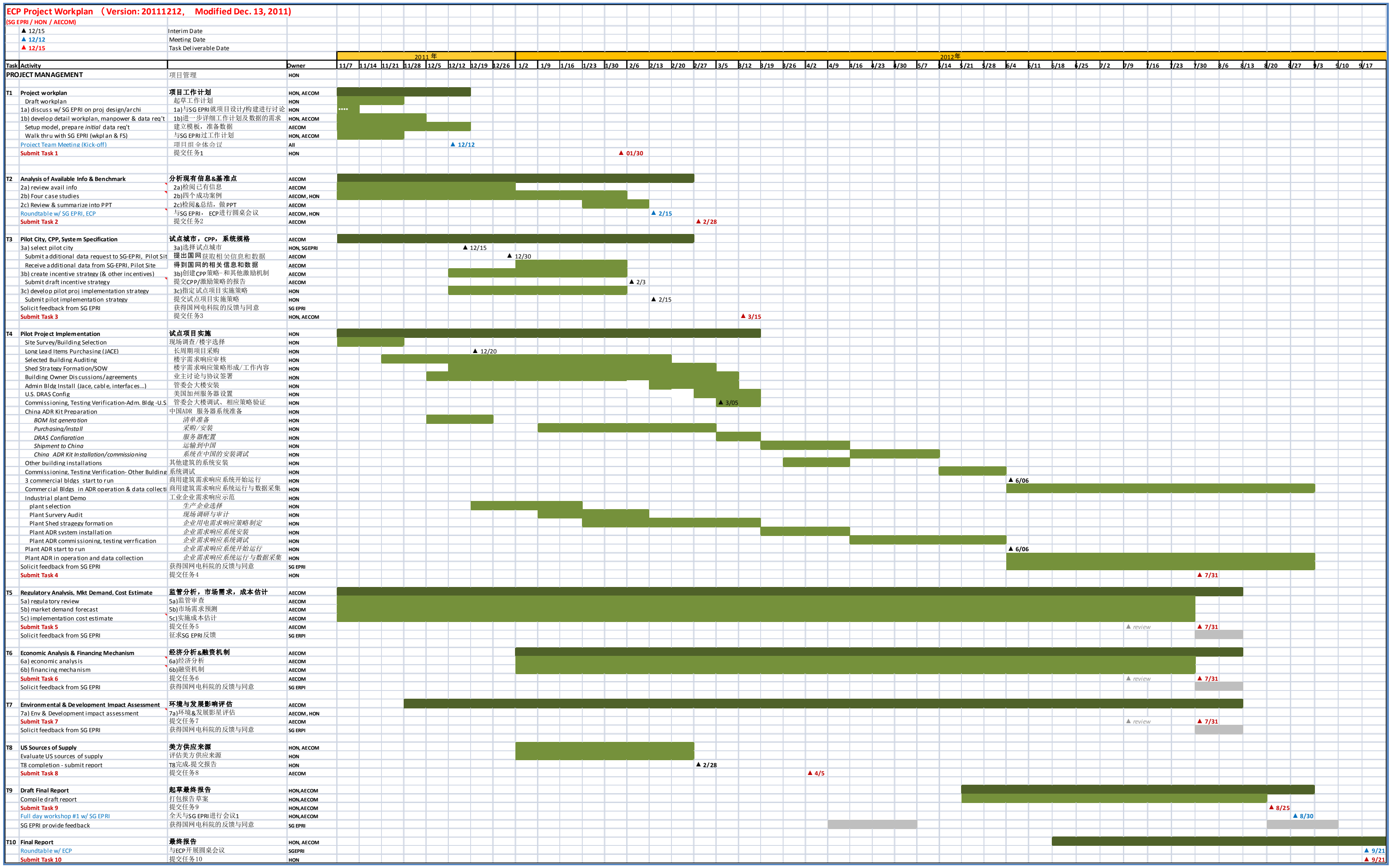

Figure App- 2. Project Schedule

A.6 Data Requirements

The key data and information required to perform the project are shown in Table App-7.. The project team is currently working with CEPRI, TEDA, and others to acquire these data items.

Table App-7. Key Data Requirements

		Requested Data						
							■	Honeywell
			A	C	D		■	AECOM
			TEDA	Tianjin City	China		■	= 需求/ State Grid/Pilot City
1		**Population (1990-2010)**	■	■	■		✓	= received
2		**Land Use Data**						
	a	# of Households	■	■	■			
	b	# of Commercial buildings (by size?)	■	■	■			
	c	# of Industrial Buildings (by industry)	■	■	■			
3		**Electricity Consumption (1990-2010)**						
	a	Consumption by user group (residential, commerical, industrial)	■	■	■			
	b	Electricity Demand by time of day	■	■	■			
4		**Current Electricity Pricing**	■	■	■			
5		**Power Sector**						
	a	Current Investment in generation	■	■	■			
	b	Current generation capacity	■	■	■			
	c	Projected investment	■	■	■			
	d	Projected generation capacity/demand	■	■	■			
6		**Current status of Energy Service Companies (ESCOs) in China**		■	■	Honeywell, AECOM, State Grid		
7		**Relevant policies and regulations affecting SG/DR**		■	■	SG to help identify policies that are most relevant		
8		**System Costs**						
	a	Hardware and Software System Components		■	■			
	b	Expected labor costs		■	■	* Note whether there are variable prices depending on location		
	c	System Logistics costs		■	■	* Note whether there are variable prices depending on location		
	d	System Insurance costs		■	■			
	e	Tax costs		■	■			

		需要的数据					■	Honeywell
			A	C	D		■	AECOM
			泰达	天津市	中国		■	= 需求/ State Grid
1		**人口 (1990-2010)**	■	■	■		✓	= 已收到
2		**土地利用数据**						
	a	#家庭	■	■	■			
	b	#商业用地	■	■	■			
	c	#工业用地	■	■	■			
3		电力消费 (1990-2010)						
	a	各类型用户的电力消费（住宅、商业、工业）	■	■	■			
	b	每日各时段的电力需求	■	■	■			
4		**当前电价**	■	■	■			
5		电力部门						
	a	目前对发电的投资	■	■	■			
	b	目前发电能力	■	■	■			
	c	预期投资	■	■	■			
	d	预期发电能力/需求	■	■	■			
6		**中国能源服务公司(ESCOs)现状**		■	■	Honeywell, AECOM, State Grid		
7		**影响智能电网/需求响应系统的相关政策法规**		■	■	SG to help identify policies that are most relevant		
8		**系统成本**						
	a	Hardware and Software System Components		■	■	* Note whether there are variable prices depending on location		
	b	预期劳动成本		■	■			
	c	系统物流成本		■	■			
	d	系统保险费用		■	■			
	e	税费		■	■			

Appendix B. International Case Studies

This Appendix presents the results of the international demand response case studies. Each of the case studies reviews a different demand response approach: automated demand response (PG&E), two different demand response program packages (SCE, OPA), and an alternative demand response program focusing on local energy generation (UK National Grid). Additionally, two of the utilities reviewed (PG&E, SCE) also include an overview of the larger smart grid programs that the utilities have implemented. The remaining two utilities (OPA, UK National Grid) have not been directly involved in smart grid system implementation.

Table App-8. Comparison between China and California Energy Sector Structures

	China	California
System Planning		
System planning entity:	• **Utilities**(State Grid and China South Grid)propose • **National Development and Reform Commission** (NDRC) approves.	**California Independent System Operation** (CAISO)
Generation		
Entity responsible for generation:	• 5 big power generation groups (as of 2000 Plant-Grid Separation reform)	• Independent Power Producers • Partial generation by utilities,
Wholesale electricity prices set by:	• Set by **NDRC** • Prices for some renewables have government-set fees	• Long-term generation agreements • Day-ahead auction • Price cap on acceptable cost
Wholesale rates regulated / deregulated	• Totally regulated, only very few pilot sites for big users purchase directly from generator groups • Fees for some renewables are regulated by government law	• Wholesale prices are deregulated (1998) • Wholesale market, however, is regulated by **FERC** for interstate sales, and **CAISO** for intra-state sales
Transmission		
Entity responsible for transmission:	State Grid and its 5 regional subsidiaries; China Southern Power Grid Corporation	Local utilities (PG&E, SCE, SDG&E)
Retail Electricity Rates		
Electricity rates set by:	• **National Development and Reform Commission** (NDRC)	• **California Public Utilities Commission** (CPUC) and **Federal Energy Regulatory Commission** (FERC) • Utilities may slightly adjust prices 2-3 times per year, any major rate recommendations must be approved by CPUC.
Retail rates regulated / deregulated	• Retail market remains regulated	• Retail market remains regulated
Local utility characteristics		
Public or private utility:	State-owned utility	Private utility
Perfect competition / monopoly	Regional monopoly	Regional monopoly
Utility responsibilities:	• Transmission and distribution of energy • Purchasing energy from generation groups	• Transmission and distribution of energy • Purchasing energy from wholesale market
Utility profit determined by:	• Profit based on amount of electricity sold	• Profit and amount of electricity volume sold are decoupled at the utility level. • Utilities also receive incentives to encourage energy efficiency, conservation, and renewable energy integration.

B.1 Pacific Gas & Electric (PG&E) – Auto-DR Program

B.1.1 Project Overview

Pacific Electric & Gas (PG&E) is one of California's three utility providers and has long been a pioneer in the United States in implementing smart grid technology. With a service area of over 18 million hectares and 15 million people, PG&E handles transmission and distribution to more than five million unique accounts. Of these, 88% (4.5 million) are residential and 12% (0.6 million) are commercial, industrial, and other.

PG&E has approached smart grid deployment as a way to manage power demand through energy efficiency, demand response, and integration of renewable energy resources. Between 2007 and the present, PG&E has installed more than eight million smart meters within the residential, commercial, and industrial sectors—1 meter for every 1.9 persons in the coverage area. To date, it is the largest smart grid and smart meter program in the United States.

The smart grid programs at PG&E have been heavily supported by statewide policies and business mandates encourage an efficient electricity market and investment in energy reduction strategies. In *PG&E's Smart Grid Deployment Plan: 2011-2020*, the utility company identifies engaged consumers, efficient energy markets, and enabling energy infrastructure and technology systems as the three fundamental components of its successful program.

In addition to infrastructure investment, PG&E has worked to develop almost 30 separate programs that allow customers to manage their energy use, increase their energy efficiency and reduce energy-related costs. Such programs and the accompanying customer education have been important components of PG&E's success. The programs include demand-response and auto-demand-response initiatives, time-of-use (TOU) pricing, peak day pricing, base interruptible programs, demand bidding, permanent load shifting, solar panel installation, energy alert access to energy use data, energy efficiency education, and home energy audits and reports, among others. The programs allow customers to participate in energy reduction and management in a variety of ways. By 2010, the entire suite of demand response programs was responsible for a 692MW load reduction [PGEA].

The company has developed the Automated Demand Response (Auto-DR) program as a key piece of PG&E's smart grid initiative. The program is primarily available to larger commercial, industrial, and agricultural customers. It is open to customers with greater than 200 kW load demand who also participate in one of PG&E's load-shedding, demand-response efforts (PeakChoice, Peak Day Pricing, Demand Bidding, Capacity Bidding) [AutoDR]. Through the program, customers design and program their own electricity reduction strategies into *energy management control systems*. The control system then responds to peak load signals from PG&E, automatically enacting the reduction strategy at the participant's site. By automating a building's response to an energy signal, PG&E has been able to increase the reliability of its demand response program. The programs are fully voluntary and non-contractual, and customers are not obligated to shed the amount of load they indicate.

According to latest PG&E accounts, the Auto-DR programs result in 60-70MW of peak load reduction. While Auto-DR customers make up only 2% of all DR participants, they account for almost forty percent of actual load shed at any given peak event time. Total peak load reduction potential is estimated around 120MW for Auto-DR programs. However, due to fluctuation in the number of participants, this reduction is rarely achieved.

Table App-9. PG&E's Auto-DR Eligible Load-Shedding Programs for Large Businesses

Program	Customer Eligibility	Participants 2011	2011 Peak Event Load Reduction	Process and Incentive
Peak Choice	• Commercial, industrial, agricultural businesses • Enrolled in TOU plan • Able to reduce >10kW • Have remotely-readable meter (installed at no cost if usage >200kW)	~300 of 100,800 eligible (0.3%)	5-15 MW	• Both voluntary and mandatory participation • Flexible time, reduction, and advance notice options • For voluntary ("best-effort") participants, rebates range from US$0.40-$1.00/kWh, depending on advance notice • For mandatory ("committed") participants, rebates range from US$4.00-$10.00/kWh, depending on advance notice and program agreement multipliers
Peak Day Pricing	Commercial, industrial, agricultural businesses	~2,000 of 161,000 eligible (0.1%)	25-55 MW	Increased pricing between 2-6pm, weekdays
Demand Bidding	• Customers who can commit to reduce >50kW during an event • Must have 15 minute interval meters	~1,000; of 10,200 eligible (10%)	45-65 MW	Participants bid on available reduction capacity in day-ahead notices in exchange for incentives; Incentives range from US$0.5-0.6 /kWh of actual reduced load
Capacity Bidding	• PG&E bundled-service and a commercial, industrial, or agricultural Direct Access customers • Customers not enrolled in any demand-response program (except Optional Bidding Mandatory Curtailment (OBMC) or Pilot OBMC)			• Receive a monthly incentive to reduce energy use to a pre-determined amount once an electric-resource generation facility reaches or exceeds heat rates of 15,000 Btu per kWh. • Load reduction commitment is on a month-by-month basis, with nominations made 5 days prior to the beginning of each month. • Customers must enroll with (or as) a third-party aggregator to join the Capacity Bidding Program.

Source: PG&E Auto-DR program websites; "Pacific Gas and Electric Company Monthly Report on Interruptible Load and Demand Response Programs for December 2011," PG&E, 23 January, 2012.

As of 2009, ten primary industries were participating in the Auto-DR program. The three largest industry groups represented were food processing (32 percent), government (20 percent), and high tech industries (17 percent). However, while industrial process industries accounted for less than 4 percent of participants, they contributed over 54 percent of the load reduction [BravoC].

B.1.2 Overview of Current Technologies and Systems Used

The DRAS architecture model (see Figure App- 3) is a standard Java 2 Enterprise Edition (J2EE) implementation provided by the JBoss application platform. The standard servlet technologies provided by the embedded Tomcat Web container in the JBoss application server talks to Stateless Enterprise Java Beans (EJBs), which in turn communicate with a MySQL database via Entity Beans. The Web, services, and persistence tiers are deployed into a single container via an enterprise archive (EAR).

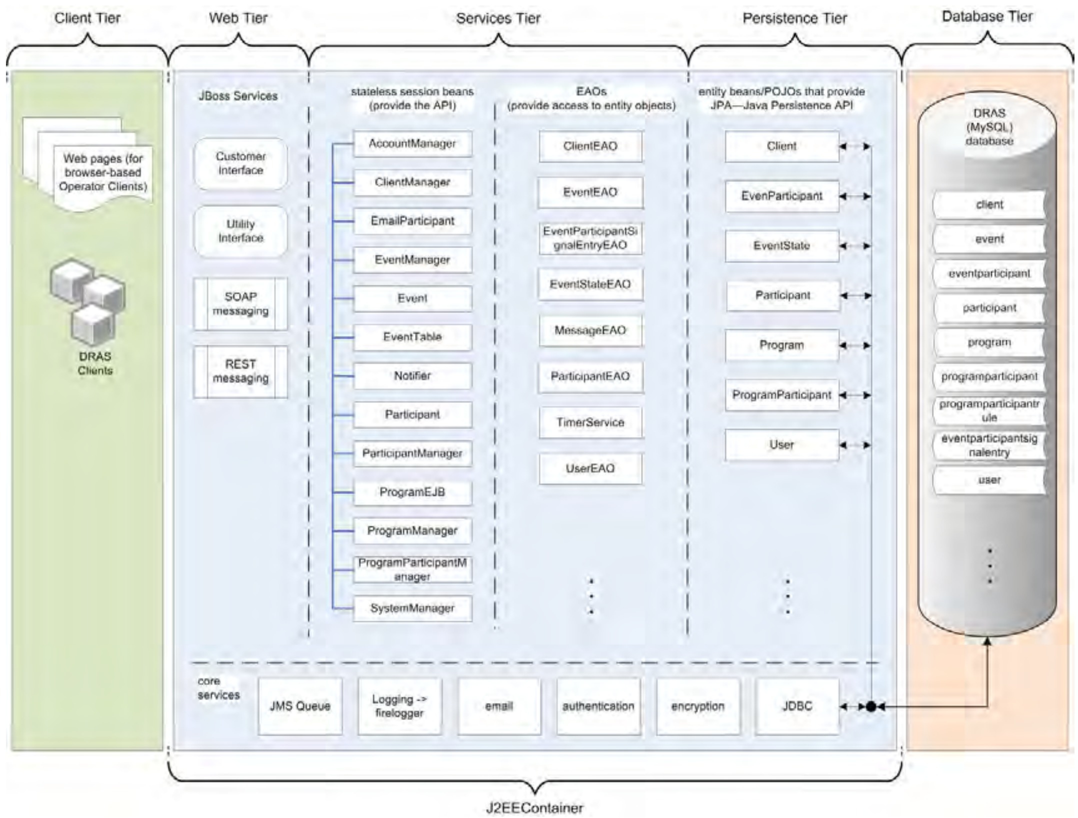

Figure App- 3. DRAS Architecture Model

Figure App- 4. illustrates a typical data flow in which a PG&E Utility Operator can issue a DBP event from the Utility Operator Interface using an HTTP/HTTPS request or from 3rd party tools through OpenADR WebService. The DRAS server then dispatches notifications to all the corresponding contacts to initiate the bidding process. A specific signal will be dispatched to the DRAS client (CLIR) through OpenADR WebService and the corresponding shed will be applied to its BMS system.

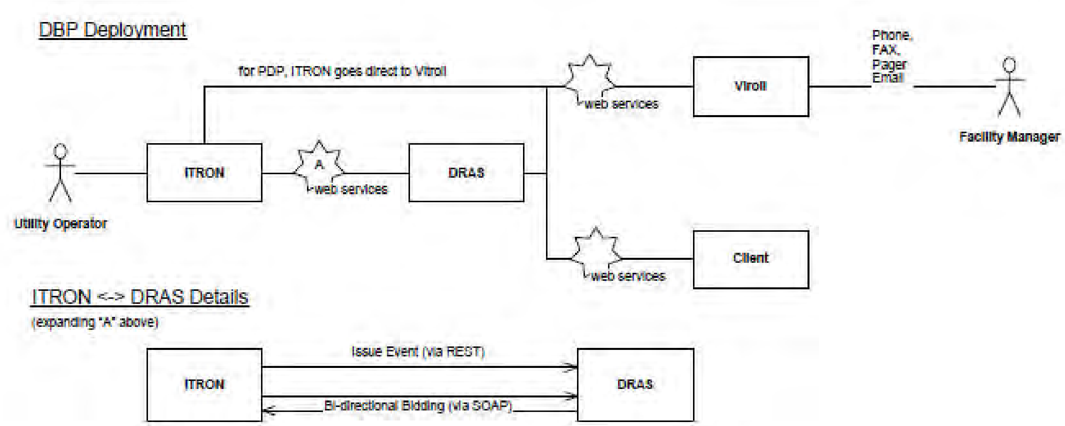

Figure App- 4. DBP Event Data Flow

The physical servers are Dell PowerEdge Servers with Quad Core Xeon 64 bit processors. The storage servers are iSCSI appliances with RAID configuration, dual power supplies, and redundant network connections. The operating system is Red Hat Linux 5 with VMWare Virtualization infrastructure. We have implemented the Web tier with physical servers running Apache 2.2. A Checkpoint firewall and a separate internal network are installed between the web servers and the application server. The application server utilizes Jboss 5.1.0 J2EE Application Server and a MySQL database server.

All these off-the-shelf components are used within the industry to build secure enterprise applications. We chose this technology set because of its wide implementation in the industry.

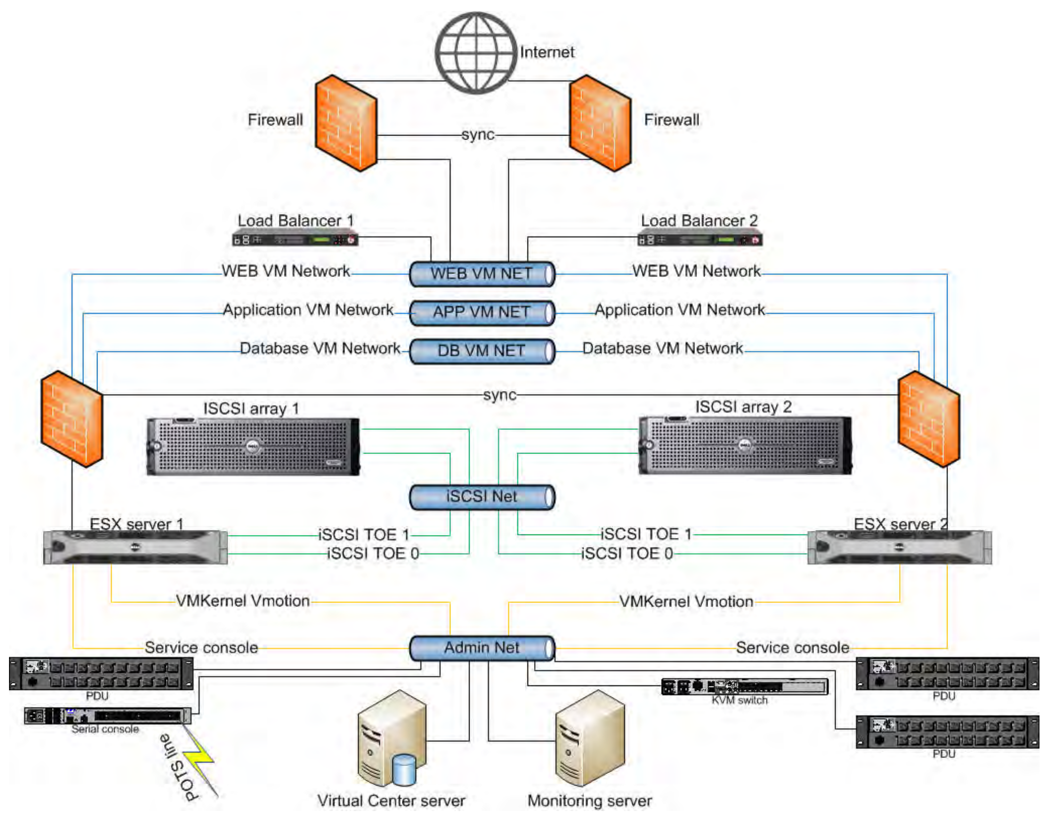

Figure App- 5. DRAS Application Diagram

B.1.3 List of Technology Standards

The DRAS server is built as a web service and utilizes standard components in its architecture.

