2011
Annual State of the Grid

California ISO
Shaping a Renewed Future
The new California ISO Folsom headquarters opened in January 2011, exemplifying our commitment to the environment by achieving the highest of green building ratings.
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A showcase feature of the new ISO headquarters is its educational lobby. A series of exhibits greet visitors and explain market, grid and generation resources. Complementing the exhibits are LED monitors that provide real-time grid data.

The ISO provides the public with a near real-time snapshot of supply and demand on its website and in the lobby.

Visual displays in the ISO lobby and online show near real-time production of solar generation.

The public can track wind generation in near real time via the website or lobby.
The new grid

The California power grid and electricity market continue to evolve as policymakers and consumers drive changes to shape a greener electricity system.

Building on its commitment to excellence and innovation, the California Independent System Operator Corporation (ISO) is making significant strides toward developing a more diverse and digital grid. This includes deploying a sophisticated market design that provides a flexible platform for meeting the state’s clean energy and clean air goals.

Nearly 8,000 megawatts of renewable power generation are now connected to the ISO grid. The addition of these resources is changing market dynamics, especially with regard to having enough fast ramping units to offset the variable nature of wind and solar resources.

Leveraging the strong foundation of a new market design, the ISO is now actively enhancing the market with demand response, storage and smart grid technologies through pilot projects and market changes.

The grid operator is also developing the systems and rules that allow emerging resources such as energy storage and demand response full participation in the ISO market. Transmission planning and interconnection processes are being improved in response to state renewable energy policies.

While the accumulated efforts of the past few years resulted in a more adaptable grid capable of reliably absorbing the introduction of thousands of megawatts of renewables, substantial work lies ahead to further identify and implement market and operational enhancements.

The ISO and its stakeholders must overcome numerous challenges, including:

• Managing the uncertain and variable nature of renewable resources as California moves toward its renewable generation goals;

• Addressing the possibility of critical power plant retirements under clean water and clean air regulations;

• Supporting a sustainable business model for the conventional generation fleet; and

• Gaining visibility to the operating characteristics of distributed resources to mitigate reliability impacts.

Market performance

During its first full year of operating under a new design, the wholesale market remained competitive in 2010, according to competitive benchmarks established by the ISO Department of Market Monitoring.

In its 2010 Market Issues and Performance Report, the market monitor found that while gas prices increased 17 percent, wholesale electricity costs decreased 7 percent, from $38/MWh in 2009 to $35/MWh in 2010, when adjusting for higher gas costs. The ancillary services market performed well and even improved in 2010 (see more in section III).

Overall, congestion decreased in 2010 partly because of lower loads, which reflects a sluggish economy. However, infrequent real-time price spikes began occurring in spring 2010, primarily caused by market modeling limitations rather than fundamental supply and demand conditions.

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2 Ancillary services are capacity products, such as reserves, regulation and voltage support the ISO uses to balance demand and supply and maintain reliability on the grid.
This contributed to pushing real-time prices a bit higher on average from the second quarter to the fourth quarter of 2010. Wholesale energy prices were nearly equal to competitive baseline prices that the Department of Market Monitoring estimates would result under perfectly competitive conditions, as shown in figure 1. In 2010, the average system-wide real-time prices exceeded this competitive baseline only by about 12 percent.

Capacity made available through the state’s resource adequacy program continues to meet reliability planning requirements and virtually all operational needs. Statewide snowpack is 326 percent of the historic percentage as of June 1, which indicates the potential for increased electric production over the summer and fall seasons. More than 1,500 MW of new gas-fired generation came on-line in 2010, in addition to 500 MW of renewable generation, as shown in figure 2.

Figure 1 – Comparison of competitive baseline with day-ahead and real-time prices

Prices in the day-ahead market have consistently been about equal to competitive baseline prices since the start of the nodal market design in April 2009.

Table: Capacity additions and retirements

<table>
<thead>
<tr>
<th>Year</th>
<th>New generation (MW)</th>
<th>Retirements (MW)</th>
<th>Net yearly total (MW)</th>
<th>Cumulative net total (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>-1,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
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<td>2008</td>
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<td>2009</td>
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</tr>
<tr>
<td>2010</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ISO is expecting about 1,147 MW of new generation to come on line in 2011, with almost two-thirds coming from renewable resources.

