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

Executive Summary

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Demo City: Tianjin Economic
-Technological Development Area

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Introduction: Making the Case for Peak Load and Base Load Reduction

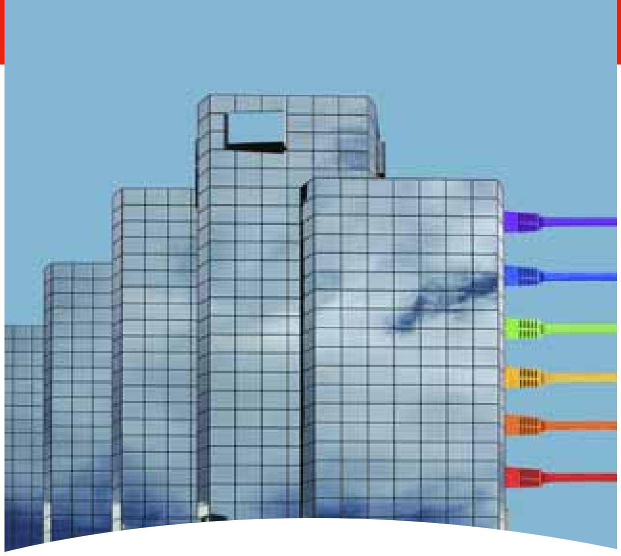
A reliable power supply is critical to China's national security, economic growth and the general welfare of its population. However, without making fundamental changes to how the electric grid operates, the task of delivering adequate electricity supply is becoming more and more difficult. In terms 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.



While energy efficiency and demand response programs have slightly different goals (overall consumption reduction vs. peak load reduction), their objectives are complementary and typically generate greater results when combined.

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 “Peak Load Reduction System Pilot and Feasibility Study” validated AutoDR can be a valuable energy resource for China.

AutoDR Project Workshop,
September 2012, Beijing, China

Executive Summary

The 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 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 Analysis and Financing Mechanism Analysis

TASK 7: Environmental and 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 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.

Automated Demand Response Explained

Source: Sila Kiliccote, Acting Group Leader
Grid Integration Group Deputy
PIER Demand Response Research Center
Lawrence Berkeley National Laboratory
U.S. Department of Energy

Traditionally, demand response programs for commercial buildings have relied on manual signals. Manual demand response is labor-intensive and can involve measures like manually turning off or changing set points at each switch or controller. Semi-automated demand response involves a pre-programmed demand response strategy initiated by a person via centralized controls.

A change is occurring, however, with the introduction of automated demand response (AutoDR), which makes participation easier, and load-shedding more effective. AutoDR does not involve human intervention and is initiated by an external communications signal. Open standards are critical to making this work.

The Demand Response Research Center at Lawrence Berkeley National Laboratory began research on AutoDR in 2002 following California's electricity crisis. The center sought to develop a low-cost automation system that would represent electricity price signals and connect easily to existing building control systems. The concept was to use the existing Internet for the physical communications layer.

The resulting technology, "OpenADR," is an information exchange model to communicate a variety of price and reliability information from the electricity grid to the buildings. OpenADR uses a client-server communications architecture with an open application-programming interface (API) available for developing building clients embedded in control systems that communicate over the Internet. OpenADR systems use an XML-based web-service architecture for platform-independent, interoperable systems. The demand response automation server, or DRAS, publishes signals from the utility, or DRAS operator, for the client. Using a "pull" client, the web service requests event data from the DRAS every minute. This is a year-round, continuous system. Therefore this system can facilitate automated continuous energy management that integrates energy efficiency, demand charge management and demand response through dynamic communication of price and reliability signals for cost-effective operations. When OpenADR signals a pending demand response event, the control system prepares to participate or waits for the event and then executes a pre-programmed demand response strategy. The client sends information to the DRAS to indicate it has received the most recent signals.

OpenADR is a general data model that supports a variety of price and demand response mode information for both push and pull implementations. Push clients are used for fast response, like those in ancillary services.