- J2EE Standard. J2EE defines the standard for platform-independent, web-based, multi-tier enterprise solutions. It extends Java Standard and provides an API for distributed and multi-tier architectures and web services.
  http://java.sun.com/j2ee/overview.html

- REST/SOAP Standard. DRAS provides both REST and SOAP Web Service interfaces to interact with client devices and 3rd party software.
  http://www.w3.org/TR/ws-arch/

- Transport Layer Security/Secure Sockets Layer (TLS/SSL)
  DRAS data communication between the various clients and server is protected with the TLS/SSL protocol. Symmetric cryptography is used for data encryption (e.g., DES [DES], RC4 [SCH], etc.). Message transport includes a message integrity check using a keyed MAC. Secure hash functions (e.g., SHA, MD5, etc.) are used for MAC computations.
  http://www.mozilla.org/projects/security/pki/nss/ssl/

- Simple Mail Transfer Protocol/Internet Message Access Protocol (SMTP/IMAP). DRAS supports SMTP and IMAP protocols for email communication.
  http://www.ietf.org/

- OpenADR Standard. OpenADR was developed by Lawrence Berkeley National Laboratories (LBNL) Demand Response Research Center to enable the automation of end-use control for the purposes of Demand Response. The original OpenADR specification was published by the California Energy Commission.
  http://openadr.lbl.gov/

- Inter-control Center Communications Protocol (ICCP). DRAS communicates with a third party Automatic Generation Control (AGC) system through ICCP protocol.

  http://www.osii.com/pdf/scada-ui/OpenICCP_PS.pdf

B.1.4 Installation Incentives

PG&E provides a number of incentives to its qualifying customers to encourage participation in the Auto-DR program. PG&E provides low or no-cost technical support and an energy audit. Companies also receive a one-time incentive of US$250 per kW load shed in order to install supporting automated metering infrastructure (AMI). These installation and support incentives are in addition to the event participation incentives offered. The company estimates that since 2006, participating companies have received over US$100 million in incentives [PGEDR]. In 2011 alone, participating Auto-DR customers earned almost US$5.3 million in incentive revenues [PGEDec].

For its Auto-DR programs, PG&E has aimed to ensure that participating customers bear little additional cost apart from what is embedded in the general rate case. In recent calculations, PG&E estimates that after the incentives have been accounted for, large participating customers reflect a net financial gain.

B.1.5 Financing Mechanisms

PG&E has been investing in its smart grid system and Auto-DR programs for more than a decade. While investment began in the form of short-term pilot projects, PG&E now has smart grid plans through the next twenty years as well as state-driven mandates to include demand response programs in the utility's capital planning.

The smart grid and demand response programs that PG&E has implemented over the years have had two primary sources of funding: the government and ratepayers. In California, the California Public Utilities Commission (CPUC) is the governing body that has both rate-making authority and can determine which cost recovery mechanisms utilities may use for their programs.

For the smart grid, PG&E has received roughly fifty percent of its funding from government sources and fifty percent from its ratepayers. Because demand response programs constitute a special infrastructure case, PG&E has been authorized to recover one hundred percent of its expected implementation costs from its ratepayers. In order to recover infrastructure and implementation investment costs from its customers, PG&E must submit detailed funding applications every three years to the California Public Utilities Commission (CPUC) The CPUC is the state's regulatory agency that oversees all privately owned utility services (electric, gas, telecommunications, water, transportation). As the regulatory agency, the CPUC reviews PG&E's applications and determines how much PG&E is allowed to recover from its customers, and what percentage of profit the utility may include. Typically, CPUC allows PG&E to include a fixed rate of returnbetween 11.2-11.6% for its shareholders. If PG&E spends more than it is allowed to recover, it must reduce profits to shareholders to pay the difference.

For just its smart meters, PG&E expects to spend roughly US$2.2 million, at an average hardware cost of US$100 per meter. While the hardware, software, and O&M costs for DR and Auto-DR programs are significant, PG&E has reported that marketing is an equally important program cost. Because DR and Auto-DR programs require a significant amount of customer attention, PG&E has recognized that marketing spending is directly proportional to program adoption rates.

To counter the high marketing and service costs, PG&E has turned to aggregator companies to pull DR and Auto-DR participants on board. Involving energy aggregators has been a successful way to defer a level of compliance risk, ensure more reliable levels of load reduction, and outsource the customer service activities that the utility is not prepared to handle. As of 2011, 40% of PG&E's demand response load reduction comes from aggregators [Kwan].

B.1.6 Benefits Qualification, Quantification

PG&E demand-response programs for non-residential (commercial and industrial) customers consist of event-based and non-event-based programs. A recent filing with the California Public Utilities Commission (CPUC) states that "PG&E's demand response programs have grown significantly over the last several years and continue to play an increasing operational role. To date, these programs have focused on maintaining system reliability. However, increasing dependence on renewable energy resources, evolving CAISO markets, Smart Grid technologies, and electric vehicles provide increased opportunities for PG&E's demand response programs. PG&E is committed to pursuing these opportunities, which help expand the role and value of demand response, by continuing to support market transformation with its broad portfolio" **[PG&E_app].**

Peak Load and Demand Response

A recent PG&E report states that its DR programs "are an important mechanism to improve transmission and distribution system reliability and avoid building new peaking power plants." The report goes on to state that its DR programs have historically performed very well and "avoided the need for 692 MW of power generation capacity in 2010" **[PG&E_sg]**. For perspective, a recent publication described PG&E's peak recorded system load as 22,554 MW (on July 25, 2006) **[CWEC].** Also, for the most recent calendar year, it was reported that the PG&E peak demand of 19,791 MW occurred on June 21, 2011 **[CAISO_tp]**.

DR Load Impact

California's Energy Action Plan emphasizes the need for demand-response resources that result in cost-effective savings and the creation of standardized measurement and evaluation mechanisms to ensure verifiable savings. The CPUC has defined a set of measurement and evaluation protocols and cost-effectiveness tests for DR, with a focus on estimating DR impacts for long-term resource planning. In 2007, the Commission began this process with two key objectives: **[CPUC_li]**

- Establishing a comprehensive set of protocols for estimating the load impacts of DR resources
- Establishing methodologies to determine the cost-effectiveness of DR resources

A total of 27 protocols are defined for guidance in performing evaluation planning, ex-post evaluations of event-based and non-event based DR programs, ex-ante estimations, aggregated DR portfolios, sampling methods, reporting, and evaluation processes. Each year, by April 1st, each of the large investor-owned utilities in California is required to file load impact evaluations for all of their DR programs

[FSC_ov]. While the protocols don't dictate methodology, standard approaches are rapidly evolving **[FSC_pro].**

PG&E's filing of 2010 DR load impact reports to the CPUC was made in April, 2011. The titles of the load impact reports are:

1. 2010 Load Impact Evaluation of PG&E's Residential Time-Based Pricing Tariffs
2. 2010 Load Impact Evaluation of PG&E's SmartAC Program
3. 2010 Load Impact Evaluation of PG&E's PeakChoice Program for Commercial and Industrial Customers Ex Post and Ex Ante Report
4. 2010 Load Impact Evaluation of PG&E's Permanent Load Shifting Program
5. 2010 Load Impact Evaluation of PG&E's Non-Residential Time-of-Use Rates

Detailed discussions of the 2010 load impacts are presented in these reports, which can be accessed via links contained in the PG&E filing notice **[PG&E_not].** A high-level overview of the load impact estimates for PG&E's DR portfolio can be found in a recent publication **[PG&E_ec].**

Another recently published report provides ex-post and ex-ante load impact estimates for 2010 for PG&E's default critical peak pricing tariff (Peak Day Pricing, or PDP) for large commercial and industrial customers (having a peak demand greater than 200kW) **[CPP_2010].** Other sources of load impact information are also available to the public **[DR_shop].**

DR Cost-Effectiveness

The CPUC has adopted a protocol for estimating the cost-effectiveness of Commission-ordered DR programs. This protocol is used to ensure that DR incentive programs are cost-effective relative to peaking power generation plants (which would otherwise be needed). The protocol was used by the Commission for the first time during the utilities' 2012-2014 DR budget applications in 2011. DR program proposals that are not cost-effective are either rejected by the Commission, or adjusted to ensure they are cost-effective and thus beneficial to ratepayers **[CPUC_dec] [CPUC_748].**

The commission's guidance states that "the methods should be used for ex-ante (future) evaluation of DR cost-effectiveness. Ex-ante cost-effectiveness evaluations should be adjusted for actual ex-post experience from previous demand response program budgeting cycles or filings" **[CPUC_pro].**

More information about the DR cost-effectiveness protocol and recent PG&E submittals can be found on the Commission's website and from other supporting information sources **[CPUC_cost] [E3_pro].**

Integrated DSM Cost-Effectiveness

Similar processes and rules also apply to utilities' cost-effectiveness obligations for their energy efficiency, distributed generation, and energy storage programs. Inconsistencies do exist between the different CPUC cost-effectiveness rules for EE, DG, DR, and ST. CPUC and other stakeholders in California hope to develop to an overall approach to define the cost-effectiveness of integrated portfolios of demand-side management programs (integrated programs consisting of combinations of energy efficiency, demand response, distributed generation, and energy storage programs).

To address these concerns, the CPUC asked the large investor-owned utilities in California (Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Company) to explore the development of an integrated approach. The initial result of this work is a whitepaper that explores the issues involved in developing a common framework for cost effectiveness of integrated demand-side management programs. The whitepaper includes the results of a literature search, interviews with industry experts, an assessment of relative issues, and comments from interested parties given at a public workshop held in March 2011. The whitepaper provides a recommended methodology for the short term and a set of additional recommendations for capturing greater benefits and accuracy in the long term **[Calmac] [ISDM_wp].**

Demand Response Pilot Programs

PG&E's extensive DR program also includes pilot projects with state and federal government agencies. PG&E participated in a 2009 pilot project sponsored by CAISO, that assessed how "smaller" demand resources, such as commercial buildings and industrial installations could provide ancillary services to the electric grid. This "participating load" (PL) project demonstrated how these loads could be bid into the

CAISO non-spinning reserve ancillary services market. The results of the project affirmed that customers with auto-DR capability can automatically respond to dispatch instructions issued by the ISO and curtail loads based on pre-defined instructions, with no human in the loop. The project also demonstrated a real-time feedback mechanism that enabled the fine-tuning of load curtailment so that the PL resource could more tightly follow ISO dispatch instructions **[CAISO_plp].**

Another pilot project was performed with CAISO in 2011 entitled “Integrating Renewable Resources in California and the Role of Automated Demand Response.” The objective of this project is to ultimately “harness the potential of demand response and demand-side storage capabilities--thermal mass, process mass, chilled water storage, and dimmable ballast lighting--to cost-effectively provide load following and ramping products that the CAISO will need to manage the grid under increased renewable generation” **[LBNL_irr].** A final report and summary of findings was planned for publication around the end of 2011.

Both of the above PG&E pilot projects have included the participation of LBNL. More information about these and other LBNL DR projects can be found at the LBNL Demand Response Research Center’s website **[DRRC].**

B.1.7 Non-traditional Benefits Evaluation

Despite funding approval and the enormous success of its Auto-DR programs, the financial evaluation of its programs has been less appealing for PG&E. The utility has noted that given the large cost of enabling technology and associated marketing and customer service, the Auto-DR program is not considered cost effective. However, the utility has been able to justify its investment in the programs based on the host of non-financial benefits.

In addition to financial and peak load shift benefits, PG&E identified other positive outcomes from its smart grid and Auto-DR program work to-date. Being a national leader in smart grid technologies and demand-response program implementation has allowed PG&E to drive standards development and ultimately drive down costs. Additionally, PG&E’s dominance in the field has been shown to empower the technology companies, research centers, and academic institutions that are located within the service area. PG&E expects that through early adoption of the smart technologies, it will further help to drive innovation and research and development within the industry. In its June 2011 *Smart Grid Deployment Plan*, PG&E reported that five key smart-grid-related industries (power management and energy efficiency, energy storage, distributed energy generation, electricity transmission and distribution, and IT) have especially high concentrations within the PG&E service area. Growth and interest within the smart grid industry has helped spur job growth and economic development. While economic growth does not necessarily benefit the utility directly, growth in related sectors increases societal awareness of DR efforts.

While PG&E has been able to secure financing for implementing, its DR and Auto-DR programs, and while companies typically reflect a net financial gain from participating, PG&E has noted that attracting and retaining participants to its DR and Auto-DR programs has been quite difficult. Customer attrition is due primarily to the inconvenience of participation. The recent recession has apparently also factored into participation rates. Customers have expressed concern over participation obligations, as well as potential penalties for non-compliance. PG&E reports that when customers experience a month in which they are required to pay penalties for non-compliance, they typically drop out of the program. Because of this, PG&E has noted that customers in the Auto-DR programs, where energy usage patterns are pre-programmed and do not rely on constant demand-side management have been substantially more successful than programs that rely on active customer response to a signal.

B.1.8 Time required for Project Implementation (in project country, China)

Table App-10. shows the estimated effort in person-hours required deploy DRAS solution with similar programs to those of PG&E in China. The estimated effort includes DRAS deployment, program configuration, and client implementation for one customer. As can be seen from the table, although DRAS can be deployed within a very short time, it will take longer time to analyze standards in China and implement Auto-DR programs for those standards. Also, much more effort will go to customer visits and auditing, so the total time to implement the project depends mainly on the number of participating customers.

Table App-10. Time per Customer for Project Implementation in China

		Person-Hours
DRAS deployment	Server Installation	8
	Server Configuration	4
	Network Configuration	8
	Third-Party System Integration	Depends on the 3rd party systems in China
Program configuration	Peak Choice	8
	Peak Day Pricing	4
	Demand Bidding	8
	Capacity Bidding	8
Customer-side implementation	Energy Audit	16-20
	JACE installation	4
	JACE Configuration	2
	Network Configuration	2
	JACE-BMS Connection and BMS programming	8
	System Testing	4

B.1.9 Lessons Learned and Relevant Points for China

The primary lessons learned from PG&E's smart grid and demand-response program experiences have been:

- **Phasing project implementation**—Phasing helps to reduce the risks associated with ineffective technologies, allows for technology improvements, and lessens the likelihood of unnecessary costs.
- **Customer education and engagement**—Education is an integral first step of successful implementation—not just for program buy-in, but to ensure that system components are being properly used and that the potential for new technology use is maximized.
- **Public policy integration**—Utility companies and government agencies must work in close coordination to develop supportive policies to make smart grid and demand-response program implementation feasible and realistic.
- **Alternatives to critical peak pricing**—PG&E has been able to develop a range of pricing programs to fit different business needs. While adjusting peak load pricing (critical peak pricing) may not be an option in China, State Grid may consider reduction rebates or incentives rather than reduced prices for large customers who are able to curtail their energy use during peak times.
- **Participation backed by regulatory environment**—Due to the large amount of customer service, the expense of implementing technologies, and the marketing costs, PG&E has not found DR and Auto-DR programs to be inherently profitable. Programs become justifiable, however, when the entire list of environmental and social benefits is accounted for, when energy resources are increasingly stressed, or when there is a strong regulatory environment in place to mandate such programs.
- **Auto-DR programs increase participation—**PG&E found that compared to its manual DR programs, the Auto-DR programs result in higher levels of participation and higher levels of response. When customers are not burdened with the task of manually having to respond to DR signals, they are also more likely to stay enrolled in programs.
- **Outsourcing customer implementation of DR programs may be a good approach for utilities**—PG&E has benefited from extensive partnerships with local aggregators, which have

assumed both a level of risk associated with DR programs, as well as the responsibility of extensive customer service and outreach. Such partnerships have increased the success of the DR programs.

B.2 Southern California Edison (SCE) – Demand Response Programs

B.2.1 Project Overview

Located in southern and coastal California, Southern California Edison (SCE) provides energy services to just under 14 million residents spread across 12.9 million hectares. As the largest U.S. utility company by revenue, SCE is involved in both electric power distribution and generation, investing in infrastructure and energy assets. In addition to its residential customers, SCE serves 280,000 small businesses and over 5,000 large businesses.

While SCE has been exploring smart grid technologies since 1995, the utility began aggressively pursuing smart grid implementation in 2007. Upon completion of its smart grid development, SCE plans to have 5.1 million smart meters installed. By 2008, SCE had already installed smart meters at 100% of large commercial and industrial clients, with a demand-response peak load shed potential of 1,500 MW. Having focused early on smart grid systems that target large commercial and industrial customers, SCE is now focusing on developing its residential market. The total cost of the smart grid program (from 2007 onwards) is expected to be US$1,981 million, or roughly US$140 per resident [SCE2010].

As part of its smart grid initiative, SCE offers a number of different demand-response programs. Because early smart grid development has focused on non-residential sectors, C+I DR programs tend to be more developed. However, the residential sector has quickly started to participate in programs. In 2011, 93 percent of all DR program participants are residential customers. Although C+I customers account for only 7 percent of DR program participation, they account for over 60 percent of load reduction capacity [SCE2011].

In order to participate in SCE's DR programs, C+I customers must typically show a minimum electricity usage ranging from 100 kW to 500kW per year in order to participate. Some of the programs are strictly voluntary, with customers able to bid on expected reduction levels, while others bind customers to variable pricing schemes. Energy reduction incentives range from reduced energy prices to cash rebates for satisfied reduction agreements. Programs also vary based on the amount of notice time given by utility companies, as well as whether energy reduction interventions are made on the part of the consumer or by SCE [SCEDR].

Variations in program design target users with different use patterns (office buildings, retail, water/wastewater, agricultural/food processing, manufacturing and warehousing, government and institutions).

To participate, customers must have smart meters that measure usage at 15 minute intervals. Like PG&E, some of the demand response programs are eligible for participation in Auto-DR as well. The following tables provide an overview of commercial and industrial DR programs. Programs eligible for Auto-DR participation are indicated with an "*". As with PG&E, all Auto-DR programs are voluntary and allow the customer to override participation.

Table App-11. SCE Commercial and Industrial Demand Response Programs

Program	Customer Eligibility	Participants, (2011)[1]	2011 Peak Event Load Reduction [1]	Process and Incentive
Emergency Response				
Time-of-Use Base Interruptible	Demand >200kW	650 of 11,500 eligible (6%)	425 MW	• 15 or 30 minute notice to reduce energy usage by >15% • Customers receive monthly credit ranging from $1.05-21.11/kWh depending on peak time, season, and voltage requirements. • Customers unable to reduce demand are charged an additional $12-13 / kWh
Commercial Summer Discount Plan	• 1 year minimum commitment • Free installation of a cycling device	10,800 of 2,100,500 (15%)	57 MW [45% load impact per customer]	• Customer provides SCE access to the air conditioner unit, allowing SCE to turn the compressor down or off all together in exchange for credits • Plan is layered over a TOU rate structure • Credits range from <$1 to $12 per ton of air reduced depending on TOU structure and turn-off option
Price Responsive				
Critical Peak Pricing *	• Customers must enroll in TOU rate • Demand >200kW	3,300 of 11,000 (30%)	25 MW [3% load impact per customer]	• Offers reduced peak-pricing on summer days • On 12-15 “event” days, prices increase significantly, promoting a shift in energy usage
Demand Bidding *	• Demand >200kW • Customers with more than 1 account	1,400 of 12,700 (11%)	61 MW [6% load impact per customer]	Customers bid for reduced demand in the hour of an event, allowing for last-minute flexibility $0.50 per kWh

[1] Participants based on average monthly service accounts for 2011

Table App-12. SCE Commercial and Industrial Demand Response Programs (cont.)

Program	Customer Eligibility	Participants, (2011)[1]	2011 Peak Event Load Reduction [1]	Process and Incentive
Aggregator Managed				
Capacity Bidding *	• Open primarily to aggregated customers • No specific usage requirements • Customers with more than 1 account	500 of 632,400 (0%)	15 MW [10-18% load impact per customer]	• Customer estimates • Incentive payments range from $2 -25 based on notification time-frame and month • Penalties associated with reduction shortfalls
Non-Event Based				
Real-Time Pricing *	• Demand >500kW	120 of 3,100 (4%)	5 MW	• Year-round, hourly varying energy costs based on temperature • Real time pricing change
Other				
OBMC [29]	• Customers must pledge 15% of reduction off peak demand	N/A	N/A	• Last resort program • No monetary incentives • Customers are allowed to be exempt from rotating power outages, but must provide 15% of their energy usage available during an event • Non-compliance results in a $6 /kWh charge
Scheduled Load Reduction	• Demand >100kW • Customers must pledge 15% of reduction off peak demand	0 of 22,500 (0%)	N/A	• $0.10 per kWh bill credit for reduction during summer month events • Day-ahead notice • Reduced load may not be shifted to other peak times

[1] Participants based on average monthly service accounts for 2011
* DR plans with "*" allow for customer upgrade to an Auto-DR program.

Sources: SCE website, "Southern California Edison's 2010 Demand Response Load Impact Evaluations Portfolio Summary," Freeman, Sullivan & Co., 1 April 2011.

[29] Optional Binding Mandatory Curtailment is technically not considered a demand-response program by SCE since it is a last resort option.

"SCE WG2 Monthly Enhanced Report for December 2011, Appendix A," Southern California Edison, 20 January 2012.

As of 2011, SCE had roughly 18,500 participating commercial and industrial customers in its primary demand response programs (excludes OBMC) [SCE2011]. The Commercial Summer Discount Program has by far the largest number of customer participants at 60 percent. In 2011, the combined load impact for the peak summer month of August for commercial and industrial DR programs was estimated to be just under 800 MW.

B.2.2 Overview of Current Technologies and Systems Used

An SCE DRAS server is delivered as software-as-a-service (SaaS) model and shares the same network architecture depicted in Figure App- 6. . DRAS employs the same J2EE infrastructure, application server, and database with a variety of service integrations.

The DRAS FTP server provides the platform to automate the interaction between utility's internal systems and DRAS system. The interfaces for this integration are secured File Transfer Protocol (FTP) end points.

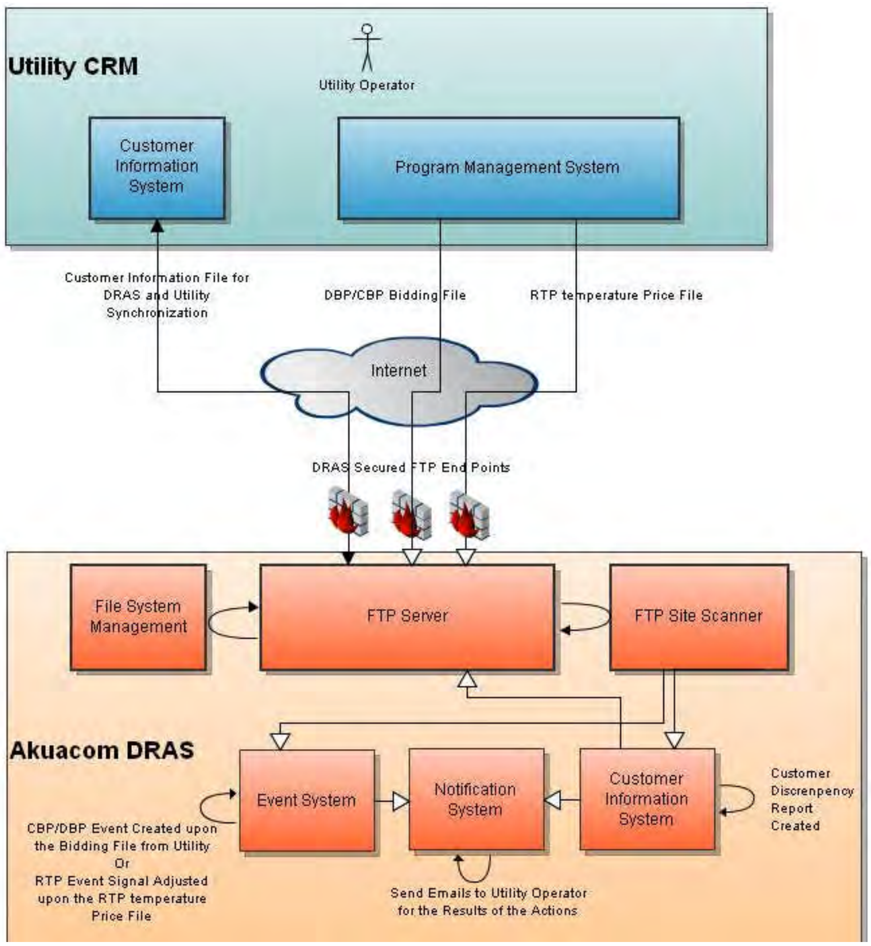

Figure App- 6. DRAS FTP Platform

As illustrated in Figure App- 6. , SCE utilizes the DRAS FTP platform for customer data validation, demand bidding (DBP)/capacity bidding (CBP) event scheduling, and real-time pricing (RTP) signal adjustment.