Figure 2 – Generation additions and retirements

Transmission for tomorrow

During the past few years, the ISO recognized the need to modify its transmission planning processes to better accommodate generation development — especially for wind and solar resources. For more than three planning cycles, the ISO worked closely with its market participants and stakeholders to analyze current processes and determine the changes needed to meet state goals. The ISO has made several significant enhancements that support environmental objectives while increasing grid reliability and security, including the following:

1) Reformed the interconnection queue processes, which streamlined study timelines and aligned relevant fees and deposits to reflect real-world conditions. The changes also accommodated timelines for projects seeking stimulus funding and provided greater process certainty so developers could make better development decisions;

2) Overhauled the transmission planning process to accommodate projects that satisfied policies such as interconnecting renewable power projects.
2010/2011 Transmission Plan

After a 10 month stakeholder process, the ISO instituted enhancements to its Order No. 8904 transmission planning process that were proposed to the Federal Energy Regulatory Commission (FERC) in June 2010 and became effective December 20, 2010. The revised transmission planning process aligned, consolidated and streamlined the ISO annual planning activities.

The ISO approved 32 transmission projects in the 2010/2011 Transmission Plan, with an estimated $1.2 billion in costs as needed for system reliability. In addition, one new policy-driven transmission element — a low cost transmission upgrade — was approved to provide higher transfer capability between Imperial Irrigation District and Southern California Edison for transporting energy from renewable resources under development in Imperial County.

The ISO found no major new upgrades are needed to support the state’s 33 percent by 2020 renewables portfolio standard other than those already approved in previous planning cycles and the generation interconnection process. Future transmission planning cycles will consider transmission needs to meet the 33 percent goal on an annual basis.

Supply, demand outlook

Supplying one step ahead of grid dynamics means performing analysis to predict supply and demand during the peak electricity season. The 2011 Summer Loads and Resources Assessment provides an analysis of the upcoming summer supply and demand outlook for the ISO balancing authority.

This year’s outlook predicts that an adequate electricity supply is available to handle a broad range of operating conditions during summer 2011.

About 49,600 MW of net qualifying capacity will be available for summer 2011, which is a 1,180 MW increase from June 1, 2010. The ISO peak demand is projected to reach 47,800 MW or 687 MW more than the hourly average peak of 47,127 MW recorded on August 25, 2010.

The instantaneous peak on August 25, 2010 was 47,350 MW. The 1.5 percent increase in projected peak demand represents a modest economic recovery over 2010 using the economic base case forecast from Moody’s Analytics.

Having an adequate summer supply under a variety of conditions and scenarios is primarily attributable to lower summer peak load projections because of the recession and the cumulative addition over the past decade of approximately 21,200 MW net dependable capacity of new generation.

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9 Net dependable capacity is generally the maximum capacity a generation unit can sustain after figuring in limitations and the capacity needed to operate the unit.
The ISO will continue to mature its renewable generation desk — considered the first dispatch control center console dedicated solely to renewable integration.
II. STRATEGIC VIEW

Five-Year Strategic Plan

The ISO is working with others in the industry to achieve the state’s environmental goals in a manner that recognizes the need to strike a balance between cost, the environment and maintaining electric grid reliability. To this end, the ISO Five-Year Strategic Plan 2011–2015\(^n\) outlines specific objectives that include enhancing market design and performance as well as developing a comprehensive transmission plan that supports the state’s 33 percent RPS. Guiding the efforts are the following strategies:

- Minimize the risk of adversely impacting reliability and market efficiency if any one or a combination of the state policy goals do not materialize as expected;
- Minimize the amount of stranded investment if the targets are exceeded; and
- Stay far enough ahead to be ready to accommodate the evolution but not so far ahead as to risk being misdirected. A balanced strategy is neither “wait and see” nor “full readiness” far in advance of a highly uncertain future.

Strategic planning

As the ISO sharpens market and grid operational readiness, it will focus on improving system flexibility. This includes increasing fast ramping capability to help integrate renewables. New ISO products and services will evolve out of the studies and pilots now underway.

The strategic plan also calls for implementing system tools, such as:

- A congestion management display that will provide greater visibility and ability to resolve transmission congestion in real time; and
- A market performance dashboard that will allow for better monitoring of system conditions in real time.