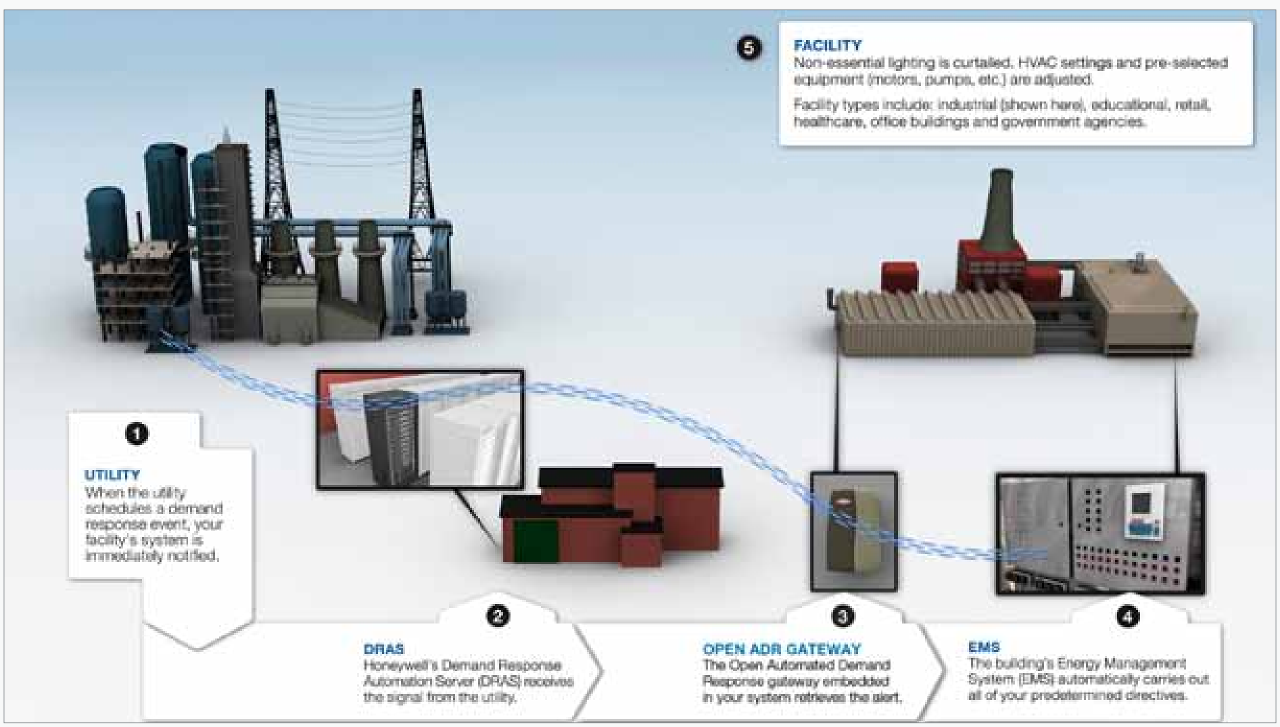
The OpenADR specification, published after 6 years of field tests, has contributed to the National Institute of Standards and Technology efforts on Smart Grid inoperability. OpenADR version 2.0A is available now following the completion of the national standards effort. This technology is being used in several countries outside the United States, including Canada, Europe, Asia and Australia.

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 three industrial facilities 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.

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 limitations of the 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.

Demonstration Site
TEDA Administration Building
Function
Commercial Building
Approximate Number of Occupants
1,000
Building Floor Area
52,653 sq. m

Demonstration Site
TEDA Library
Function
Library & Commercial Building
Approximate Number of Occupants
3,000 (visitors) +700
Building Floor Area
66,000 sq. m

Demonstration Site
Kumho Tire
Function
Motor Vehicle Parts / Rubber Products Manufacturing
Approximate Number of Occupants
2,300
Building Floor Area
310,000 sq. m

Demonstration Site
Vestas Machining Factory
Function
Wind Turbine
Approximate Number of Occupants
1,700
Building Floor Area
400,000 sq. m

Demonstration Site
Honeywell Environmental & Combustion Controls
Function
Environmental & Combustion Controls
Approximate Number of Occupants
300
Building Floor Area
20,000 sq. m

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.