- Utility's customer relationship manager (CRM) system integration

The DRAS FTP server gets a daily upload of extracted records for the utility CRM system. Data in this file contains many customer attributes, including the automated demand response programs in which they are enrolled. The system uploads all of this demographic information into the DRAS for viewing by the DRAS operators. A daily discrepancy report identifies any differences between enrollment in the utility system and enrollment in the DRAS. All of the discrepancies are resolved by utility operations staff so that when automated events are triggered, the utility is confident that the appropriate buildings are being signaled with the appropriate shed commands.

- DBP/ CBP event scheduling

To schedule a DBP/CBP event, the utility's program management system automatically uploads the DBP/CBP bidding files to DRAS FTP server. The DRAS FTP scanner picks up the event, participant, and bid information from the uploaded bidding file and sends to DRAS event manager. At the same time, the DBP/CBP event is being created in the DRAS system. The DRAS sends event creation notification to utility operators.

- RTP signal adjustment

The utility's program management system automatically uploads the RTP temperature-price files to the DRAS FTP server. The DRAS FTP scanner picks up the temperature information from the uploaded file and sends it to DRAS event manager. The DRAS event manager adjusts the signals based on the modified temperature and correspondingly dispatches the new signals to all the clients enrolled in the RTP program. In the meantime, the report, including old and new temperatures and signals, is sent to the utility operators to view.

In addition to the FTP platform for utility system integration, DRAS is also the integration platform for many other third-party integrations, such as:

- Weather service integration

DRAS program and event engines are integrated with National Oceanic and Atmospheric Administration (NOAA) service. Each day, the integrated server retrieves the highest temperatures from NOAA service, forecasts each customer's OpenADR signals for the next five days, and creates an RTP event for the coming day.

- Third-party event scheduling system integration

DRAS enables APX event scheduling system (http://www.apx.com) integration through a secured REST web service end point. Upon receiving an APX event information xml file from the REST end points, a CBP event is created in DRAS. The DRAS sends an event creation notification to utility operators and APX service operators.

- News server integration

The Open Source blogging and content management tool, WordPress, is incorporated with DRAS to broadcast alerts and news to a utility's customers.

- Open Building Information Xchange (oBIX) usage data integration

DRAS provides an oBIX-based REST web service end point to enable usage data feedback. The service enables facilities to transfer the meter data in oBIX data format through the secured REST end points. The SCE client device and software utilizing the oBIX uploading technology include Tridium Java Application Control Engine (JACE) and Novar Energy Systems.

On top of this variety of system integrations, DRAS releases two key features to SCE: the DRAS Reporting Suite and the Automated Demand Limiting Program.

- DRAS Advanced Reporting Suite

The DRAS Advanced Reporting Suite lets the platform roll up DRAS data including usage, event information, and client communication information from facilities to aggregators, to event, and to utilities. The following reports are generated daily at event, facility, aggregator, and utility levels: Event Performance Report, Client Communication Report, Event Participation Report, and Usage Report.

The DRAS Advanced Reporting Suite also presents a comprehensive view for utilities to track and analyze the performance of demand-response events; it provides an event scorecard that details load reduction, participant opt out, system communication status per event or facility, and other metrics. This granular level of detail improves the precision of demand-response programs by identifying patterns and issues so utilities can better collaborate with program participants and remedy technical issues. Participating facilities can also generate reports detailing event results to help refine shed strategies and quantify the benefits of participating.

- Automated Demand Limiting Program

The DRAS Automated Demand Limiting Program helps facility managers manage energy expenditures by initiating shed strategies to avoid peak demand charges — even when their utility hasn't called an event.

As shown in the Figure App- 7, the utility operator assigns facilities to the Demand Limiting Program. The demand-limiting-enabled facilities custom configure their demand charge threshold. When the facility's usage exceeds the pre-configured demand limiting threshold, the DRAS event system will trigger shedding points to automatically implement load-reduction changes. Notifications also alert the facility team as demand hits prescribed levels, providing the opportunity to make manual adjustments if all automated strategies are enabled and demand continues to near the threshold.

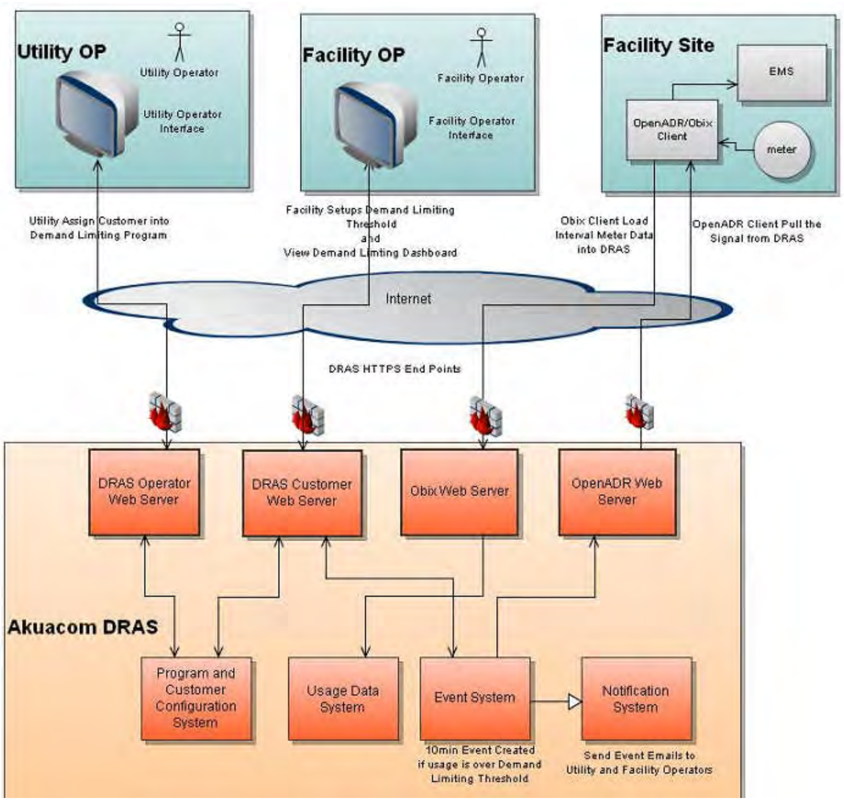

Figure App- 7. Demand Limiting Program Usage Example

B.2.3 List of Technology Standards

In addition to technologies and standards described in section 3.1.3, SCE DRAS also utilizes secured File Transfer Protocol (FTP) for each utility's CRM system integration.

http://tools.ietf.org/html/rfc959

B.2.4 Installation Incentives

Technology installation incentives vary greatly depending on the demand-response program a customer uses. Because some demand response programs do not rely on additional technology, some incentives are very minimal.

Aside from the varied price incentive structures that are offered in demand response programs, SCE provides a Technical Assistance and Technology Incentive (TA&TI) program. Customers eligible to participate in SCE's Automated Demand Response (Auto-DR) programs receive an incentive of up to US$300 per kW of verified load reduction after undergoing a TA&TI energy audit. This incentive is intended to offset the costs of Auto-DR communication equipment installation.

B.2.5 Financing Mechanisms

As with PG&E, SCE has financed its demand response programs primarily through CPUC-approved ratepayer cost increases. In the current three-year funding cycle (2009-2011), SCE spent just under US$100 million on its various residential, commercial, industrial, and agricultural DR programs.

Similar to PG&E, SCE spends a significant amount on marketing its DR programs. In 2011, the utility spent roughly US$3.3 million, or 9 percent of its annual DR program costs on marketing, education, and public outreach. Again, all of these costs were recovered via rate increases or additional customer fees.

B.2.6 Benefits Qualification, Quantification

Southern California Edison has developed its 2012-2014 demand-response program portfolio with the objective of operating successful programs during this three-year program cycle, while also preparing for the "customer-centric, market-oriented, price-responsive future of DR" **[SCE_app].**

With the full deployment of SCE's smart meter infrastructure to customers with demands of less than 200 kW, SCE will be able to offer a new array of smart meter-enabled DR programs to these customers. This will allow SCE to transform its existing DR portfolio from being primarily reliability-based to one that is primarily price-responsive. The implementation of these programs will allow SCE's DR portfolio to grow from 1,530 MW today to nearly 1,900 MW by 2014. Under SCE's proposals, price responsive DR will, for the first time, be SCE's primary delivery method for DR and will represent approximately two-thirds of SCE's DR portfolio by 2014. Further, by 2014, SCE will be able to bid approximately 1,360 MW of its portfolio in the CAISO markets with full locational dispatch capability **[SCE_vol1].**

A detailed description of SCE's 2012-2014 demand-response program portfolio can be found in its recent filing with the CPUC **[SCE_vol2].**

Peak load and demand response

SCE's DR capacity grew by more than 25 percent between 2009 and 2011; its growth was from approximately 1,200 MW to 1,530 MW **[SCE_app].** For perspective, a 2008 publication described SCE's peak recorded system load as 23,303 MW (on August 31, 2007) **[SCE_pb].** For the most recent calendar year, SCE's reported peak demand of 23,388 MW occurred on September 7, 2011 **[CAISO_tp].**

Within its DR portfolio, SCE offers an automated demand response program "Auto-DR." Under this program, SCE sends an automated signal to the customer's equipment, which will then shed electric load "without manual interaction." To qualify for the Auto-DR Program, customers must enroll and participate in one of SCE's automated DR Programs (the Capacity Bidding Program, Critical Peak Pricing, Demand Bidding Program, Demand Response Contracts, or Real-Time Pricing Rate) **[SCE_adr].**

DR load impact

SCE utilizes the CPUC DR load impact protocols to evaluate the performance and benefits of its DR programs. A high-level overview of these DR load impacts can be found in SCE's recent 2012-2014 DR program filing **[SCE_vol4].** A detailed evaluation of SCE's DR program load impacts for 2009 and 2010 can be found in recent publications **[FSC_09] [FSC_10].**

SCE's filing of 2010 DR load impact reports to the CPUC was made in April 2011. The titles of the load impact reports are:

1. Final Base Interruptible Program Statewide 2010 Ex-ante and Ex-Post Impact Evaluation Report and Appendices
2. Final Load Impact Estimates for SCE's 2010 Demand Response Programs (API Program, RTP Program, Res SDP, Commercial SDP)
3. Final Statewide 2010 Aggregator Programs Ex-Ante and Ex-Post Load Impact Evaluation Report and Appendices

4. Final Statewide 2010 DBP Ex-Post and Ex-Ante Load Impact Evaluation Report for Non-Residential Customers and Appendices
5. Final Statewide CPP 2010 Ex-ante and Ex-Post Load Impact Evaluation Report and Appendices

Detailed discussions of the 2010 load impacts are presented in these reports, which can be accessed via links contained in the SCE filing notice **[SCE_not]**.

DR cost-effectiveness

SCE is utilizing the CPUC cost-effectiveness protocols and has collaborated with PG&E and other utilities to explore improved processes for measuring the effectiveness of DR programs. Recent SCE submittals of cost-effectiveness reporting can be found on the Commission's website and from other supporting information sources **[CPUC_cost] [E3_pro].**

In a recent filing with the CPUC, SCE presented their approach for measurement and evaluation (M&E) activities associated with its proposed DR portfolio for 2012-2014. The primary objective of this effort is to assess the efficacy of DR resources. The results of these M&E studies will provide the Commission, and other stakeholders in California with a rigorous, systematic quantification of the demand reduction achieved and will provide program administrators with an improved view of the DR environment for use in future planning **[SCE_rp].**

Cost-effective DR allows SCE to make more efficient use of its generating resources. Demand response can improve the system load factor and defer the need for building or purchasing new peaking capacity, which reduces SCE's costs and the rates of its customers. Further, a portfolio of price-responsive DR programs that can be launched on a day ahead or day-of basis, as supply resource issues are resolved, mitigates the need for rotating outages that might otherwise occur. Price-responsive DR programs allow SCE to avoid the inconvenience of firm load interruptions to customers and also the potential economic loss of business from commercial and industrial customers. **[SCE_vol1]**

Integrated DSM cost-effectiveness

As described in the previous section of this report, SCE is an active participant (with the other large investor-owned utilities in California) in the development of an integrated approach to defining and assessing the cost-effectiveness of Integrated DSM programs. A description of SCE's IDSM programs can be found in a recent filing with the CPUC. **[SCE_vol3]**

Demand response pilot programs

SCE's extensive DR program also includes pilot projects with state and federal government agencies. SCE participated in a 2009 pilot project sponsored by CAISO, in which an assessment was made of the technical and economic feasibility of utilizing small (less than 5 kW) SCE-aggregated participating load (PL) demand response resources in the CAISO energy markets. This project demonstrated the technical feasibility of small, aggregated air conditioning load to act as a PL resource and verified that this type of resource would be closely aligned with the proposed CAISO proxy demand resource (PDR) market product in which demand response performance can be bid and settled in the wholesale market. This PLP resource was also shown to be able to comply with the CAISO's market process and system requirements for telemetry, bidding, dispatch and settlement **[CAISO_plp].**

This and other SCE pilot projects have included the participation of LBNL. More information about these and other LBNL DR projects can be found at the LBNL Demand Response Research Center's website **[DRRC].**

The CPUC approved several other SCE pilot DR projects for the period 2009-2011. This plan included a smart thermostat customer experience pilot to assist the planned transition of SCE's air conditioning direct load control program, utilizing one-way communication, to a new program that achieves load reduction through use of two-way communicating smart thermostats. Another project assessed the impact of programmable communicating thermostats on the load reductions of residential and small commercial customers enrolled in critical peak pricing DR programs **[CPUC_dr].**

B.2.7 Non-traditional Benefits Evaluation

While SCE is mandated by the State to provide DR programs to its customers, it does consider a number of non-traditional benefits that come with the programs. In addition to environmental benefits of peak load reduction, SCE also acknowledges that the DR programs have resulted in increased customer awareness and education about what they can reasonably do to lower energy consumption and their own energy costs. Such efforts benefit both SCE and customers.

B.2.8 Time Required for Project Implementation (in project country, China)

Table App-13 shows the estimated effort in person-hours required to implement a similar project to SCE's program in China. It includes DRAS deployment, program configuration, and client implementation for one customer. As can be seen from the table, although DRAS can be deployed within a very short time, it will take longer time to analyze standards in China and implement Auto-DR programs for those standards. Also much more effort will be required for customer visits and auditing. The total time to implement the project depends mainly on the numbers of participating customers.

Table App-13. Time per Customer for Project Implementation in China

		Man-Hours
DRAS deployment	Server installation	8
	Server configuration	4
	Network configuration	8
	Third-party system integration	Depends on the 3rd party systems in China
Program configuration	Demand bidding	8
	Capacity bidding	8
	Critical peak pricing	4
Customer-side implementation	Energy audit	16-20
	JACE installation	4
	JACE configuration	2
	Network configuration	2
	JACE-BMS connection and BMS programming	8
	System testing	4

B.2.9 Lessons Learned

- **Program variety**—As with PG&E, SCE offers a range of program options tailored to various business types. The diversity in DR selections has helped to increase participation in the program and subsequently energy consumption reduction.
- **Customer education and engagement**—Education is an integral first step of successful implementation—not just for program buy-in, but to ensure that system components are being properly used and that the potential for new technology use is maximized.
- **Public policy integration**—Utility companies and government agencies must work in close coordination to develop supportive policies to make smart grid and demand-response program implementation feasible and realistic.
- **Participation backed by regulatory environment**—Due to the large amount of customer service, the expense of implementing technologies, and the marketing costs, SCE has not found DR and Auto-DR programs to be inherently profitable. Programs become justifiable, however, when the entire list of environmental and social benefits is accounted for, when energy resources are increasingly stressed, or when there is a strong regulatory environment in place to mandate such programs.
- **Commercial and industrial customers have most shed potential —**While SCE offers a range of DR programs targeted at commercial, industrial, agricultural and residential customers, commercial and industrial customers have shown to provide the most load shed potential on a per-customer basis. Sixty percent of SCE's DR peak shed comes from its commercial and industrial customers, despite only representing 7 percent of participants. Because DR programs

tend to be very customer service intensive, it is worthwhile to target such large energy users first and take advantage of their reduction potential before focusing much more energy on smaller customers.

B.3 Ontario Power Authority (OPA) – Demand Response Programs (DRP)

B.3.1 Project Overview

The Ontario Power Authority (OPA) is the primary agency responsible for long-term planning of the Province's energy demand and supply. A non-profit organization, OPA is an independent organization that works with the Ontario Energy Board, the Independent Electricity System Operator (IESO), and the Ministry of Energy to set energy prices. OPA also coordinates with more than 90 electricity distributors (utilities) to manage the implementation of the Province's larger energy plan. While OPA manages the planning of Ontario's energy needs, the agency is not directly responsible for energy generation, transmission, and distribution [IESO].

While Ontario is a net energy exporter, OPA is still tasked with meeting growing energy demand in the Ontario region. In recent years, the province has invested heavily in renewable energy sources (wind, biomass), while simultaneously shutting down larger coal power plants. However, new energy sources alone are not enough to manage growing demand. OPA has also been implementing energy reduction programs. As part of OPA's energy reduction plan, the organization has focused on both energy efficiency initiatives and a number of demand management programs to reduce peak demand. By 2025, OPA hopes to meet 20% of its peak demand reduction goals via demand management strategies. Such strategies include time of use pricing policies for residential customers, real-time pricing policies for commercial customers, and a trio of demand response programs targeted at large commercial and industrial customers.

The three DR programs for larger commercial and industrial programs are DR1, DR2, and DR3. In general, the three DR programs were designed to help address summer peak load issues. However, each program targets a different customer group and offers and different level of commitment and compensation. While OPA designs and oversees the DR programs, OPA contracts out most of the management roles to local utilities. For the DR programs, large participants who provide more than 5MW of load reduction per event may contract directly with OPA. Smaller participants are required to contract with a utility or aggregator.

DR programs often work with existing time-of-use base rates. These rate structures are set by the Ontario Energy Board for the entire province. Some local customers choose to purchase electricity from independent electricity retailers rather than utilities. The prices that these independent retailers charge may vary from the Energy Board regulated utilities.

- DR1 is a voluntary load shedding program, available to commercial and industrial participants able to reduce their load by more than 500 kW. Customers who choose to participate receive financial incentives and compensation from the utility provider.
- DR2 is a mandatory load shifting program in which customers commit to permanently shifting their load from peak hours to off-peak or nighttime hours. Because this program requires a fundamental change in operation processes on a daily basis, DR2 results in a larger total load shift. Typical DR2 customers are large industries that have flexibility in their production process. Customers must be able to provide more than 5MW in demand response.
- DR3 is a mandatory load shedding program in which commercial and industrial customers must shed load on demand, after a signal from the OPA. Non-compliance results in financial penalties. DR3 allows customers the option of committing either 100 or 200 hours of reduction per year. Under DR3, OPA pays participants both an *availability payment*, for all hours that the customer makes its load available for curtailment, and a *utilization payment*, for actual load reduction.

Moving forward, OPA expects that DR2 and DR3 will be more reliable, in terms of systems planning than DR1. This results in large part from DR1's voluntary nature. As mandatory or contracted programs, DR2 and DR3 produce more reliable results. All three programs rely on 5-minute meter interval readings. As a result, OPA now views voluntary DR1 as an entry-level DR program, providing customers with a way to test whether the contractual DR2 and 3 programs would be appropriate for them.

Table App-14. summarizes OPA's three DR programs. As of 2010, the two DR programs resulted in just under 400 MW of peak load reduction. DR1 was on hold during 2010. In 2010, DR2 and DR3DR programs contributed 40 percent to the Province's peak load reduction of just over 1,000 MW. Additional OPA DR programs targeting smaller and residential users contributed an additional 165 MW of peak load reduction. Additional savings came from energy efficiency programs. The Province's eventual goal is to reduce peak load by 1,350 MW.

Table App-14. OPA Demand Response Programs

Program	Customer Eligibility	Participants	Peak Event Load Reduction (2010)	Process and Incentive
DR1	Demand >500kW	N/A	0 MW (Program on hold in 2010)	• Voluntary load shedding • Activated when wholesale electricity price is high • CA$2000-4000 per MW per month
DR2	Demand >5 MW	N/A	120 MW	• Mandatory load shedding • Participants commit to regular shifting of peak usage to off-peak hours (7pm-7am) • Time-of-year contracts • Incentives range from CA$10-115 per MWh, depending on contract length, season, and number of hours pledged
DR3	• Demand >5 MW • Demand >200 kW may participate, but must contract with aggregator, not directly with OPA	N/A	264 MW	• Mandatory load shedding • Few hundred event hours per year • Activated when energy surplus is low • 2.5 hours advance notice • 100 or 200 hours/year • Incentives range from CA$200-400 per MWh depending on contract length, hours of access

Source: "Managing a Complex Energy System – Results: Annual Energy Conservation Progress Report – 2010, Volume 2" Environmental Commissioner of Ontario, December 2011.

In addition to participating in one of the demand response programs directly through OPA or a local utility, a number of "energy aggregators" provide technical infrastructure and manage groups of customers' DR participation. These energy aggregators assume the risks of non-participation, allowing customers to participate in the contractual program on a voluntary basis. Aggregators help lower the amount of capacity that any one customer must contribute in order to participate. For the DR3 program, most energy aggregators require just 200 kWh of annual contribution to be eligible.

B.3.2 Overview of Current Technologies and Systems Used

The DR-2 program operates in the following fashion, per the OPA website: "Participants of the program can contract to reduce a predetermined amount of load for a minimum period of four consecutive hours up to a maximum of 12 consecutive hours, each business day On-Peak Period, and to therefore increase load during the Off-Peak Period. There are three options for participation: summer months, winter and summer months, or all year." As such, no specialized communications or control technologies are required to participate in the DR-2 program.