The strategic plan also highlights the need to remain vigilant in complying with federal standards and rules. To this end, the ISO has established an initiative to promote proactive behaviors and processes that ensure compliance throughout the organization.

California’s Clean Energy Future

The ISO partnered with California Air Resources Board, Public Utilities Commission, California Energy Commission and California Environmental Protection Agency to create a process to facilitate cooperation between organizations tasked with implementing the state’s environmental and energy mandates.

California’s Clean Energy Future\(^{n1}\) overview is a consensus vision and a formal implementation plan that details how the five organizations will coordinate more than 50 interrelated activities. The plan covers issues such as job training and retraining for the new clean energy economy. It includes planning expectations for new electricity generation and developing enhanced transmission.

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\(^{n1}\) California’s Clean Energy Future, http://www.cacleanenergyfuture.org
Clean water rules impact coastal plants

Implementing the once-through cooling rule adopted by the State Water Resources Control Board in 2010 is underway, but its effects remain uncertain and make grid planning a challenging task. The rule requires power plants that use ocean and estuarine water to cool generation turbines — 16 within the ISO grid — to either retrofit, repower or retire.12

About 17,500 MW of generation are subject to the once-through cooling policy (see figure 3), which has phased-in levels of compliance through 2024. The ISO is working closely with transmission owners, state energy agencies, generation plant owners and regulators through its transmission planning process to ensure grid reliability is maintained. The ISO will perform additional comprehensive grid reliability assessment studies as part of the 2011/2012 transmission planning process.

Table 1 — OTC units retired/repowered 2010-2011

<table>
<thead>
<tr>
<th>Plant</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humboldt</td>
<td>105 MW — repowering</td>
</tr>
<tr>
<td>South Bay</td>
<td>693 MW — retired</td>
</tr>
<tr>
<td>Potrero</td>
<td>206 MW — retired</td>
</tr>
</tbody>
</table>

Reliability must-run

Potrero, South Bay and Humboldt Bay were also on the list of ISO reliability must-run plants. The ISO has authority to designate any unit as a reliability must-run resource if necessary. Since the inception of the state’s resource adequacy requirement in 2004, the ISO has steadily reduced the number of generation units and megawatts needed for reliability must-run, as shown in figure 4.

In 2009, about 2,100 MW of capacity was under reliability must-run contracts. In 2010, the ISO reduced capacity under these contracts to about 1,000 MW. This compares to 2005 when nearly 10,000 MW of capacity was under must-run obligations.

As shown in table 1, two once-through cooling (OTC) plants retired in 2010. Potrero Generating Station and South Bay Generation Facility were shut down. Potrero was retired after PG&E completed Bay Area reconductor work and the Trans Bay Cable was energized.13 South Bay was able to close following final approval of the Sunrise Powerlink and generation additions. Humboldt Bay Power Plant was repowered. It replaced old turbines with more efficient ones that use are air-cooled engines that eliminate the need for water cooling.

12 http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/index.shtml
13 The 53-mile underwater cable under San Francisco Bay and through the Carquinez Strait has a capacity of 400 megawatts, enough to provide 40% of San Francisco’s peak power needs. Owned by SteelRiver Transmission Company, the line connects PG&E’s Potrero Substation to its 230 kV transmission line in Pittsburg. The system was completed in November 2010. http://www.transbaycable.com/
In its second year, the ISO’s new nodal market design continued to produce efficiencies. A high degree of forward contracting by load-serving entities assisted with keeping wholesale electricity prices low.
III. THE MARKET

Market performance
The ISO market, with 4,500 pricing points on the grid, remained stable and competitive in 2010, according to the ISO Department of Market Monitoring.\(^\text{14}\)

Wholesale costs of serving load in 2010 were $8.6 billion or about $40/MWh, which is an increase of about 5 percent from 2009, as shown in figure 5. Gas prices did increase 17 percent, but when accounting for the higher gas prices, energy costs decreased from $38/MWh in 2009 to $35/MWh in 2010, which represents a decrease of over 7 percent with gas normalized prices.

The ancillary services market performed well and even improved in 2010 under the new market design. Total ancillary services costs were $84 million, representing a 6 percent decrease over 2009.