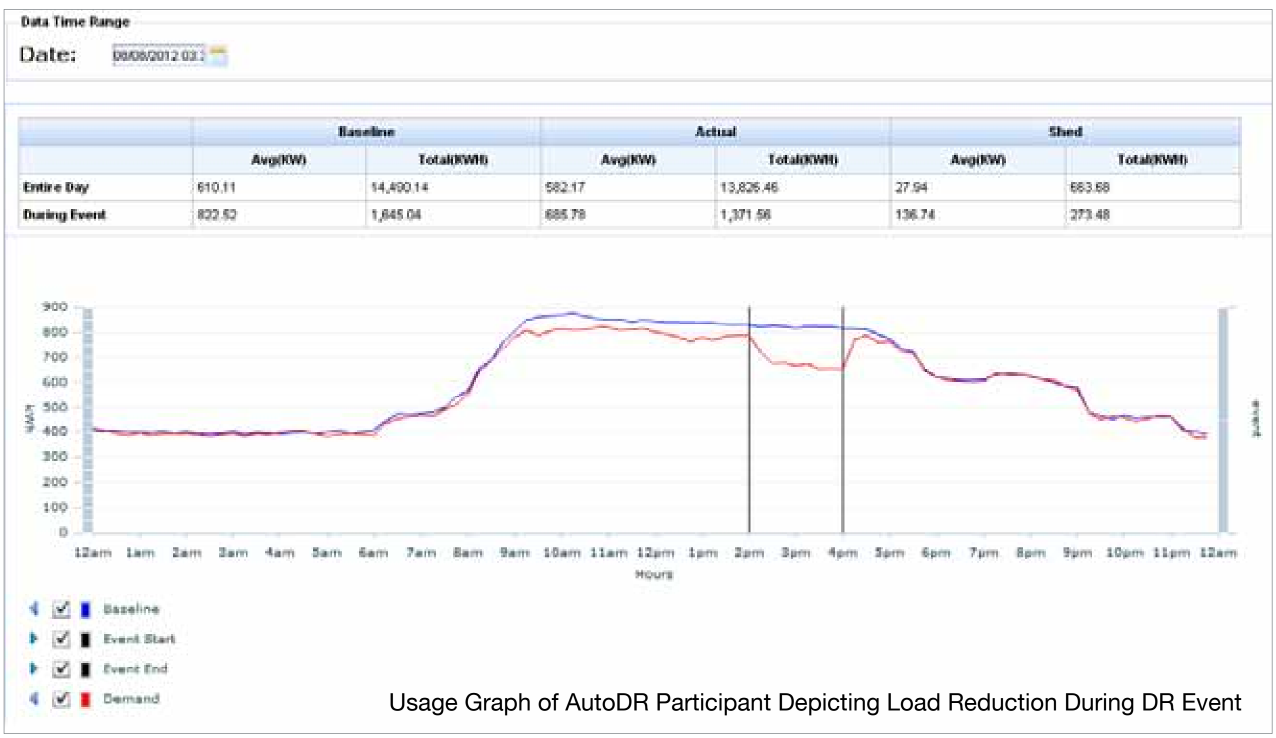
- In comparison with commercial buildings, the industrial site had a much greater load shedding capacity, indicating that in the future, industrial sites should receive particular focus.

- From a load shed stability perspective, the two commercial buildings provide 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.


Data Time Range

Date: 08/08/2012 03:

	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

Usage Graph of AutoDR Participant Depicting Load Reduction During DR Event

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.

	Mining and Quarrying	Manufacturing	Commercial Building
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.

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.

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 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 on next page). In Tianjin, the CPP program alone is expected to result in an NPV gain of ¥10.7 billion by 2022.

Table 1. 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.

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

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]

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.

[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.

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.

Smart Grid Demand Response Demo and Feasibility Study Workshop, November 2012, Beijing, China

Key Findings

1. The potential benefit to China from supporting programs to encourage peak load reduction could be significant. By example, if the participation rates for the CPP incentive program alone were increased to 50 percent of industrial buildings and 80 percent of eligible commercial buildings, then the peak load reduction has the potential to be as high as 5.2 percent 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
- Demand response 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

- Identify specific funds dedicated for the AutoDR incentives
- 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 “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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