Participants in DR-3 can choose to enroll directly with OPA, provided they meet minimum load reduction criteria, or can participate through an aggregator. One DR aggregator describes their customer DR control interface options as: "when a demand response event is called by ISO or utility, the DR aggregator network operations center responds by sending a DR alert to the DR participants via email, phone, text or automated control" **[Rodan].** Standard communications technologies are used to achieve DR control.

B.3.3 List of Technology Standards

The OPA DR programs use standard communications technologies. These programs do not use the OpenADR standard.

B.3.4 Installation Incentives

For the most part, participating customers bear little to no costs for program participation. With the exception of an interval meter, which most companies already have installed, customers do not require special infrastructure or technology to participate in DR events.

B.3.5 Financing Mechanisms

To date, OPA has found that compensating customers for *not* using energy is generally more expensive than accessing *existing* sources of energy. Currently, OPAs DR programs generate no net financial gain for the utility. However, the real value in implementing DR programs is typically in avoided costs of building new generators. Because of the new nature of the programs, avoided cost metrics are not available.

As the DR programs continue to develop, OPA is increasing the accuracy of the measurement and reducing the amount of incentives they must pay out by refining the accuracy of the baseline energy demand measures.

Additionally, because the price curve for electricity in Ontario and other jurisdictions is very steep (i.e., price increases dramatically towards peak energy demand periods), small reductions in demand during peak times can have significant impact on generation price. During peak generation times, energy costs are estimated to be roughly twenty times that of non-peak times.

In order to recover any net losses from its DR programs, the IESO charges ratepayers a g*lobal adjustment* fee. The global adjustment fee helps make up the difference between market revenues and expenditures on energy generation, conservation services (including demand response programs), and additional service contracts. This fee is either included in the base rate for residential customers, or added on as an additional rate in a customer's monthly bill. For customers with peak demand of greater than 5 MW, the global adjustment fee is based on the percentage of their contribution to the five largest peak day events. OPA and the various Ontario energy agencies try to distribute the costs of extra energy generation and conservation proportionately among all ratepayers [IESOGA]. Fees from OPA to energy distributors and large customers range from CA$35–45 per MWh of usage in a given month.

By adjusting electricity pricing to reflect true costs of generation, and encouraging behavioral change, OPA hopes to continue to delay the need for future generation infrastructure.

B.3.6 Benefits Qualification, Quantification

Ontario's electricity system has a current capacity of approximately 35,000 MW, and OPA is implementing an ambitious plan to reduce greenhouse gas emissions through increased utilization of renewable resources and modernized nuclear generators **[OPA_plan].** OPA's stated energy conservation targets will be met through a combination of initiatives, including demand response programs. Note that Ontario is currently a net exporter of electricity **[OPA_exp].**

Evaluation of DR program performance is a key initiative at the Ontario Power Authority. The OPA website states that "Evaluation, Measurement and Verification (EM&V) plays an important role in planning and operation of the Conservation programs … and is aimed at assessing the impacts (e.g., energy and demand savings) and effectiveness of a Conservation program on its participants and/or the market" **[OPA_emv]**.

DR load impact

A recent report details the 2010 performance of the OPA commercial and industrial DR programs **[FSC_ci].** An overview of the 2010 results can be found in the executive summary section of that report. The following paragraphs present some of the highlights of the report.

DR-2 Program:

- OPA's DR-2 program reached a steady state in 2010 and did not experience new growth. In some instances DR participants informed OPA operators in advance that they would be unable to shift load due to facility shut downs or other reasons (perhaps due to poor economic conditions).
- The ex-ante estimates are conservative and smaller than the actual demand reduction realized in 2010. For the average hour, the contracted load was 91.3 MW and the ex-ante load reduction estimates are 60.8 MW in the summer, 62.2 MW in the winter and 47.5 MW in the shoulder months.

DR-3 Program:

- OPA's DR-3 program enjoyed significant growth in 2010, adding 146 new contributors in 2010, accounting for an additional 95 MW of contracted load reductions. By the end of 2010, there were 246 total contributors in the DR-3 program with an aggregate contracted load reduction of 253 MW.
- Average load reduction as a percentage of contracted MW increased to 81.1% (delivered) in 2010. Including other factors, 78.8% of the contracted load reduction is expected for planning, resulting in an ex-ante load reduction estimate of 199.5 MW. For the future, OPA believes that improving performance should remain a goal because it would substantially increase the overall cost-effectiveness of the DR-3 program.

Load impacts of non-C&I DR programs

In addition to the C&I programs described above, OPA has other demand response initiatives within its Conservation and Demand Management initiative. The peaksaver® Small Commercial Pilot Program also contributes to OPA's demand response objectives. The impact of the peaksaver® program in 2010 is presented in a recently published report. **[FSC_peak]**

B.3.7 Non-traditional Benefits Evaluation

While current financial estimates of demand response programs result in little net benefit, this calculation does not include avoided GHG emissions or social benefits associated with avoiding new generation. The Ontario Clean Air Alliance recently found that each MWh of reduced energy usage results in a 1 ton CO_2 reduction [Rodan]. Such environmental benefits align closely with OPA's larger conservation mission.

B.3.8 Time Required for Project Implementation (in project country, China)

The DR-2 program operates on a contractual basis for participation in the summer months, winter and summer months, or all year. No specialized communications or control technologies are required to operate this type of DR program, so this type of DR could be implemented in China in a relatively short period of time.

Participants in DR-3 can choose to enroll directly with OPA, or can participate through an aggregator. Standard communications technologies are being used for this purpose, so implementation time in China could be relatively short if DR aggregator companies are in place.

B.3.9 Lessons Learned

Aggregator networks can provide support and impetus— OPA's DR-2 and DR-3 programs are successful and are providing benefits for electric grid operators, and customers. If a network of DR aggregators can be established, these kinds of DR programs could be implemented fairly quickly in China.

Demand response as a support initiative—In reviewing the results of the OPA's three DR programs, it is clear that DR is an important component of the larger load shifting program. However, in Ontario, DR programs have been found less effective than traditional energy efficiency and energy reduction efforts.

DR programs must be justified non-financial benefits—OPA's demand-response programs are justified not by net financial gains, but rather because of the role that they play in the Province's larger energy reduction and environmental improvement goals. Being able to understand demand response in a larger context has helped OPA and local utilities to justify the program costs.

B.4 United Kingdom National Grid – Short Term Operating Reserve (STOR)

B.4.1 Project Overview

Over the next two decades, the United Kingdom expects its total energy demand to increase by more than thirty percent. To meet growing demand, the UK is preparing for a six-fold increase in renewable energy generation in the next decade. However, while such energy sources have incredible potential, they are understood to be unreliable, and may leave gaps between energy generation and demand, particularly during peak hours.

Spurred by the shift towards greater reliance on renewables, in 2007, the United Kingdom's primary energy transmission company, National Grid, began a comprehensive review of all sources of operating reserve available to bridge temporary and unexpected gaps between demand and generation. Such sources include both standby generation and demand reduction. To this end, National Grid has developed the Short Term Operating Reserve (STOR) program.

To participate in the STOR program, customers must meet five key requirements [NatGrid]:

1. Be able to provide a minimum contracted capability (whether in generation or reduction) of 3MW
2. Be able to respond to the request in less than 4 hours (typically within 20 minutes)
3. Be able to deliver the contracted MW for no fewer than 2 continuous hours
4. Be able to recover from a STOR event within 20 hours
5. Be able to participate in up to 3 STOR events per week

Customers may offer *committed service* or *flexible service*. Committed service contractually obligates customers to participate in generation / reduction events. Flexible service allows customers the option of not participating. However, National Grid may reject a flexible service provider's bid to participate in an event, and customers would not be compensated for rejected bids.

Each year is broken down into six seasons. Customers may bid for one or more of the seasons, making commitment levels more flexible and customizable. In five years of operating, committed MW per season has ranged from 2000–4000 MW, with the average operating reserve available per season around 2500 MW [STOR_3]. By 2020, National Grid expects to need 8000MW of contracted operating reserve.

Typical STOR access time is from 7am to 11:30pm. Customers are called on for 50-60 hours of participation per year. Messages are typically sent via SMS, phone calls, and emails.

Customers may contract directly with National Grid or go through a local utility or aggregator.

Table App-15.. National Grid STOR Program

Program	Customer Eligibility	Participants, 2011	Energy Generation Potential, 2011	Process and Incentive
Short Term Operating Reserve (STOR)	• Generation >3 MW • Short notice generation • Frequent generation	35-45 Companies/ season	2,000- 4,000 MW	Roughly £200–360 per MWh of generation

Programs similar to National Grid's STOR currently also operate in France and the United States.

B.4.2 Overview of Current Technologies and Systems Used

The National Grid Balancing Mechanism provides a means of adjusting the level of production or consumption of individual generators or demand-side resources. Energy providers who contract with National Grid (under the terms of the Balancing Settlement Code) and actively participate in the Balancing Mechanism are referred to Balancing Mechanism Unit (BMU) providers. These providers are generally holders of generation, transmission, distribution and supply licenses. Energy traders and others (e.g., large demand-side loads who can reduce their electricity consumption) may also choose to become parties to the Code, and are referred to as Non-BMU providers **[STOR_1]**.

The STOR program operates in the following fashion, per the National Grid website: "Short Term Operating Reserve (STOR) is a service for the provision of additional active power from generation and/or demand reduction." Both BMU and non-BMU providers are able to contract for committed service. Only non-BMU providers are able to contract for flexible service **[STOR_2]**.

B.4.3 List of Technology Standards

The Balancing Mechanism (BM) system is the key information system used by National Grid to balance the system and manage real-time electricity supply and demand. The BM system interfaces with National Grid's market participant systems and settlement systems **[BM]**. The BM system is currently approaching the end of its design life, and National Grid will be replacing it with a global best practice "Electricity Balancing System" (EBS) for balancing the real-time electricity supply and demand. The new system is planned to go live in 2013 **[EBS]**.

The OpenADR standard is not being utilized in the National Grid STOR program.

B.4.4 Installation Incentives

Participation in the STOR program does not rely on the installation of specific technology. National Grid does not pay additional participation incentives beyond what the STOR program contractually agrees to.

B.4.5 Financing Mechanisms

Because the required smart grid and demand response technology is already a part of the larger utility grid system, and because National Grid manages energy transmission but not distribution, the STOR program does not require the implementation of additional technology. Participating customers have paid for additional monitoring technology or energy generation technology themselves.

Participating customers are compensated for their energy provisions. Two types of payments are typically made to participating customers: *availability payments* and *utilization payments*. Availability payments (£/MW/h) are made to providers who successfully reduce their demand, or make their energy available during the STOR event. In the sixth year of operation, availability payments ranged from £7 to £11 per MW/h. Utilization payments (£/MWh) are made for the total amount of energy generated. In the sixth year of operation, availability payments ranged from £200 to £360 per MWh. Baseload power costs in the UK are currently just under £50 per MWh.

National Grid typically spends between £4.5 and £6.5 million per month in payments to its participating energy providers.

B.4.6 Benefits Qualification, Quantification

As reported in the most recent National Grid Monthly Balancing Services Summary for December, 2011, the contracted volume of STOR capacity for the month of December 2011 was 3971MW **[MBSS]**. That National Grid monthly report does not give a breakdown of demand reduction capacity vs. generation capacity procured for the month.

For comparison, the total generating capacity of the National Grid is about 70 GW (70,000 MW), supplied roughly equally by nuclear, coal fired and gas fired power stations. In the UK, the peak winter demand is 57 GW **[NGrid].**

Since STOR is not purely a demand-response program (much of the STOR capacity comes from generation sources), no analyses of DR load impact have been found in the literature.

Detailed STOR operational information can be found in summary monthly Balancing Services reports on the National Grid website **[NMS].** A report describing the operational results of STOR for the 2010–2011 operating year can be found on the National Grid website **[Ann].**

B.4.7 Non-traditional benefits evaluation

As with most DR programs, the primary benefits of the STOR program are increased energy reliability, and the potential to delay the construction of power plants.

B.4.8 Time Required for Project Implementation (in project country, China)

As described in an earlier section, the STOR program uses the National Grid Balancing Mechanism system for balancing infrastructure. A demand-response capability for system balancing in China could be developed in a similar fashion. No new or specialized communications or control technologies would be required to operate this type of DR program, so this type of demand response could be implemented in China in a relatively short period of time.

B.4.9 Lessons Learned

- **System balancing**—The STOR program has been very successful in providing system balancing benefits for the National Grid. If a network of DR aggregators can be established, a similar DR program could be implemented fairly quickly in China.
- **Demand response has many forms—**While incentive pricing is still an option in the United Kingdom, tapping into customers' reserve power sources has proved to be a successful way to supplement capacity without having to pay customers to reduce their consumption.

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Appendix C. Laws and Regulations Affecting Smart Grid Development in China

The two tables in Appendix C summarize key laws and policies set by the Chinese government. The tables include assessed impact of the measure on smart grid and, potentially, demand-response development in China.

Table App-16. Laws Affecting Smart Grid and Demand Response Development in China

Related Governmental Sectors and Institutions [1]	Policies			
	Policy Type	**Year**	**Policy Name and Articles**	**Implications for Smart Grid / Demand Response Programs**
N/A	Law	2007	Law on Energy Conservation	
	Law	2007	**Article 5** The State Council and local governments at the county level and above shall incorporate energy conservation into the national social and economic development plan and annual plan and compile and implement medium or long term special energy conservation plan and annual energy conservation plan	The recognition of the importance of energy efficiency measures is expected to support development of smart grid and related technologies.
	Law	2007	**Article 15** Special assessment of rational energy utilization shall be included in the feasibility analysis reports of fixed capital investment projects.	Smart grid and DR programs are excellent tools to encourage thoughtful energy use, and may lead to a reduction in future capital costs.
	Law	2007	**Article 16** The state applies a system for discontinuing backward, over energy-intensive, energy-consuming products and equipment.	Smart grid technologies and DR programs aid in the identification and control of these sectors and their energy-intensive equipment.
	Law	2007	**Article 17** Energy utility products and equipment whose elimination the State has explicitly ordered or that fall short of mandatory energy efficiency standard are prohibited from being produced, imported and distributed. Energy utility equipment and processing techniques are prohibited from being used.	
	Law	2007	**Article 27** Energy consumption units shall strengthen energy metrology management and equip and use energy measurement instruments that have passed examinations according to rules.	Strengthening energy metering will promote the development of energy measurement instruments like smart meters.
	Law	2007	**Article 31** The State encourages enterprises to adopt high-efficiency and energy-saving electric motors, boilers, furnaces, blowers, pumps and other equipment and to implement combined heat and power generation, waste heat, and pressure using clean coal and advanced energy consumption monitoring and control technologies.	A focus on energy efficiency supports additional smart grid technologies such as smart meters and integrated building management systems.
	Law	2007	**Article 49** Public institutions shall make annual energy conservation plans	These articles directly support

Related Governmental Sectors and Institutions [1]	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
			and embodiment, strengthen energy consumption measurement, monitoring and management, and report the annual energy consumption situation to government offices administrations at the corresponding levels.	the development of both smart grid technologies, such as smart meters, and the implementation of DR programs to manage energy use and smooth energy consumption patterns.
	Law	2007	**Article 50** Public institutions shall strengthen energy utility system management to comply with national standard. Public institutions shall process energy audits according to rules and adopt measures to improve energy efficiency based on energy audit outcomes.	
	Law	2007	**Article 51** Public institutions shall give priority to purchase energy utility products and equipment listed in the government procurement directory of energy conservation products and equipment. Energy utility equipment and equipment are prohibited from being purchased.	
	Law	2007	**Article 63** The State encourages the import of advanced energy conservation technologies and equipment and controls the export of products for which the producing process is highly energy-consuming and heavy polluting.	Favorable tax policies, government procurement directory policies, credit and price policies, and other incentives directly support the development of energy-conservation products such as smart meters, building management systems, and utility-managed DR programs.
	Law	2007	**Article 64** The government procurement supervision and management department provides a government procurement directory of energy conservation products and equipment. Certified energy conservation products and equipment shall be given priority.	
	Law	2007	**Article 65** The State shall guide financial institutions to increase support for energy conservation projects and provide loans on favorable terms for qualified energy conservation projects.	
	Law	2007	**Article 66** The State shall implement price policies in favor of energy conservation to guide energy conservation in utilities and individuals.	
	Law	1996	Electric Power Law	
	Law	1996	**Article 10** The planning for electric power development shall be drawn up according to the requirements of the national economy and social development and shall be incorporated into the national economic and social development plan. The planning for electric power development shall reflect the principles of rational use of energy resources, coordinated development of electric sources and electric networks, improvement of economic results, and conducive to environmental protection.	Smart grid and energy-saving technologies are becoming necessary components of national electric power planning.
	Law	1996	**Article 31** A consumer shall install a metering device [to measure] its	Accurate metering requirements

Related Governmental Sectors and Institutions [1]	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
			power consumption. The amount of electric power consumed as adopted by the consumer shall conform to the amount as recorded by a metering device that has been approved according to law by a meter rating organization. The design, installation, and operations management of a consumer's device [for measurement of] consumed electricity shall comply with standards [established by] the state or electric power industry standards.	set the stage for additional interval and smart metering options.
	Law	1996	**Article 44** Any unit or person is forbidden to levy surcharges in addition to the electricity price; however, if otherwise provided in laws and administrative regulations, such provisions shall apply. For surcharges in addition to the electricity price on electricity produced by locally-funded power enterprises, the people's governments of the provinces, autonomous regions, or municipalities directly under the central government shall formulate measures in accordance with the relevant regulations of the State Council. Any power-supplying enterprise is forbidden from collecting surcharges in addition to the electricity price on another's behalf.	Current DR incentive options are limited by inability to levy surcharges.
	Law	1996	**Article 49** Local people's governments at the county level and above and their departments for comprehensive economic administration shall, when allocating quotas for electricity consumption, preserve an appropriate ration between the consumption of electricity [earmarked] for agriculture and by rural communities [in general] and shall give priority to electricity consumption for the purposes of flood diversion, drought protection, and seasonal agricultural activities required for production in rural communities. Electric Power Enterprises shall carry out the above provision in their allocation of electricity consumption, and may not reduce electric power quotas for [other] agriculture of rural communities.	
	Law	2006	Renewable Energy Law of People's Republic of China	
	Law	2006	**Article 13** The State encourages and supports renewable energy combined to the grid.	Smart grid development specifically allows for the incorporation of renewable energies, as well as other non-traditional energy sources. Utilities have been given authority to recover costs associated with
	Law	2006	**Article 14** Power grid companies shall sign agreements with renewable Power Generation Enterprises that have legally obtained license or that have reported for records, to fully purchase the electricity these enterprises generate and to provide service of connecting to grid.	
	Law	2006	**Article 21** Grid connection and other rational expenses in purchasing renewable electricity by power grid companies can be included in power	

Related Governmental Sectors and Institutions [1]	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
			transmission costs of power grid companies and can be returned from retail electricity prices.	this incorporation.
	Law	2000	Law on the Prevention and Control of Atmospheric Pollution	
	Law	2000	**Article 25** The relevant departments under the State Council and the local People's governments at various levels shall adopt measures to improve the urban energy structure and popularize the production and utilization of clean energy.	Smart grid development supports both the urban energy structure and incorporation of renewable.
	Law	2005	Construction Law	
	Law	2005	**Article 4** The state supports construction science research to improve design and encourage energy conservation and environmental protection and advocate for the use of advanced technologies, equipment and processes, new building materials, and modern management methods.	Smart grid, building management systems and the incorporation of DR programs directly support this article.

[1] As laws are not issued by related governmental sectors or institutions, this column is left blank

Source: Government Articles

Table App-17. Rules and Regulations Affecting Smart Grid and Demand Response Development in China

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
State Council	Rules	1996	Rules on Electric Power Supply and Use	
State Council	Rules	1996	**Article 5** The state [government] shall implement the electric power supply, and issue the management principle of using the electric power in a safe, saving, and planned way.	
State Council	Rules	1996	**Article 26** Users shall install [their] power consumption metering devices. The capacity and energy consumption shall be determined by the records of a power consumption–metering device recognized by a measurement verification organization pursuant to the laws.	
State Council	Rules	1996	**Article 27** Power Enterprises shall compute the electricity charges payable by their Users according to the electricity rates approved by the state [government] and the consumption records measured by a metering device.	Electricity pricing is set at national level and may be difficult to customize for DR incentives.
State Council	Rules	1996	**Article29.** The electric power administrative departments of the People's governments above county level shall implement the state industrial policies and shall work out the plan of electric power use in accordance with the principle of overall planning and all around consideration, securing key [Users] and supplying power to those that are outstanding [profit-making Users]. Both Power Enterprises and Users shall submit their own projections for power saving and shall promote and utilize new technology, new materials, new techniques, and new equipment in connection with power saving so as to reduce electric power consumption.	Supports demand-side technology investment in energy efficiency. Smart meters would be key information and planning tools for customers.
State Council	Rules	2011	Regulation rules on waste electrical and electronic products recycle and disposal	
State Council	Rules	2011	**Article 7** The State establishes funds as subsidies for expenses of waste electrical and electronic products recycle and disposal. Manufacturer, importer and its agent of electrical and electronic products have the responsibility to contribute to the funds according to regulations.	When smart meters and associated smart grid technology is implemented, the State will support disposal costs.

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
State Council	Rules	2011	**Article 10** Manufactured and imported electrical and electronic products shall comply with relevant national pollution control regulations, and adopt designs that are suitable for comprehensive utilization of resources and harmless treatment, and use toxin-free, non-hazardous or low-toxin and low-harm and easily recycled materials.	Imported smart grid technologies must comply with national standards
State Council	Rules	2002	Regulations of the People's Republic of China on administration of technology import and export	
State Council	Rules	2002	**Article 10** License management is adopted for limit entry technologies. Import is forbidden without license.	Regulation of technology imports
State Council	Rules	2002	**Article 11** Import of limit entry technologies need to apply to foreign trade department under the State Council for license accompanied by relevant files.	
State Council	Rules	2002	Regulations of the People's Republic of China on administration of goods import and export	
State Council	Rules	2002	**Article 11** Quota management is adopted for limit entry goods with quantity limitation; license management is adopted for other limit entry goods.	Regulation and control of technology imports
State Council	Rules	2002	**Article 12** Limit entry goods under quota management are administrated by foreign trade department and administrative departments of import quotas under the State Council according to their duties.	
State Council	Rules	2002	**Article 25** The list of goods under customs quota management is made, adjusted, and issued by foreign trade department and relevant departments under the State Council.	
State Council	Rules	2002	**Article 26** Different customs duties are adopted for imported goods within and beyond customs quota.	
State Council	Rules	2004	Regulations on import and export duties	Regulation of technology imports will likely increase competitiveness of domestic products.
State Council	Rules	2004	Regulation of the People's Republic of China on the customs protection of intellectual property rights	Subsidies on domestic technologies and additional regulations on imported technologies may affect
State Council	Rules	2004	The State Council decision about adjusting regulations on subsidy and countervailing measures of the People's Republic of China	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
State Council	Rules	2004	The State Council decision about adjusting anti-dumping act of the People's Republic of China	development of smart grid related sector.
State Council	Rules	2005	Implementation rules for Law of The People's Republic of China on import and export commodity inspection	
National Development &Reform Commission (NDRC)	Notice	2011	NRDC notice on improving on-grid price policies of solar energy power generation.	
NDRC	Notice	2011	For solar energy power generation projects approved before July 1st, 2011 and completed and put into operation before December 31, 2011, and prices of for project that have not been valuated, the on-grid price is set at 1.15 RMB per KWh (inclusive of tax).	Competitive pricing of solar energy increases support for incorporation into the grid, placing reliance on smart grid technologies that allow for this incorporation.
NDRC	Notice	2011	For solar energy power generation projects sectioned after July 1st, 2011, and projects sectioned before July 1st, 2011 but which were not completed and put into operation before December 31, the on-grid price is set at 1 RMB per KWh, except for Tibet, within which the price is 1.15 RMB per KWh.	
NDRC	Notice	2011	For solar energy power generation projects with fund allowance from state revenue, the on-grid price is set at the same level with local de-sulfured coal-fire unit on-grid pole price.	
NDRC	Notice	2011	For solar energy power generation projects with higher on-grid price than that of local de-sulfured coal-fire unit, the excess part is returned from renewable energy electricity additional price collected countrywide according to "*Tentative management measures for price and sharing of expenses for electricity generation from renewable energy".*	
NDRC	Notice	2010	NRDC notice on improving on-grid price policies of Agricultural and Forest biomass power generation.	
NDRC	Notice	2010	On-grid pole price policy is implemented for agricultural and forest biomass power generation projects. For projects not determined by bidding, the on-grid pole price is 0.75 RMB per KWh (inclusive of tax).	Competitive pricing of biomass energy increases support for incorporation into the grid, placing a reliance on smart grid

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
NDRC	Notice	2010	For sanctioned projects (except for bidding projects) with prices lower than pole price, the price is raised to 0.75 RMB per KWh; projects with prices higher than pole price remain at the original level.	technologies that allow for this incorporation.
NDRC	Notice	2010	For agricultural and forest biomass power generation projects with on-grid price within local de-sulfured coal-fire unit on-grid pole price, provincial power grid corporations bear the price; the excess part is returned from renewable energy electricity additional price.	
NDRC	Measures	2010	Electric Power Demand Side Management Requirements	
NDRC	Guidance	2010	NRDC guidance on residential multistep electricity price	Multistep or TOU pricing requires interval meters, and allows for easier DR program implementation
NDRC	Notice	2009	NRDC notice on improving on-grid price policies of wind energy power generation.	
NDRC	Notice	2009	The on-grid pole price of on-shore wind energy power generation projects is determined according to wind resource areas. Each of the four areas has a specified on-grid pole price. The on-grid pole price for electric field on trans-provincial boarder is set at the higher on-grid pole price.	Competitive pricing and regulatory support for wind energy increases support for incorporation into the grid, placing a reliance on smart grid technologies that allow for this incorporation.
NDRC	Notice	2009	The on-grid price of offshore wind energy power generation projects will be determined by the department of price under the State Council.	
NDRC	Notice	2009	For wind energy power generation projects with on-grid prices within local de-sulfured coal-fire unit on-grid pole price, provincial power grid corporations bear the price; the excess part is returned from renewable energy electricity additional price.	
NDRC	Notice	2009	NRDC notice on standardizing electricity trading price management	
NDRC	Notice	2009	The on-grid price for power-generating sets in operation shall follow the rate determined by the department of price, except for that of trans-provincial or trans-regional electricity trading and other situations under special regulations.	Local pricing control restrictions limit DR incentive options. Under current laws, DR program incentives would need to be

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
NDRC	Notice	2009	Trans-provincial or trans-regional electricity receiving price is composed of sending price, transmission expense and transmission losses.	agreed to at the national level.
NDRC	Notice	2009	The trans-provincial or trans-regional electricity trading price shall strictly follow national regulations. In areas without national regulations, the price is determined by negotiation of both sending end and receiving end with reference to the average of sending and receiving prices in both areas. The transmission price (transmission loss included) of sending end power grid corporations shall be lower than 0.03 RMB per KWh.	
NDRC	Notice	2009	Retail prices shall strictly follow NDRC's price rate; governments and power grid corporations at different levels are forbidden to raise or lower retail prices or to give privilege prices in the name of direct power purchase for large users.	
NDRC	Notice	2007	NRDC notice on further implementation of discriminating power price policy	
NDRC	Notice	2007	Additional electricity fee income of power grid corporations from implementation of discriminating power price shall be fully turned over to local treasury and be included in provincial financial budget. These revenues and expenditures are managed separately and the funds are used specifically in local economic structure adjustment and energy conservation and emission reduction.	Local utilities are discouraged from developing DR programs that may result in net profit for utilities.
NDRC	Notice	2007	Eliminate the preferential policies for electricity prices for electrolytic aluminum, ferroalloy and chlor-alkali industries.	Reduction of favorable pricing may encourage industries to seek alternative energy efficiency measures, or encourage them to participate in DR and TOU programs.
NDRC	Notice	2007	Immediate end preferential electricity measures issued by local governments for high energy consumption industries.	
NDRC	Measures	2006	Tentative management measures for price and sharing of expenses for electricity generation from renewable energy	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
NDRC	Measures	2006	**Article 5** Renewable energy power prices are mandated by the government or based on government-issued pricing guidelines. The prices based on government-issued pricing guidelines are the prices determined by bidding. The part of renewable energy power prices in excess of local de-sulfured, coal-fire unit, on-grid pole prices are shared in provincial and above power grid retail prices.	Regulatory support for renewable energy increases support for incorporation into the grid, placing a reliance on smart grid technologies that allow for this incorporation.
NDRC	Measures	2006	**Article 17** Additional prices of renewable energy power are included in retail prices of power grid corporations and charged by power grid corporations. The income shall be placed into special accounts and used for specified purposes only.	
NDRC	Measures	2006	**Article 18** Additional prices of renewable energy power are adjusted by the department of price under the State Council. The adjustment cycle shall not be less than 1 year.	
NDRC	Guidance	2005	NRDC guidance on promoting trans-regional electricity trading	
NDRC	Guidance	2005	The State Grid is responsible for organizing trans-regional electricity trading.	Efficiency of smart grid systems may increase cost effectiveness and reduce energy loss associated with trans-regional electricity trading.
NDRC	Guidance	2005	Sending and receiving prices determined by the government shall be strictly followed. In areas without national regulations, the price is determined by negotiation of both the sending and receiving ends in reference to the average of sending and receiving prices in both areas. Trading prices within market trading area are determined by market.	
NDRC	Guidance	2005	Sending and receiving prices can follow peak-valley and high-low prices under contract or agreement. The prices shall not exceed 70% of the set price.	
NDRC	Guidance	2005	Trans-regional electricity transmission prices shall report to relevant department for approval and issue to major trading parts under relevant regulations.	
NDRC	Measures	2005	Temporary Measures on on-grid electricity price management	
NDRC	Measures	2005	**Article 9** While maintaining a relatively stable general price level, peak-valley and high-low price systems will be gradually implemented.	TOU (peak-valley) pricing has been an important introduction for customers to potential future

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
NDRC	Measures	2005	**Article 10** While reflecting supply and demand relationships in good times, on-grid price links to fuel price when fuel price rises and declines by large margins.	dynamic pricing programs.
NDRC	Measures	2005	**Article 12 "**Two-part Tariff" system is implemented for power plants in competition for connecting grid. Capacity price is determined by the relevant governmental department while electricity degree price is formed by market.	
NDRC	Measures	2005	**Article 19 I**n electricity markets within which a power grid corporation is the only buyer, partial or total electricity of power plants is allowed to compete for connecting grid at spot market. On the basis of open bidding and adequate competition, power grid corporations and power plants are allowed to make long-term trades.	
NDRC	Measures	2005	**Article 21** In electricity markets with power plants and consumers, electricity quantity and price are determined by agreements of both sides. In front-end competition, relative rules are made to adjust agreed upon prices.	
NDRC	Measures	2005	**Article 22** After competition for connecting grid, retail prices link to on-grid prices.	
NDRC	Measures	2005	Temporary Measures on electricity transmission and distribution management	
NDRC	Measures	2005	**Article 13** Under the management system of cost plus revenue, government price departments supervise the total income of electricity transmission and distribution business in power grid corporations, and determine all kinds of electricity transmission and distribution prices on basis of approved income.	Efficiency of smart grid system may increase cost effectiveness and reduce energy loss associated with long haul energy transmission.
NDRC	Measures	2005	**Article 14** The approved income of grid-sharing service and special service shall be determined. The approved income is composed of approved cost, approved revenue, and tax.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
NDRC	Measures	2005	**Article 25** The electricity transmission and distribution price and grid-connecting price of grid-sharing service and special electricity transmission price are determined by department of price under the State Council. Grid-connecting price for trans-provincial grids is determined by the department of price under the State Council. Grid-connecting price for provincial grids is proposed by the department of price on provincial level and approved by the department of price under the State Council. The electricity distribution price for independent electricity distribution industries is determined by department of price on provincial level.	
National Energy Administration (NEA)	Technological principles	2010	Rural grid reform and upgrade technological principles	
NEA	Technological principles	2010	In an upgrade of rural power grids, smart grid implementation shall be reasonably propelled. Pilot projects of new energy dispersed grid-connecting, distribution automation, intelligent distribution district and rural power consumption information collection shall be vigorously demonstrated.	Smart grid and related technology (smart meter) implementations are directly supported in rural communities.
NEA	Technological principles	2010	One meter shall be mounted on each house; the meter shall be suitable for loading and capacity of no less than 4KW.	
NEA	Technological principles	2010	Centralized meter-copy devices could be mounted and a smart meter application could be gradually popularized in some areas.	
NEA	Technological principles	2010	The complete needs of various automatic systems shall be considered in newly implemented and upgraded automatic systems. Data collecting platform shall be planned and designed unified.	
NEA	Technological principles	2010	Communication systems in rural power grids shall meet the demands for data, voice and image transmission in automatic systems.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
State Electricity Regulation Commission (SERC)	Measures	2007	Method for supervising power grid enterprises fully purchasing renewable energy electricity	
SERC	Measures	2007	**Article 5** Power grid corporations above the provincial level shall make implementation plans for supporting grid facilities for renewable energy power generation. Power grid corporations shall construct or upgrade supporting grid facilities for renewable energy power generation according to plans and finish the construction, test, acceptance, and application of connecting projects of renewable energy power generation by given time.	Regulatory support for renewable energy increases support for incorporation into the grid, placing a reliance on smart grid technologies that allow for this incorporation.
SERC	Measures	2007	**Article 6** Power grid corporations and renewable energy power generation corporations shall make agreements for electricity purchasing and grid-connecting and dispatching.	
SERC	Measures	2007	**Article 8** Power dispatching stations shall make and implement power generation dispatching according to relevant regulations and requirements for renewable energy power fully connecting grid.	
SERC	Measures	2007	**Article 10** Power grid corporations shall fully purchase the grid-combined renewable energy power within its area.	
SERC	Measures	2007	**Article 11** Power grid corporations shall settle electricity fees and allowance in a timely manner, according to state approved on-grid price, allowance rate and electricity trade agreements of renewable energy electricity.	
SERC	Rules	2007	Rules of power grid operating (Trial)	
SERC	Rules	2007	**Article 30** Power grid corporations and dispatching stations are responsible for keeping frequency voltage and electricity supply stable.	Increased pressure on grid reliability may create additional support for smart grid development.
SERC	Rules	2007	**Article 39** Power grid corporations and users shall arrange maintenance according to plans and strengthen maintenance of equipment to reduce unplanned stop and accident.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
SERC	Rules	2007	**Article 40** Power grid corporations and users shall offer supportive services for keeping voltage and frequency stable and recovering from faults.	
SERC	Measures	2007	Methods on supervision and management of electric Power Reliability	
SERC	Measures	2007	**Article 7** Power grid corporations shall report the following information: reliability of electricity transmission and dispatching facilities; reliability of direct current electricity transmission system; reliability of electricity supply system; electricity reliability management report and technical analysis report.	Information reporting requirements create additional support for smart grid and smart metering development.
SERC	Rules	2007	Temporal rules of management and supervision of network and information security in power electric industry.	
SERC	Rules	2007	**Article 9** Power grid corporations shall adopt classified protection for their network and information systems according to the national requirements for information system safety, classified protection systems, and electric power secondary system safety protection.	Network and information safety in the electric power industry will be much more important after implementation of smart grid requirements such as classified protection system, risk assessment, emergency preplans, a full-time job position and special fund will increase the cost of power grid and power generation corporations.
SERC	Rules	2007	**Article 10** After determining its own information safety grade according to the national requirements for information system safety, classified protection system, and electric power secondary system safety protection, each electric power corporation shall use information technology products and services that meet the demands of safety protection. Electric power corporations are encouraged to use advanced and matured home-made product with independent intellectual property to implement or upgrade information system safety protection projects.	
SERC	Rules	2007	**Article 11** On completing information system construction or upgrading, electric power corporations shall entrust qualified test institutions to regularly verify the condition of the information system safety.	
SERC	Rules	2007	**Article 12** Electric power corporations shall follow relevant regulations to undertake safety risk assessment work, establish and improve information safety self-assessment and examination-assessment systems and entrust qualified test institutions to do risk assessment work.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
SERC	Rules	2007	**Article 14** Electric power corporations shall make and revise their own network and information safety emergency preplans and practice emergency drills according to industrial preplans.	
SERC	Rules	2007	**Article 17** Electric power corporations shall create a full-time information safety position; staff shall pass relevant examinations.	
SERC	Rules	2007	**Article 19** Electric power corporations shall establish network and information system safety mechanisms for fund guarantees.	
SERC	Measures	2006	Temporal methods of grid-connecting power plants ancillary service management.	
SERC	Measures	2006	**Article 5** Supportive services provided by grid-combined power plants are divided into two types: basic service and paid service.	Fixed payments to power plants will need to be considered as they affect DR pricing strategies.
SERC	Measures	2006	**Article 6** Basic service shall be provided by power plants to keep electric power system safe and stable and to guarantee electricity quality. Such service includes frequency modulation, basic peak shifting, and basic reactive power modulation. Basic service is unpaid.	
SERC	Measures	2006	**Article 7** Paid service is provided by grid-combined power plants, including automatic generation control (AGC), paid peak shifting and black start.	
SERC	Measures	2006	**Article 22** A compensation mechanism for supportive service is established according to principles of “special account, balanced budget and reasonable compensation. ”	
SERC	Measures	2006	**Article 23** According to local grid conditions, two kinds of compensation methods are available for selection: (1) compensation is made according to principles of “compensation for cost and reasonable profit,” compensation funds come from examination fees for supportive service, and the shortage is shared by grid-combined power plants. (2) Examination fees for supportive service are allocated to grid-combined power plants according to their contribution.	
SERC	Notice	2006	SERC notice on supervision of trans-regional electricity trading price.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
SERC	Notice	2006	On the promulgation date of this notice, SERC is responsible for auditing electricity transmission price of new trans-regional electricity transmission lines and then reports to NDRC for approval.	Pricing is set at the national level and affects local utilities from developing additional DR incentives.
SERC	Measures	2004	Temporal methods on power consumers purchasing electricity directly from experimental units of power generation enterprises.	
SERC	Measures	2004	Power grid corporations shall offer on-grid electricity transmission service on condition of transmission capacity, operation and safety permission.	Pricing is set at the national level and affects local utilities from developing additional DR incentives.
SERC	Measures	2004	The prices and settlement methods of direct electricity purchase from power plants by large users are determined by negotiation and indicate in contract.	
SERC	Measures	2004	Electricity transmission and distribution prices are determined by government price departments according to principles of "reasonable cost, reasonable profit, paying taxes in conformity with law and fair burden."	
SERC	Measures	2004	Power grids are responsible for offering special and supportive service according to requirements of reliability and service quality. Power plants and large users provide supportive service to power grid corporations according to agreements. Special and supportive prices shall comply with relevant regulations.	
SERC	Rules	2003	Temporal rules of trans-regional and trans-provincial electric power dispatching optimizing.	
SERC	Rules	2003	State Grid Corporation is responsible for inter-grid electricity dispatching and electricity trading within its duty area.	Peak shifting measures are already being encouraged at the grid level. Demand-side management will be an additional tool to help the grid manage its load.
SERC	Rules	2003	Power grid corporations are allowed to participate in trans-regional electricity trading as traders.	
SERC	Rules	2003	Power grid corporations and affiliated dispatching stations shall strengthen load forecasts and provide accurate long-term, mid-term, short- term, and ultra-short-term load forecasts.	
SERC	Rules	2003	Dispatching institutions shall adopt peak-shifting measures on connected grids according to peak-valley and high-low conditions within grids.	

Related Governmental Sectors and Institutions	Policies			
	Policy Type	**Year**	**Policy Name and Articles**	**Implications for Smart Grid / Demand Response Programs**
Ministry of Finance (MF)	Notice	2011	Notice on further propelling the application of renewable energy building	Regulatory support for renewable energy increases support for incorporation into the grid, placing a reliance on smart grid technologies that allow for this incorporation.
MF	Notice	2011	Temporary measures on the administration of the earmarked fund for the development of Internet of Things	
MF	Notice	2011	Notice on further propelling public building energy conservation	
MF	Notice	2011	State revenue supports areas where conditions permit development of a local, public-building energy consumption monitoring platform and implementation of subentry measures and dynamic monitoring in major buildings. And energy consumption quota standard shall be made to strengthen public-building energy conservation.	Pressure on building efficiency will create demand for building management systems and additional energy efficiency technologies that may tie into a smart metering device, making future DR programs more effective.
MF	Notice	2011	Strengthen the development of a public-building energy conservation monitoring system and the supervision of quality safety in the total process of energy conservation upgrade. Strengthen safety controls in relevant upgrade projects, and strengthen quality management in materials of measurement instruments.	
MF	Notice	2010	Notice on adjusting import tax policy of major technical equipment catalogue.	Regulation and control of technology imports
MF	Notice	2010	Catalogue of non-duty-free imported major technical equipment and products (Edited in 2010)	
MF	Notice	2010	Catalogue of government-supported major technical equipment and products (Edited in 2010)	
Ministry of Housing and Urban-Rural Development (MHURD)	Specifications	2011	1000KV over-head transmission line design specification.	Standards may increase smart grid construction costs.

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
MHURD	Specifications	2011	1000KV transformer substation design specification.	
MHURD	Specifications	2011	35kV～110kV transformer substation design specification.	
Ministry of Environmental Protection (MEP)	Technical regulations	2007	Technical regulations on environmental impact assessment of electric & magnetic fields related with HVDC transmission engineering(exposure draft)	
MEP	Technical regulations	2007	Technical guidelines for environmental impact assessment of electric power transmission and conversion projects (exposure draft)	
MEP	Specifications	2007	Technical guidelines for environmental protection in ecological construction projects for check & accept completed projects.	
MEP	Standards	2007	Emission standard of air pollutants for electrical industry from electron terminals products (exposure draft)	
MEP	Standards	2007	Discharge standards for electrical industrial pollutants from semiconductor industry (exposure draft)	
MEP	Standards	2007	Discharge standards for electrical pollutants from electrical unit industry (exposure draft)	
MEP	Standards	2007	Discharge standard of pollutants for electrical industry—special electronic materials (exposure draft)	
MEP	Standards	2007	Discharge standard of electrical industrial pollutants from electro-vacuum, flat panel display and photoelectron industry (exposure draft)	
MEP	Specifications	2010	Technical specifications of pollution control for processing waste electrical and electronic equipment.	
Ministry of Commerce (MC)	Measures	2008	Measures on the control over the import of electromechanical products	Regulation and control of technology imports
General Administration of Customs (GAC)	Measures	2011	Relevant policies and measures on the customs support software industry and integrated circuit industry development	Regulation and control of technology imports

Related Governmental Sectors and Institutions	Policies			
	Policy Type	Year	Policy Name and Articles	Implications for Smart Grid / Demand Response Programs
GAC	Measures	2009	Implementation measures of the customs of the People's Republic of China on regulation of the People's Republic of China on the customs protection of intellectual property rights	
GAC	Measures	2009	Measures of the customs of the People's Republic of China on tax reduction and exemption of import and export Goods	
GAC	Rules	2007	Provisions of the customs of the People's Republic of China on the administration of the commodity classification of import and export goods	
GAC	Measures	2005	Measures of the customs of the People's Republic of China on duties of import and export goods.	

Source: Various Government Agencies' sites.

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Appendix D. Facility Audit Results

This appendix summarizes the results of auditing three customer sites: TEDA Administration Building, TEDA Library, and Kumho Tire. The selected pilot sites offer a good example of typical commercial buildings (i.e., HVAC system design, and major HVAC and lighting equipment types. Geographical differences in commercial buildings across China are not significant for the purposes of this study and are mostly limited to the length and severity of the winter and summer seasons. HVAC system designs and equipment types will be very similar for most large commercial buildings across China.

This project's analysis addresses typical DR programs used in the USA: time of use (TOU), critical peak pricing (CPP), and real time pricing (RTP), generically. Details of implementing these types of DR programs in China will differ from USA experience, due to regulatory constraints and other factors.

D.1 TEDA Administration Building

Table App-18. through Table App-21. describe the TEDA Administration building and it's systems.

Table App-18. TEDA Administration Building: Basic Site Information

Building Sector	Commercial Building
# of Employees	about 1000 persons
Hours of Operation	8:30 to 17:00, Monday to Friday

Table App-19. TEDA Administration Building: Building Information

Floor	Main Functionality of Premises on Each Floor
Total Floor Area	Total 52,653 Sq.m, including 4 wings (Wing A and B have 5 floors, Wing C has 14 floors and Wing D is an indoor garden). The basement is 12,777 Sq.m.
Basement	Parking garage, chiller plant, electrical rooms, power generator room
Wing A	
1/F	Hall for tax declaration
2/F-5/F	Offices
Wing B	
1/F	Service center, shops, banks
2/F	Cafeteria
3/F-5/F	Offices
Wing C	
1/F-4/F	Meeting rooms
6/F-10/F	Offices
11/F-14/F	Management offices
R/F	Cooling tower, elevator control room, AHU rooms
Wing D	Indoor Garden

Table App-20. TEDA Administration Building: Electricity Feed Information

Electricity Feed Type	Detail
Main power supply	Two main circuits, 10kV for each
Standby power supply	Diesel generator (Brand: WESTAC, Model: WPC1278, Size: 1250KVA), only for fire emergency usage
Electricity consumption(kWhr) for previous full year	Total electricity consumption for year 2011 is 4,848,000 kWhr.

Table App-21. TEDA Administration Building: Facilities Information

Facility	Detail
Chiller	Three Carrier chillers: 2 x 700 RT (input power 485 kW) and 1 x 400 RT (input power 212kW).
	Supply/return chilled water temp: 7/12 C
	The chillers aren't connected to BMS. They are manually operated during cooling season (May to September).
Chilled water pump	45KW, 共计180KW 4 x 45 kW Chilled water pumps (2 standby)
	All the pumps are tied into BMS (Brand: KMC) and can be monitored and on/off controlled. Only one has VFD installed. However, this VFD is not used.
Condenser water pump	3 x 75 kW condenser water pumps (1 standby)
	All the pumps are tied into BMS (Brand: KMC) and can be monitored and on/off controlled. Only one has VFD installed. But this VFD is used for occasionally.
Air handling unit (AHU)	13 x AHUs, total fan motor power is 418.2 kW. All the AHUs are tied into BMS (Brand: KMC) and fan motors have VFDs installed already. SAT = 22 to 23 C.
Pre-cooling air handling unit (PAU)	10 x PAUs, total fan motor power is 70 kW. All the PAUs are tied into BMS (Brand: KMC) and fan motors have no VFDs installed.
Fan coil unit (FCU)	676 x FCUs, total fan motor power is 84.5 kW. Local control.
Cooling tower	3 x cooling towers (4 fans for each). The fans are tied into BMS (Brand: KMC) and can be on/off controlled.
Lighting	Total 427kW (Wing A 1/F to 5/F: 150kW; Wing B 1/F to 5/F: 150kW; Wing C 1/F to 4/F: 36kW; Wing C 6/F to 10/F: 50kW; Wing C 11/F to 14/F: 3kW; Basement: 38 kW) Office plug load is connected to the lighting circuit.
Passenger & cargo lifts	13 x elevators (11kW x8 in Wing A and B, 15kW x3 + 22kW x2 in Wing C) 4 x escalators (total 26kW) All elevators and escalators aren't tied into BMS. The escalators are automatically running at low speed during idle time.

Building management system	Chilled water pumps, condenser water pumps, AHU, PAU, cooling tower fans and basement's lighting can be controlled by KMC's BMS system. Otherwise, lighting can be controlled by Honeywell BMS system. Due to some faulty DDCs, the customer doesn't currently use the Honeywell BMS to control this part of lighting. This lighting is controlled manually.
Meter installed	Two master utility meters (non-smart meter) are installed on the main 10kV power supply. Some low voltage smart meters, including 2 master meters, are installed. The load data of these meters was collected by Tianjin Energy Center and can be viewed on its website.

D.2 TEDA Library

Table App-22. through Table App-25 describe the TEDA Library and it’s systems.

Table App-22. TEDA Library: Basic Site Information

Building Sector	Library & Commercial Building
# of Employees	about 3000 (visitors) + 700
Hours of Operation	Library open hours: 9:00am – 8:00pm in winter, 9:00am – 9:00pm in summer, Tuesday-Sunday Archives working hours: 8:30am - 5:00pm, Monday - Friday

Table App-23. TEDA Library: Building Information

Floor	Main Functionality of Premises on Each Floor
Total floor area	Total is about 66,000 Sq.m, including library (5 floors) and archives (11 floors). The basement is about 16,000 Sq.m.
Basement	Parking garage, chiller plant, electrical rooms, power generator room, pump room, AHU room, and exhaust fan rooms
Library	
1/F-4/F	The left half of the library (Area1) is the reading area. The right half of the library(Area2) is the office, the editors of information, children and foreign language reading room, personal research room, electronic retrieval room and the reader service department
5/F	Lecture and exhibition hall
Archives	
1/F-4/F	Archives
5/F	Archives Offices
6/F-11/F	Offices
R/F	Cooling Tower, Elevator Control Room and Exhaust Fan Room

Table App-24. TEDA Library: Electricity Feed Information

Electricity Feed Type	Detail
Main power supply	Two main circuits, 10kV for each
Standby power supply	Diesel generator (Mitsubishi, Model: MG-HCK7F, Size: 1650KVA), mainly for fire alarm system and data center emergency usage.
Electricity consumption(kWhr) for previous full year	Total electricity consumption(kWhr) for year 2010: 5948440 kWhr Total electricity consumption(kWhr) for year 2011: 5868560 kWhr

Table App-25.TEDA Library: Facilities Information

Facility	Detail
Central chilled water plant	Four York centrifugal chillers: 4 x 500 RT (input power 346.5 kW)
	Supply/Return chilled water temp: 7/12 C
	All the chillers are connected to BMS (Honeywell EBI). But they are not controlled by BMS currently. They are manually operated during cooling season (May to September).
Primary chilled water pump	5 x 30 kW primary Chilled water pumps
	All the pumps are tied into BMS (Honeywell EBI), but they are not controlled by BMS currently and have no VFD installed.
Secondary chilled water pump	4 Secondary Chilled water pumps, 2 x 45 kW + 2 x 37kW
	All the pumps are tied into BMS (Honeywell EBI), and all pumps have VFDs installed. But they are not controlled by BMS currently. The VFDs are only adjusted locally.
Cooling tower	10 x cooling towers (8 x 5.5 kW cross-flow cooling towers + 2 x 3 kW counter-flow cooling towers). They are not tied into BMS.
Condenser water pump	5 x 55 kW condenser water pumps
	All the pumps are tied into BMS (Honeywell EBI), but they are not controlled by BMS currently and have no VFD installed.
Cooling water make-up pump	2 x 11 kW cooling water make-up pumps
	All the pumps are tied into BMS (Honeywell EBI), and all pumps have VFDs installed. But they are not controlled by BMS currently. The VFDs are only adjusted locally.

Air handling unit	50 x AHUs, total fan motor power is 224.9 kW. All the AHUs are tied into BMS (Honeywell EBI) and fan motors have VFD installed already. But 10% VFDs are disconnected from BMS by the customer due to the device problems.
Pre-cooling air handling unit	33 x PAUs, total fan motor power is 41.25kW. All the PAUs are tied into BMS (Honeywell EBI), but fan motors have no VFD installed.
Constant temperature and humidity machine	13 x 29 kW constant temperature and humidity machines in archives storerooms.
Exhaust fan	21 exhaust fans in library (total power is 21.85 kW); 9 exhaust fans in archives (total power is 54.25 kW); 6 exhaust fans in archives storeroom (total power is 18 kW); 9 exhaust fans in basement (total power is 18.35 kW). All the exhaust fans are tied into BMS (Honeywell EBI).
Fan coil unit	513 x ceiling-mounted FCU, 419 x floor-stand FCU. All FCUs are controlled locally.
Diversion fan	69 x 0.12 kW diversion fans in basement.
Lighting	The plug circuits are separated from lighting circuits. Total lighting power is 569.9 kW (Library: 299.4 kW; Archives: 226.7 kW; Basement: 43.8 kW). The lighting control is tied into BMS (Honeywell EBI).
Passenger & cargo lifts	10 x elevators (5 x 15kW in Library, 3 x 15kW + 1 x 10.5kW + 1 x 11kW in Archives) Not all elevators are tied into BMS.
Building management system	HVAC, exhaust system, water supply & drainage system, and lighting control have been integrated with Honeywell EBI building management system.
Meter installed	Two utility master meters (smart meter) are installed on the main 10kV power supply. Some low voltage smart meters, including 2 master meters, are installed. The load data of these meters is collected by SCADA NT system (Nanjing INT Company).

D.3 Kumho Tire

Table App-26 through Table App-29 describe the Kumho Tire site and its systems.

Table App-26. Kumho Tire: Basic Site Information

Industrial Sector	Motor Vehicle Parts/Rubber Products
# of Employees	about 2300
Primary products manufactured	Tires
Hours of operation	24 hours x 7 days, 4 shifts

Table App-27. Kumho Tire: Building Information

Floor	Main Functionality of Premises on Each Floor
Total Floor Area	about 310,000 sqm

Table App-28. Kumho Tire: Electricity Feed Information

Electricity Feed Type	Detail
Main power supply	One 110kV main circuit, 2 transformers.
Standby power supply	1 diesel generators (1 x 2000 kW for phase I plant,). They are mainly for fire alarm system, water treatment system, power supply usage.
Electricity consumption(kWhr) for previous full year	Total electricity consumption(kW.h) for January to September of year 2011: 74,061,027 kW.h

Table App-29. Kumho Tire: Facilities Information

Facility	Detail
Central chilled water plant	Four LS direct-fired lithiumbromide absorption-type refrigerating machines (270 RT, input power 155 kW for each); Three YORK screw refrigerating machines (input power 475 kW for each)
	For airconditioning, the Supply/Return chilled water temperature is 11/15℃; For production, the Supply/Return chilled water temperature is 16/20℃.
	Due to many heating equipments in production workshops, so these areas need to be cooled year round. The chiller general operation is: November to April uses cooling tower cooling, May to October uses chiller cooling. In summer, 2 lithiumbromide refrigerating machines and 2 screw refrigerating machines are used. The remaining machines are spare.
Chilled water pump	Total 8 chilled water pumps: 3 x 15 kW + 5 x 160 kW .
Cooling tower	Total 19 cooling towers: 5 for process cooling(5 x 7.5 kW), 14 for HVAC(14 x 15 kW)..
Condenser water pump	Total 12 condenser water pumps: 4 x 90 kW + 8 x 75 kW
Air handling unit	Total 68 air handling units: 15 x 37 kW + 53 x 22 kW =1721kW
Exhaust fan	Total 192 exhaust fans are used for Vulcanization and Rolling Workshops. 3 kW for each.
DR Panel Installation	DR Panel is installed in Power Monitoring Room.
Compressors	Total 8 compressors (3 x 315 kW + 5 x 710 kW). The compressors are for process usage.
Lighting	Total lighting power is 1188 kW.
Network	Currently, there is no spare network port to be used for DR controller. Need their IT support to do wiring and configuration.
Meter Installed	There are 2 utility master meters (smart meter) installed on two 6.3kV power supply circuits by Tianjin power bureau. In addtion, 2 smart meters(Brand: SFERE, Model: PD194E-2S4) are installed for monitoring voltage temporarily.

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Appendix E. Install OpenADR Gateway

Appendix E describes OpenADR Gateway installation at each site.

E.1 TEDA Administration Building

OpenADR Gateway is installed in the power distribution room.

- **Connection with DRAS.** OpenADR Gateway is access to Internet by DHCP from TEDA Administration office network, which can communicate with DRAS directly.
- **Connection with Power Meter.** Power Meter communicates with OpenADR Gateway by Modbus/RS485.
- **Connection with BMS.** Four DO of OpenADR Gateway is connected with DI of KMC system.

E.2 TEDA Library

The OpenADR Gateway is installed in the Library's power distribution room.

- **Connection with DRAS.** OpenADR Gateway accesses the Internet using DHCP from TEDA Library office network, which can communicate directly with DRAS.
- **Connection with Power Meter.** Power Meter communicates with OpenADR Gateway by JBus/Modbus.
- **Connection with BMS.** Four DO of OpenADR Gateway is connected with DI of Honeywell EBI.

E.3 Kumho Tire

The OpenADR Gateway is installed in a power substation at Kumho Tire.

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Appendix F. Demonstration ADR Event Results

Appendix F contains the ADR events in the pilot demonstration.

F.1 TEDA Admin Building ADR Shed Strategy

Table App-30. TEDA Administration Building Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - Limit fan variable frequency driver	Automated	5.8	30.9	30.9
Strategy B - Reduce fan quantity	Automated	8.8	17.6	35.2
Strategy C - Shut off elevators	Manual	17.6	35.2	64.8
Strategy D - Lighting switching	Manual	3.6	3.6	3.6
Strategy E - Increase chilled water temperature	Manual	20.8	41.6	62.4
	Total kW Reduction =	**56.6**	**128.9**	**196.9**

F.2 TEDA Library ADR Shed Strategy

Table App-31. TEDA Library Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - Limit AHU fan variable frequency driver	Automated	9.8	23.0	32.1
Strategy B - Switch off exhaust fan	Automated	17.8	28.8	37.8
Strategy C - Reduce PAU fan quantity	Automated	4.4	6.6	11.0
Strategy D - Shut off elevators	Manual	21.0	31.5	39.2
Strategy E - Lighting switching	Automated	54.4	161.8	161.8
Strategy F - Increase chilled water temperature	Manual	9.2	18.3	27.5
	Total kW Reduction =	**116.6**	**270.0**	**309.4**

F.3 Kumho Tire ADR Shed Strategy

Table App-32. Kumho Tire Shed Strategy

Demand Reduction Measure	Response Type	Low	Medium	High
Strategy A - AHU Fan Switch Off	Manual		270	557
Strategy B - Shift the Running Time of Rubber Mixers	Manual		1,200	2,400
Strategy C - Shift the Running Time of Semi-finished Rubber Parts Process	Manual		1,195	1,418
Total kW Reduction =			**2,665**	**4,375**

F.4 Event 1 Result

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	973.73	23,126.02	903.71	21,463.17	70.01	1,662.85
During Event	1,592.42	1,592.42	1,339.12	1,339.12	253.30	253.30

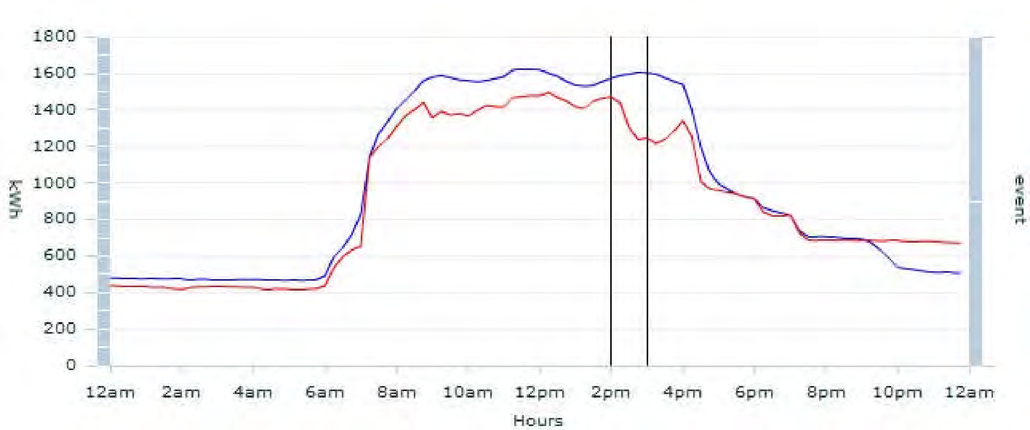


Figure App- 8. TEDA Admin Building Load Curve during Event 1

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	533.12	12,661.55	547.58	13,005.10	-14.47	-343.55
During Event	720.88	720.88	740.80	740.80	-19.92	-19.92

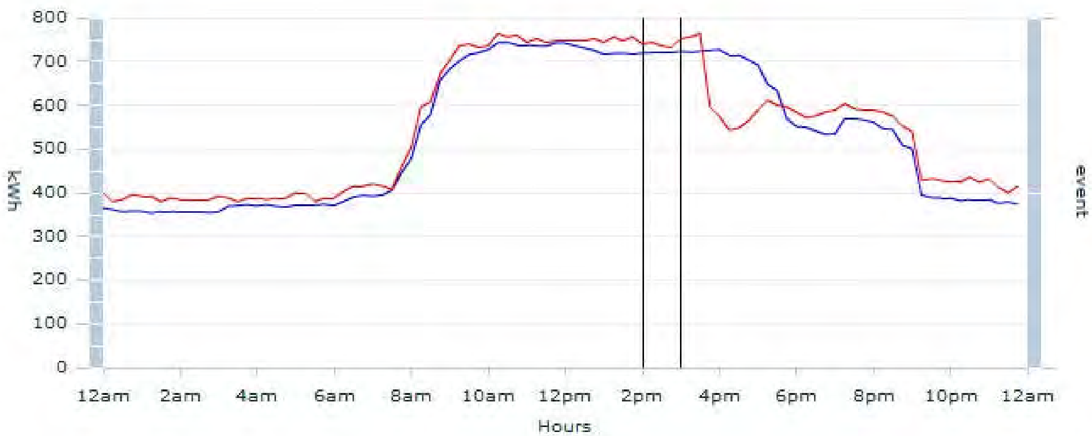


Figure App- 9. TEDA Library Load Curve during Event 1

Table App-33. TEDA Admin Building Survey during DR Event 1

Customer Name	TEDA Admin Building		
Temperature	28.6℃		
Estimated Load Shedding	180kW	Actual Load Shedding	233.38kW
Device Response Survey			
Name	Mode (Auto or Manual)	Actual Operation (Yes√ No×)	Result
Air Conditioner (Frequency reduced to 30Hz)			
AK1	Auto	√	Finished
CK5	Auto	√	Finished
CK6	Auto	√	Finished
AHU Stop			
CCK1	Auto	√	Finished
CCK2	Auto	√	Finished
ACK1	Auto	√	Finished
BCK1	Auto	√	Finished
ACK2	Auto	√	Finished
BCK2	Auto	√	Finished
CK8	Manual	√	Finished
CK7	Manual	√	Finished
BK2	Manual	√	Finished
CK9	Manual	√	Finished
DK1	Manual	√	Finished
Other Devices Stop			
Waterfall pool	Manual	√	Finished
Individual AC 1	Manual	√	Finished
Individual AC 2	Manual	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees?	No		

F.5 Event 2 Result

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	1,114.20	26,462.18	1,027.67	24,407.08	86.53	2,055.10
During Event	1,758.53	3,517.07	1,479.16	2,958.31	279.38	558.76

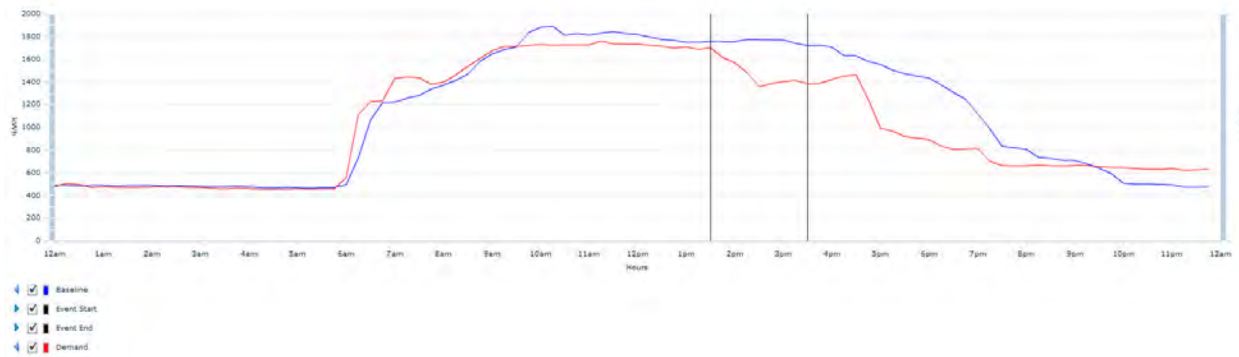


Figure App- 10. TEDA Admin Building Load Curve during Event 2

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	589.75	14,006.56	576.00	13,680.00	13.75	326.56
During Event	793.48	1,586.96	687.11	1,374.22	106.37	212.74

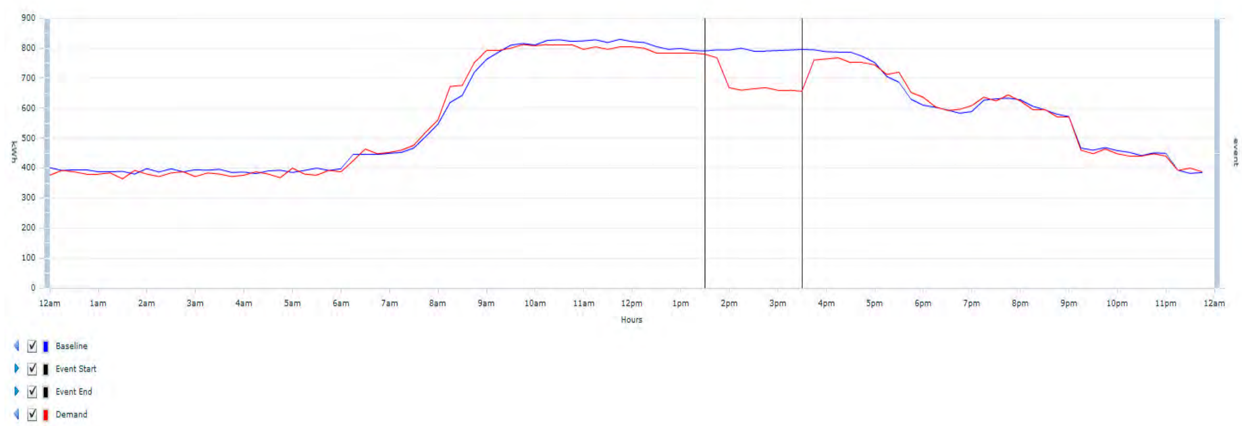


Figure App- 11. TEDA Library Load Curve during Event 2

Table App-34. TEDA Admin Building Survey during DR Event 2

Customer Name	TEDA Admin Building		
Temperature	31.7℃		
Estimated Load Shedding	180kW	Actual Load Shedding	75.01kW
Device Response Survey			
Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Air Conditioner (Frequency reduced to 30Hz)			
AK1	Auto	√	Finished
CK5	Auto	√	Finished
CK6	Auto	√	Finished
AHU Stop			
CCK1	Auto	√	Finished
CCK2	Auto	√	Finished
ACK1	Auto	√	Finished
BCK1	Auto	√	Finished
ACK2	Auto	√	Finished
BCK2	Auto	√	Finished
CK8	Manual	√	Finished
CK7	Manual	√	Finished
BK2	Manual	√	Finished
CK9	Manual	√	Finished
DK1	Manual	√	Finished
Other Devices Stop			
Waterfall pool	Manual	√	Finished
Individual AC 1	Manual	√	Finished
Individual AC 2	Manual	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees?	No		

Table App-35. TEDA Library Survey during DR Event 2

Customer Name	TEDA Library		
Temperature	31.7℃		
Estimated Load Shedding	150kW	Actual Load Shedding	81.07kW
Device Response Survey			
Device Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Exhaust Fan Stop			
PW1-21	Auto	√	Finished
P1-P6	Auto	√	Finished
AHU Stop			
X1-11	Auto	√	Finished
K1-K5	Auto	√	Finished
Lighting Turn Off			
1AL-11AL	Auto	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	Yes	Due to lights turned off, some readers can feel the different during the event.	
Complaints from employees?	Yes	Some readers complained that the event affected their reading activity.	

F.6 Event 3 Result

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	8,252.98	196,008.37	7,959.69	189,042.65	293.29	6,965.72
During Event	8,164.09	16,328.17	7,530.18	15,060.37	633.90	1,267.81

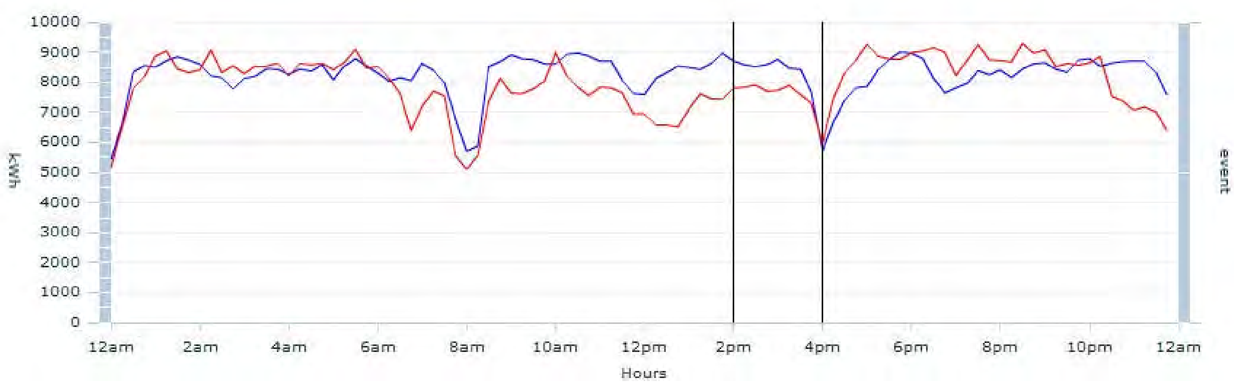


Figure App- 12. Kumho Tire Load Curve during Event 3

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	1,147.16	27,245.04	1,123.24	26,676.89	23.92	568.15
During Event	1,819.99	3,639.97	1,679.20	3,358.40	140.79	281.57

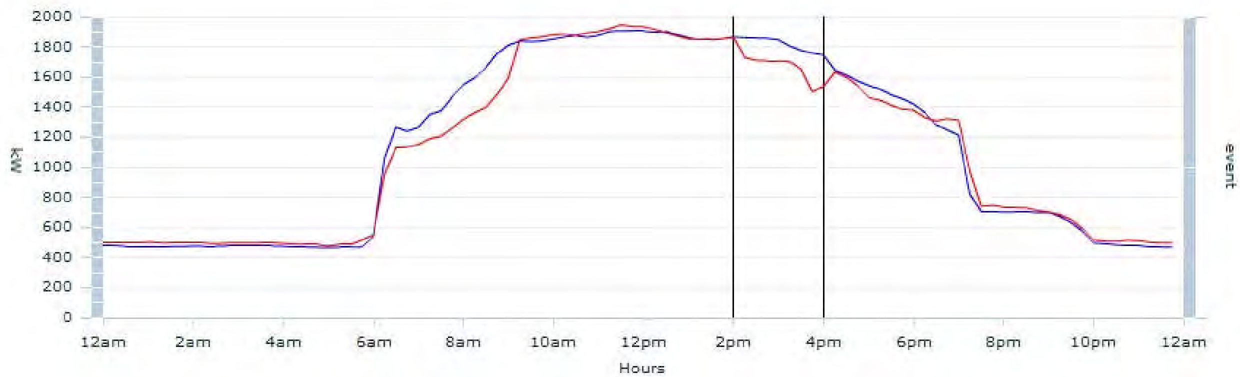


Figure App- 13. TEDA Admin Building Load Curve during Event 3

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	610.11	14,490.14	582.17	13,826.46	27.94	663.68
During Event	822.52	1,645.04	685.78	1,371.56	136.74	273.48

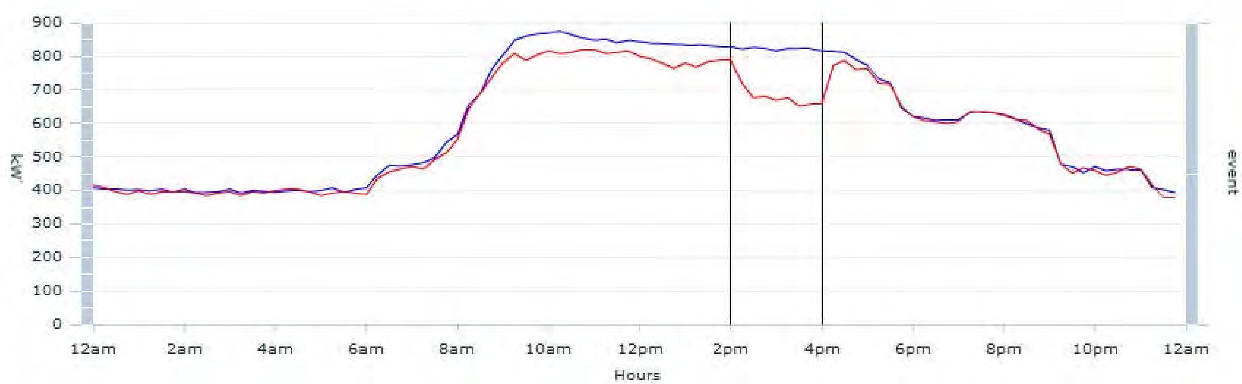


Figure App- 14. TEDA Library Load Curve during Event 3

Table App-36. TEDA Admin Building Survey during DR Event 3

Customer Name	TEDA Admin Building		
Temperature	29℃		
Estimated Load Shedding	180kW	Actual Load Shedding	140.79kW
Device Response Survey			
Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Air Conditioner (Frequency reduced to 30Hz)			
AK1	Auto	√	Finished
CK5	Auto	√	Finished
CK6	Auto	√	Finished
AHU Stop			
CCK1	Auto	√	Finished
CCK2	Auto	√	Finished
ACK1	Auto	√	Finished
BCK1	Auto	√	Finished
ACK2	Auto	√	Finished
BCK2	Auto	√	Finished
CK8	Manual	√	Finished
CK7	Manual	√	Finished
BK2	Manual	√	Finished
CK9	Manual	√	Finished
DK1	Manual	√	Finished
Other Devices Stop			
Individual AC 1	Manual	√	Finished
Individual AC 2	Manual	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees?	No		

Table App-37. TEDA Library Survey during DR Event 3

Customer Name	TEDA Library		
Temperature	29℃		
Estimated Load Shedding	150kW	Actual Load Shedding	136.74kW
Device Response Survey			
Device Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Exhaust Fan Stop			
PW1-21	Auto	√	Finished
P1-P6	Auto	√	Finished
AHU Stop			
X1-11	Auto	√	Finished
K1-K5	Auto	√	Finished
Lighting Turn Off			
1AL-11AL	Auto	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees?	No		

Table App-38. Kumho Tire Survey during DR Event 3

Customer Name	Kumho Tire		
Temperature	29℃		
Estimated Load Shedding	2400kW	Actual Load Shedding	633.9kW
Device Response Survey			
Device Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Stop 2 intermix machines	Manual	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees?	No		

F.7 Event 4 Result

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	7,585.66	180,159.35	5,715.15	135,734.86	1,870.50	44,424.49
During Event	7,237.19	10,855.79	3,197.11	4,795.67	4,040.08	6,060.12

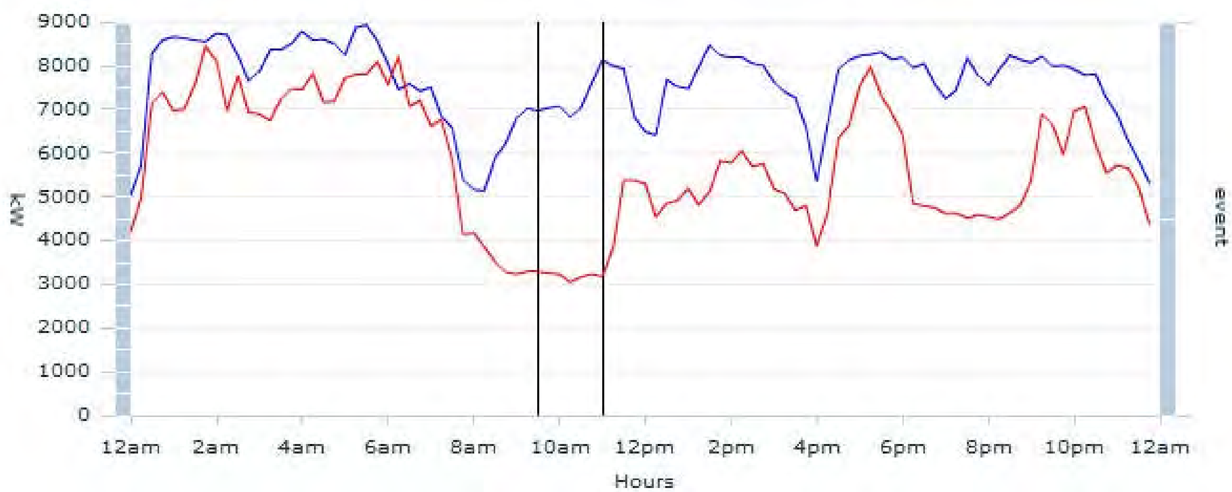


Figure App- 15. Kumho Tire Load Curve during Event 4

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	1,096.13	26,033.13	943.08	22,398.13	153.05	3,635.00
During Event	1,768.15	2,652.23	1,353.54	2,030.31	414.61	621.91

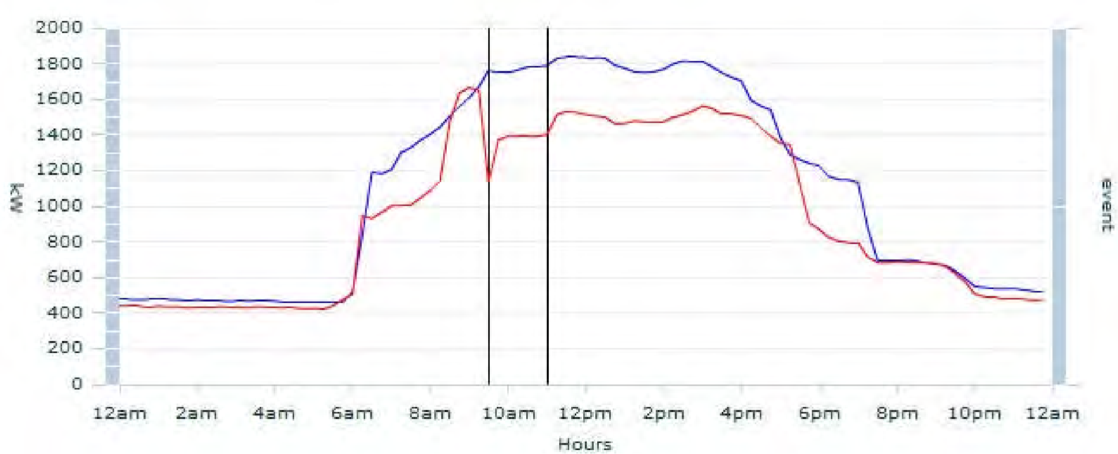


Figure App- 16. TEDA Admin Building Load Curve during Event 4

	Baseline		Actual		Shed	
	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)	Avg(KW)	Total(KWH)
Entire Day	572.33	13,592.92	542.71	12,889.32	29.62	703.59
During Event	810.48	1,215.71	653.71	980.57	156.76	235.14

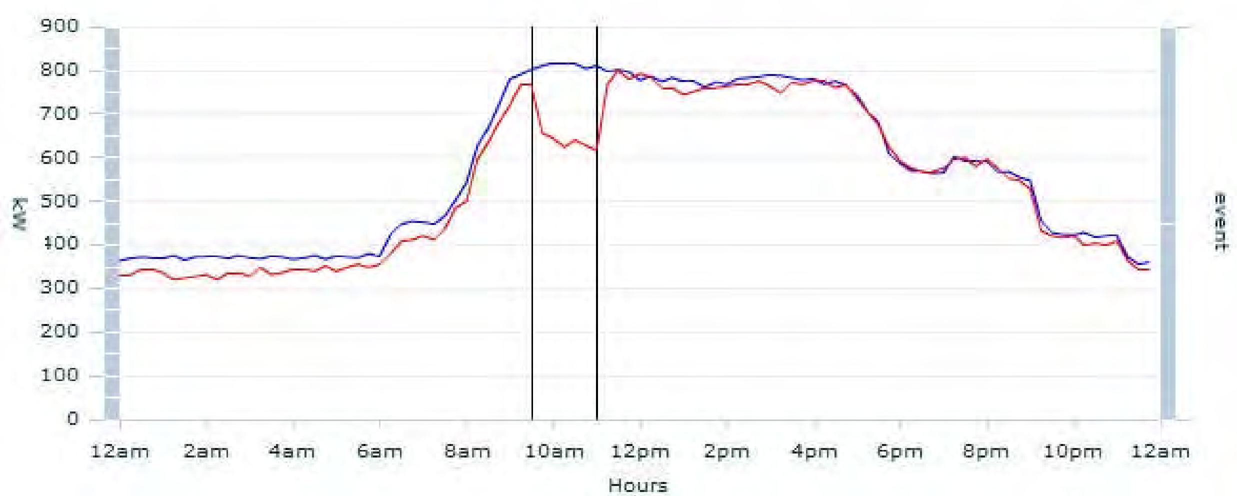


Figure App- 17. TEDA Library Load Curve during Event 4

Table App-39. TEDA Admin Building Survey during DR Event 4

Customer Name	**TEDA Admin Building**		
Temperature	27℃		
Estimated Load Shedding	180kW	Actual Load Shedding	414.61kW
Device Response Survey			
Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Air Conditioner (Frequency reduced to 30Hz)			
AK1	Auto	√	Finished
CK5	Auto	√	Finished
CK6	Auto	√	Finished
AHU Stop			
CCK1	Auto	√	Finished
CCK2	Auto	√	Finished
ACK1	Auto	√	Finished
BCK1	Auto	√	Finished
ACK2	Auto	√	Finished
BCK2	Auto	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees？	No		

Table App-40. TEDA Library Survey during DR Event 4

Customer Name	**TEDA Library**		
Temperature	27℃		
Estimated Load Shedding	150kW	Actual Load Shedding	156.76kW
Device Response Survey			
Device Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Exhaust Fan Stop			
PW1-21	Auto	√	Finished
P1-P6	Auto	√	Finished
AHU Stop			
X1-11	Auto	√	Finished
K1-K5	Auto	√	Finished
Lighting Turn Off			
1AL-11AL	Auto	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees？	No		

Table App-41. Kumho Tire Survey during DR Event 4

Customer Name	**Kumho Tire**		
Temperature	29℃		
Estimated Load Shedding	2400kW	Actual Load Shedding	4040.08kW
Device Response Survey			
Device Name	Mode (Auto or Manual)	Actual Operation(Yes√ No×)	Result
Stop 2 intermix machines	Manual	√	Finished
Stop 5 forming machines	Manual	√	Finished
Stop 13 vulcanizing machines	Manual	√	Finished
Post-Event Survey			
Notification	Email, Phone		
During the event, do employees feel the difference?	No		
Complaints from employees？	No		

Appendix G. OpenADR Gateway Installation and Configuration

Appendix G explains how we configured the OpenADR gateway at each demonstration site.

Figure App- 18 illustrates the OpenADR Gateway.

Figure App- 18. OpenADR Gateway

G.1   TEDA Administration Building

The OpenADR Gateway is installed in the power distribution room. Its connection is illustrated in Figure App- 19 and described below.

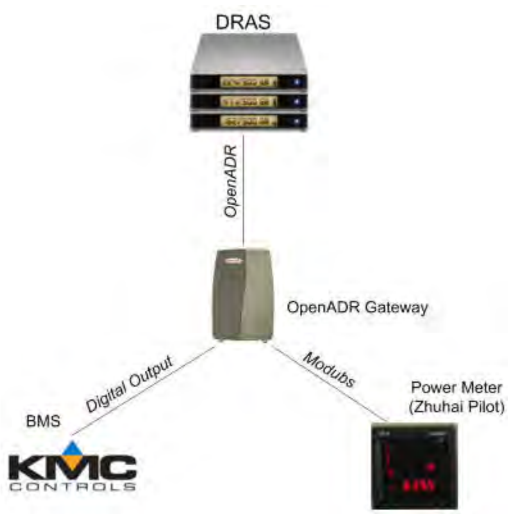


Figure App- 19. TEDA Admin Building OpenADR Gateway Connection

- Connection with DRAS. OpenADR Gateway accesses the Internet using DHCP from the TEDA Administration office network, which can communicate with directly the DRAS.
- Connection with power meter. The power meter communicates with the OpenADR Gateway via Modbus/RS485.
- Connection with building management system (BMS). Four digital outputs on the OpenADR Gateway were connected to digital inputs on the KMC system.
- Based on the auditing results and building owner agreed shedding strategies, some programming work was done in KMC building management system to reflect the mid, low, high load shedding classifications, also to ensure the return of the system to normal after the ADR events. In principle, the KMC building management system is similar to the Honeywell EBI system.

- Figure App- 20 shows the operator's interface of KMC system.

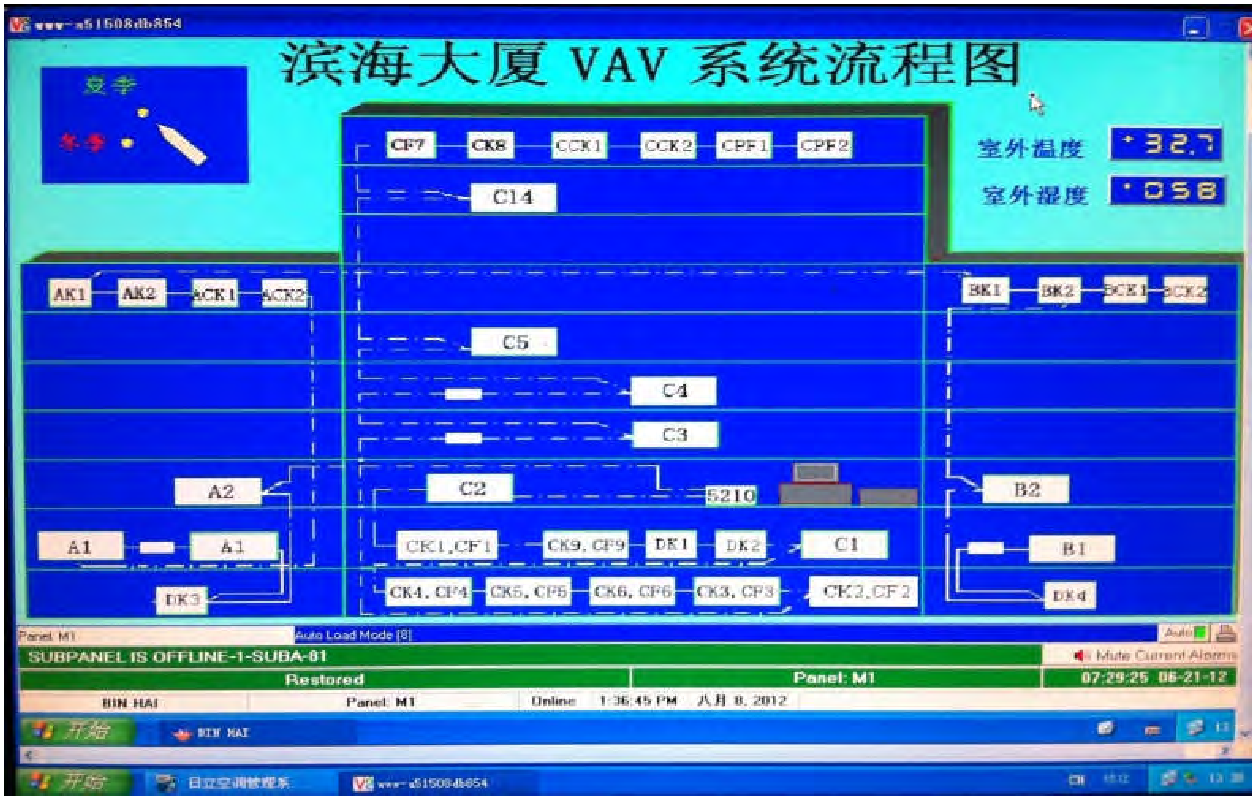


Figure App- 20. KMC VAV Operation Interface

G.2 TEDA Library

The OpenADR Gateway is installed in the library's control room. Its connection is shown in Figure App- 21 and described below.

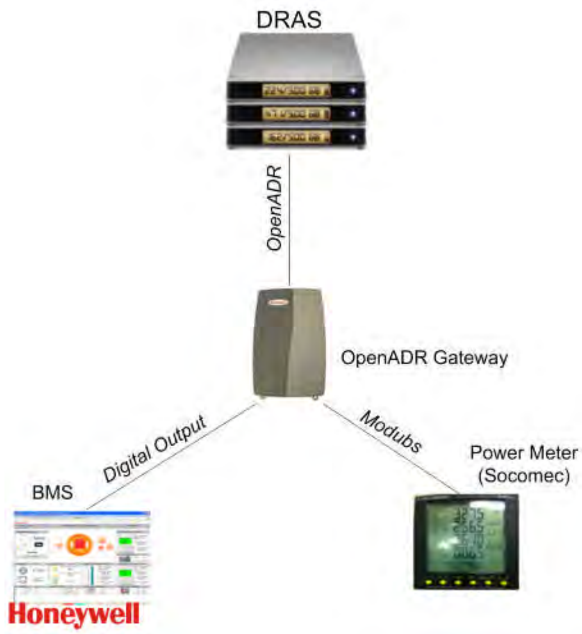


Figure App- 21. TEDA Lib OpenADR Gateway Connection

- Connection with DRAS. OpenADR Gateway accesses the Internet using DHCP from the TEDA Library office network, which can communicate directly with the DRAS.
- Connection with power meter. The power meter communicates with OpenADR Gateway using JBus/Modbus.
- Connection with BMS. Four digital outputs on the OpenADR Gateway is connected with digital input on the Honeywell EBI.
- For the mid, low, high shed requirement from TEDA electricity dispatching center based on the peak situation in the area, the DRAS will prompt OpenADR Gateway to trigger a pre-programmed software which will then turn on/off or change the operating frequencies of VFD motors to reduce the loads. Figure App- 22 is a typical HON EBI system structure.

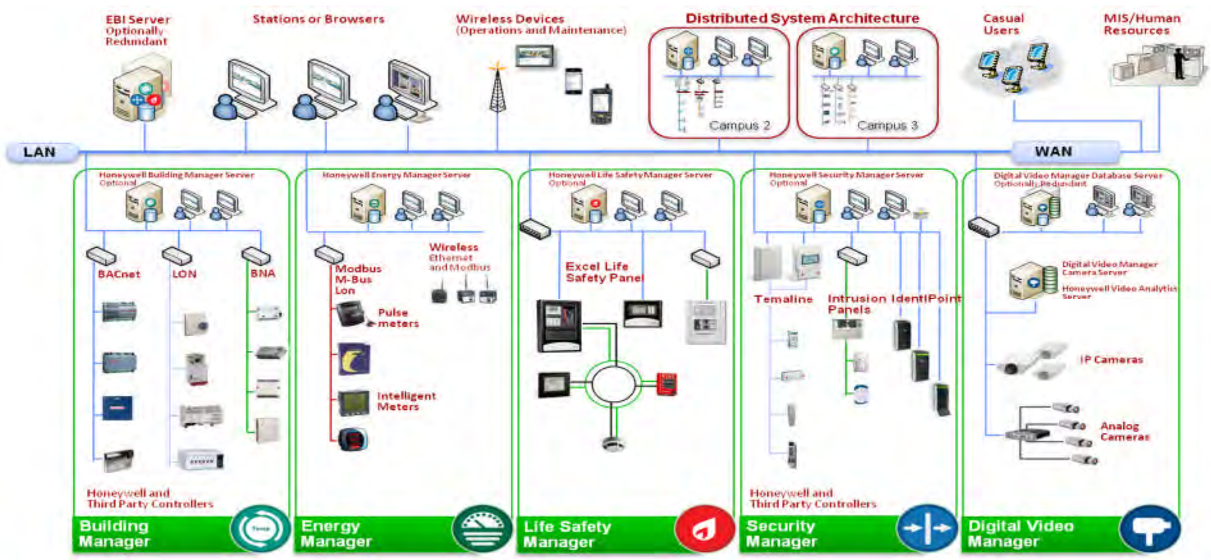


Figure App- 22. Typical Building Management System

G.3 Kumho Tire

The OpenADR Gateway is installed in a power substation at Kumho Tire as shown in Figure App- 23. For security reasons, the OpenADR Gateway is not connected with its control system. Kumho Tire responds to DR events manually.

Figure App- 23. Kumho Tire OpenADR Gateway Connection

- Connection with DRAS. OpenADR Gateway accesses the Internet from the Kumho Tire office network, which can communicate directly with the DRAS.
- Connection with power meter. The power meter communicates with the OpenADR Gateway via Modbus.
- Kumoho tire has many submeters corresponding to key electricity consumption machines , with one Honeywell OpenADR Gateway, 32 submeters were connected together, sending electrical load signals real time to DRAS.

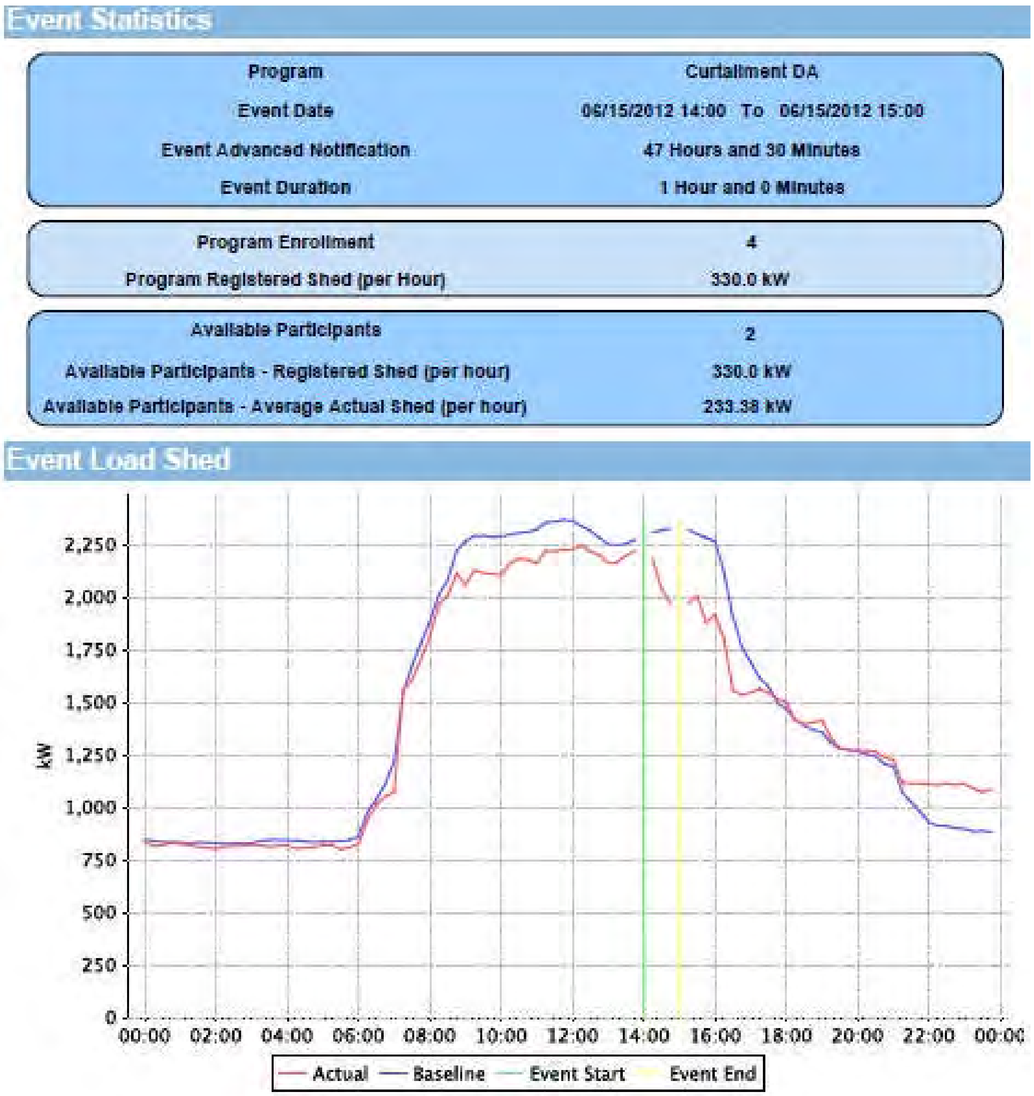
Appendix H. Demonstration Results

Appendix H presents the measured data and other results collected during the demonstration.

H.1 Event 1

Figure App- 24 gives the score card for Event 1. During the event, two participants responded as follows.

- TEDA Admin Building responded very well and contributed 253kW load shedding.
- TEDA Libray didn't respond because its BMS was not working. After the event, one test event is triggered manually to test the BMS so that load shedding occurred during 15:30 to 17:00.



Event Statistics

Program	Curtailment DA
Event Date	06/15/2012 14:00 To 06/15/2012 15:00
Event Advanced Notification	47 Hours and 30 Minutes
Event Duration	1 Hour and 0 Minutes
Program Enrollment	4
Program Registered Shed (per Hour)	330.0 kW
Available Participants	2
Available Participants - Registered Shed (per hour)	330.0 kW
Available Participants - Average Actual Shed (per hour)	233.38 kW

Figure App- 24. Event 1 Score Card

H.2 Event 2

Figure App- 25 gives the score card for Event 2. During this event, two participants responded as follows:

- Because the TEDA Admin Building baseline is much lower than the actual load, its actual load shedding is lower than the estimated load shedding.
- All devices for the TEDA Library respond automatically, so the response speed is very fast.

Event Statistics

Program	Curtailment DA
Event Date	07/06/2012 13:30 To 07/06/2012 15:30
Event Advanced Notification	26 Hours and 30 Minutes
Event Duration	2 Hours and 0 Minutes
Program Enrollment	2
Program Registered Shed (per Hour)	330.0 kW
Available Participants	2
Available Participants - Registered Shed (per hour)	330.0 kW
Available Participants - Average Actual Shed (per hour)	385.75 kW

Event Load Shed

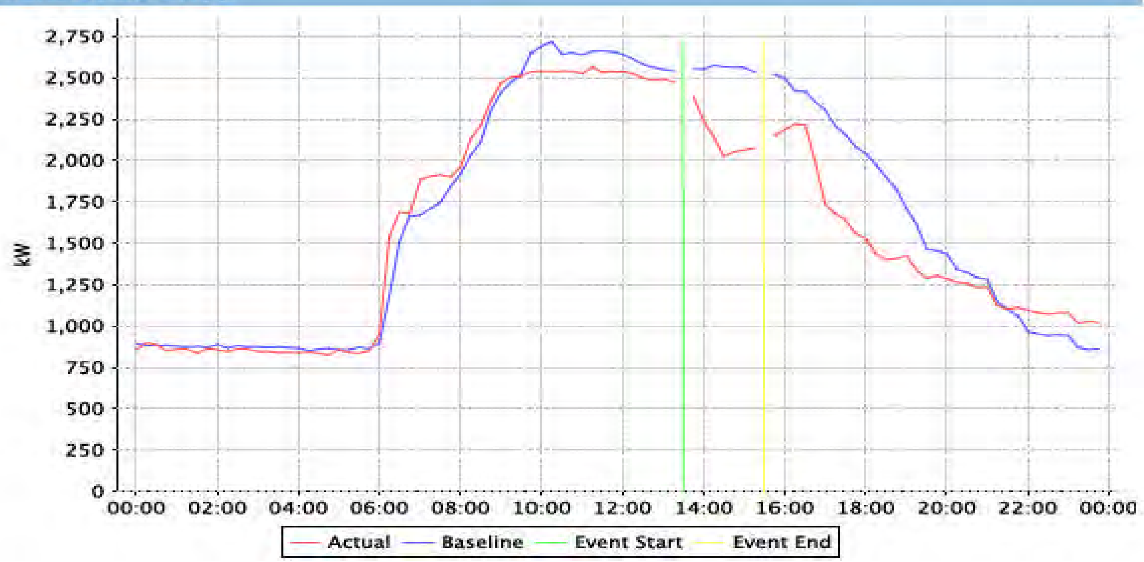


Figure App- 25. Event 2 Score Card

H.3 Event 3

Figure App- 26 gives the score card for Event 3. During the event, three participants responded as follows.

- Kumho Tire contributed the largest load shedding, which took seventy percent of total load shedding. Due to the physical limitation, the OpenADR Gateway is not connected automatically to its load control system; all DR resources are trigged manually, which also gave the manufacturing plant a sense of self-control which is important when the concept is new to them. Due to the plant maintenance arrangement, actually shedding took place 2hrs ahead of the beginning of the shedding window set 24hrs before in the DRAS. As a result, it can be seen from the figure that actual load shedding started at 12:00 noon and ended at 16:00.
- The TEDA Admin building and Library responded correctly to the autoDR signals as expected.

Event Statistics

Program	Curtailment DA
Event Date	08/08/2012 14:00 To 08/08/2012 16:00
Event Advanced Notification	28 Hours and 0 Minutes
Event Duration	2 Hours and 0 Minutes
Program Enrollment	3
Program Registered Shed (per Hour)	2730.0 kW
Available Participants	3
Available Participants - Registered Shed (per hour)	2730.0 kW
Available Participants - Average Actual Shed (per hour)	911.43 kW

Event Load Shed

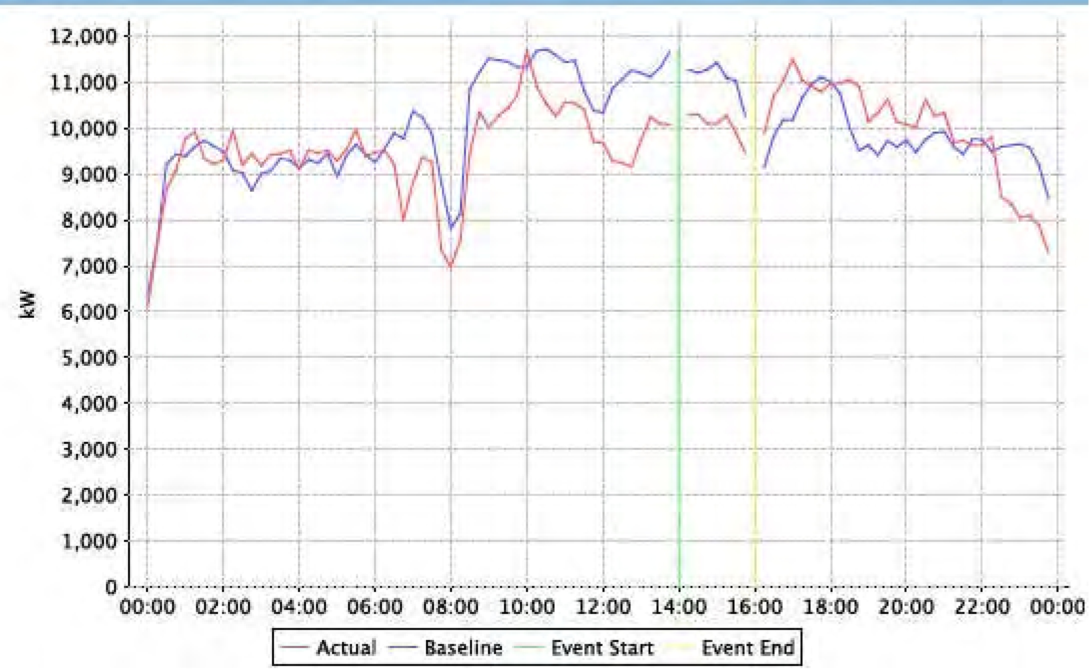


Figure App- 26. Event 3 Score Card

H.4 Event 4

Figure App- 27 gives the score card for Event 4. During this event, three participants responded as follows:

- As Kumho Tire has fewer production tasks than usual on this day, the minimal load demand is kept so that large load shedding occurred during the event, which is about 50 percent.
- Pre-cooling in the TEDA Admin building was prepared for the event.
- The TEDA Library responded correctly to the autoDR signals as expected, which reduced load by more than 20 percent.

Event Statistics

Program	Curtailment DA
Event Date	08/23/2012 09:30 To 08/23/2012 11:00
Event Advanced Notification	13 Hours and 30 Minutes
Event Duration	1 Hour and 30 Minutes
Program Enrollment	3
Program Registered Shed (per Hour)	2730.0 kW
Available Participants	3
Available Participants - Registered Shed (per hour)	2730.0 kW
Available Participants - Average Actual Shed (per hour)	4611.45 kW

Event Load Shed

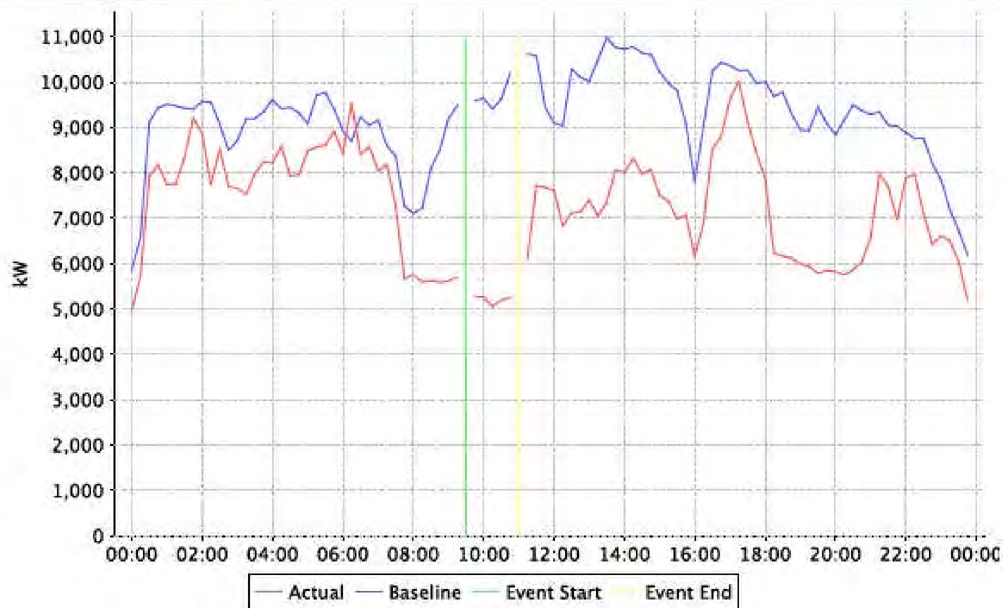


Figure App- 27. Event 4 Score Card

Appendix I. Open ADR Gateway Datasheet

Honeywell's WEB-602-XPR(GW) Open ADR gateway is described on the following pages.

Honeywell

WEBs-AX 602 Express

WEB-602-XPR/WEB-602-XPR-GW

PRODUCT DATA

PRODUCT DESCRIPTION

Honeywell's WEB-602-XPR(GW) is an embedded controller and server platform designed for remote monitoring and control applications. Save labor and space with the WEBs-AX 602 Express – this powerful controller is pre-mounted in a compact enclosure that's designed for finished space or mechanical room mounting with 16 points of on-board I/O and an integral power supply. The unit combines integrated control, supervision, data logging, alarming, scheduling, network management functions, and a Graphical User Interface on a powerful, reliable platform.

The WEB-602-XPR is part of Honeywell's portfolio of products, software applications, and tools, designed to integrate a variety of devices and protocols into unified, distributed systems. Honeywell's WEBs-AX products are powered by the Niagara^{AX} Framework®, the industry's leading software technology that integrates diverse systems and devices into a seamless system. Niagara^{AX} supports a range of protocols including LonWorks®, BACnet®, Modbus, oBIX and many Internet standards. The Niagara^{AX} Framework also includes integrated management tools to support the design, configuration and maintenance of a unified, real-time controls network.

APPLICATION

For smaller facilities, the WEB-602-XPR is an ideal solution – this powerful platform with its embedded user interface, rich graphical displays, and on-board IO is all that's needed to handle the control, monitoring, and energy applications of a small to medium sized facility. The system may be accessed via an Ethernet LAN or remotely from anywhere over the Internet.

For medium to large facilities, multi-site applications, or large scale control applications, the WEB-602-XPR is ideal for providing the distributed control and monitoring required for reliable operation of a large scale system. For sites with multiple WEBs-AX controllers, the WEBs-AX Supervisor may be used to aggregate data from multiple sites and controllers, manage global control functions, monitor energy usage, support multiple networks, and host multiple client connections for a single unified system presentation.

On-board inputs and outputs facilitate local control near the controller location. Remote monitoring and control may be accomplished by installing up to fifteen remote input / output modules interfaced via the controller's RS-485 port.

The WEB-602-XPR-GW controller comes with a factory installed GPRS modem option for remote access via the cellular network with service provided by Wyless Communications. Various service plans are available from Wyless depending on the amount of data needed to be passed on a monthly basis. Additionally, an optional GPRS modem card is available to allow installation in the field if it was not initially purchased with the WEB-602-XPR.

Contents

FEATURES

- **Embedded Power PC platform @ 524 MHz**
- **Supports wide variety of open and legacy protocols**
- **Web User interface serves rich graphical presentations and live data to any browser**
- **Runs stand-alone control, energy management, and multi-protocol integration**
- **BTL® listed when BACnet driver is used – complies with B-BC (BACnet Building Controller)**
- **Option board socket for optional communications card**
- **Compact wall-mount design for easy installation**
- **Built-in 24 volt AC/DC power supply**
- **Onboard 16 point I/O**
- **Integral GPRS modem with Wyless SIM available for remote access via Wyless ISP service**

SPECIFICATIONS

Hardware Platform
AMCC PowerPC 440 @ 524 MHz processor with math coprocessor
256 MB SDRAM, 128 MB Serial Flash

Operating System
QNX RTOS, IBM J9 JVM Java Virtual Machine
Real-time clock - 3 month backup minimum via on-board NiMh battery
Requires NiagaraAX Release 3.4 or later

Communications
2 Ethernet Ports – 10/100 Mbps (RJ-45 Connectors)
1 RS-232 Port (RJ-45 connector)
1 RS-485 non isolated port (Screw Connector on base board)
1 socket for optional communication cards
1 USB port (future use)

Onboard I/O
8 Universal Inputs
0-100K ohm – Input accuracy is +/- x% of span without calibration
0-10 volts - Input accuracy is +/- 2% of span without calibration
0-20 mA - Input accuracy is +/- 2% of span, without calibration, self-powered or board-powered sensors accepted, uses an external resistor for current input (four provided).
10K type 3 thermistor - Sensor Range –23.3°C to +115.5°C (–10° to +240° F), input accuracy is +/-1% of span. Dry contact; 3.3 volt open circuit, 300-uA short-circuit current.
Pulsing dry contact at a rate of up to 20 Hz; 50% duty cycle
4 relay outputs - Form A contacts, 24 VAC/ 30 VDC, 0.5 Amp, suitable for on / off control only, floating control not supported
4 analog outputs - 0-10 volt, 2500 Ohm minimum impedence

Power Input
24 Volts AC or DC, 40 Watts Max
Screw terminal connection

Battery Backup
On-board NiMh Batteries - 5 minutes of run-time typical. Shut-down/database backup begins within 10 seconds of power failure detected.
Optional external 12 VDC Sealed Lead Acid battery(s) – runtime dependant upon AH rating of battery(s) and connected devices.

Controller Connections
All IO terminated via removable screw terminal blocks for easy installation. Terminations are on 0.2” centers for all inputs and outputs in blocks of 6 or more screws.

Mechanical
12 5/8” (320.7 mm) L x 7 1/2” (190.5mm) W x 2 1/4” (57.2mm) H
Weight: 2.5 lbs (1.13 Kg) net; 3.5 lbs (1.59 Kg) gross
Molded plastic enclosure
Wall mount - screw mount chassis
Cooling: Internal air convection
Wiring access holes provided at top and bottom of case and via knockouts on base for hidden wiring

Environment
Operating temperature range: 0° to 50° C (32° F to +122° F)
Storage Temperature range: 0° to 70° C (32° F to +158° F)
Relative humidity range: 5% to 95%, non-condensing

ORDERING INFORMATION

WEBs-AX 602 Controllers

Part Number	Description
WEB-602-XPR	Building controller includes 256 MB RAM/128 MB Flash, (2) 10/100 Mb Ethernet ports, (1) RS-485 serial port, (1) RS-232 serial port, onboard IO including (8) universal inputs, (4) digital outputs, and (4) analog outputs, (1) socket for optional communication cards, and a 24 Volt AC or DC input power supply. Standard features include Niagara-AX station and Web User Interface. Standard drivers include oBIX Client/Server and Niagara Network (Fox) Client/Server. Factory mounted in a wall-mount vinyl enclosure. Embedded Workbench is optional. Requires Niagara AX Release 3.4 or higher.
WEB-602-XPR-GW	Same as WEB-602-XPR but with factory installed GPRS modem and Wyless SIM card.
WEB-602-XPR-O	Building controller includes 256 MB RAM/128 MB Flash, (2) 10/100 Mb Ethernet ports, (1) RS-485 serial port, (1) RS-232 serial port, onboard IO including (8) universal inputs, (4) digital outputs, and (4) analog outputs, (1) socket for optional communication cards, and a 24 Volt AC or DC input power supply. Standard features include Niagara-AX station and Web User Interface. Standard drivers include oBIX Client/Server and Niagara Network (Fox) Client/Server. Factory mounted in a wall-mount vinyl enclosure. Embedded Workbench is optional. Controller with WEBs open license (accept.wb.in = "*"). Requires Niagara AX Release 3.4 or higher
WEB-602-XPR-GW-O	Same as WEB-602-XPR-O but with factory installed GPRS modem and Wyless SIM card.

WEBs-AX 602 Controller Communication Option Cards

Part Number	Description
NPB-LON	78 Kbps FTT10 Compatible Lon Adapter
NPB-DR-LON-AX	78 Kbps FTT10 Compatible Lon Adapter Card and Lon Driver Bundle
NPB-RS232	Optional RS-232 port adapter with 9 pin D-shell connector
NPB-2X-RS485	Optional dual port RS-485 adapter; electronically isolated
NPB-MDM	Optional 56 Kpbs Auto-dial/Auto-answer Modem.
NPB-GPRS-W-XPR	GPRS Modem retrofit kit for WEB-602-XPR(O) controller. Uses the slot for optional communication cards. Includes a Wyless SIM and a remote mount antenna with mounting bracket.

AGENCY LISTINGS

- RoHS compliant
- UL 916, E207782 Energy Management
- C-UL listed to Canadian Standards Association (CSA) C22.2 No. 205-M1983 “Signal Equipment”
- FCC part 15 Class A
- BTL B-BC BACnet Building controller listed when the BACnet driver is installed and configured
- CE

EMS Standards Applied	Standard Description	Criteria Met
CISPR 16-2-3:2006	Radiated Emissions - Class A	Compliant
IEC 61000-4-2	Electrostatic Discharge Immunity	PASS Class B
IEC 61000-4-3	Radiated Electromagnetic Field Immunity	PASS Class A
IEC 61000-4-4	Electrical Fast Transient/Burst Immunity	PASS Class B
IEC 61000-4-6	Conducted Radio-Frequency Immunity	PASS Class A
IEC 61010-1	Safety requirement for electrical equipment for measurement, control and laboratory use	PASS

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