![Figure 5 — Total annual wholesale costs per MWh of load](image.png)

Under the new market design, the estimate of total wholesale market costs uses the prices and quantities cleared in each of the three energy markets: day ahead, hour ahead and five-minute real time.\(^\text{15}\)

As shown in figure 6, ancillary services costs decreased from $0.93/MWh of load in 2006 to $0.37 in 2010.

![Figure 6 — Ancillary services costs per MWh of load](image.png)

Ancillary services costs decreased from $0.93/MWh of load in 2006 to $0.37 in 2010.

Software improvements
Exceptional dispatches are instructions issued by system operators when the automated market optimization is not able to address a particular reliability requirement or constraint. The ISO has made an effort to reduce exceptional dispatches by incorporating additional constraints into the market model that reflect these reliability requirements. Total energy from all exceptional dispatches was significantly lower in 2010, dropping to 0.3 percent from 0.9 percent of system load in 2009.

The ISO continues to refine the market software to eliminate the limitations that trigger the bulk of the exceptional dispatches issued.

POWER FACT

Ancillary Services are capacity products or reserves used by the ISO to balance demand and supply and maintain grid conditions within specified operating limits and provide reserves for unexpected events.

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\(^{15}\) The estimate also includes costs associated with ancillary services, residual unit commitment, bid-cost recovery, reliability must-Run contracts, the interim capacity procurement mechanism and grid management charges.
Mitigation
The local market power mitigation provisions in the new market design have proven to be effective without imposing an excessive level of mitigation. During each quarter in 2010, an average of less than one unit per hour was subject to mitigation in the day-ahead market.

Although these market power mitigation provisions have not had a significant direct impact on market results, this does not mean that these provisions are unneeded or did not have a more significant indirect impact. Having effective market power mitigation provisions in the day-ahead and real-time markets encourage forward contracting and deter attempts to exercise market power.

Market enhancements
Among the market enhancements released after receiving FERC approval in 2010 was functionality for multi-stage generating units (see enhancement timeline in figure 7 below). Multi-stage generators pose particular challenges with modeling and dispatch because they have multiple configurations in which they can operate and regions in which they cannot. Since implementation, the ISO and stakeholders have been working closely to identify issues that need to be addressed as unit owners gain more experience in bidding and dispatching under the rules.

The convergence bidding feature began in February 2011. Also known as virtual bidding, this feature allows market participants to submit financial demand and supply bids into the day-ahead market that are then liquidated at the opposite position in the real-time market.

In addition, suppliers can use the bids to hedge against generator outages, which may be particularly useful in peak conditions.

POWERT FACT

Convergence bidding moves market prices closer together, which is intended to improve overall market efficiency.

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ADVANCING THE GRID
The mission critical wing of the new headquarters houses one of the most modern control centers in the world. Advanced features include enhanced visualization capabilities and synchrophasor technology that takes a snapshot of the power grid every 33 milliseconds complementing the traditional supervisory control and data acquisition (SCADA) resolution of four seconds. High-tech tools focus on fast start up of power plants, voltage stability and congestion management. A video wall displays multiple arrays of information that can be pulled up in 26 different ways.
The California ISO has been moving for the last few years to integrate renewable generation resources into the grid, which includes approving new transmission and infrastructure upgrades that will enable the delivery of over 22,000 MW of clean and sustainable electricity to California consumers.
Revised transmission planning

A crucial challenge for transmission planning in the environmental policy-driven context is developing sufficient transmission on a timetable that supports the 33 percent RPS and developing it efficiently — in the right places — so ratepayers are not saddled with high costs of under-utilized transmission.

After a 10-month stakeholder process, the ISO implemented a series of enhancements in December 2010 to its transmission planning processes, as noted in figure 8. These are the first steps in an effort to align the processes and give the ISO additional grounds to approve transmission upgrades needed to achieve the renewables portfolio standards.

The ISO developed the plan in coordination with neighboring balancing authorities, stakeholders and planning entities. It also used information and analyses developed by the California Transmission Planning Group and Renewable Energy Transmission Initiative.

The revised planning process includes the following:

• Identifies and approves transmission projects that have the highest likelihood of being fully utilized;
• Identifies, for later reevaluation, projects that could be highly utilized but whose approval must await stronger evidence of committed generation development;
• Improves the coordination between planning and the generator interconnection procedures;
• Allows all interested project sponsors, including independent developers and existing participating transmission owners, opportunities to propose to construct and own policy-driven and economically-driven transmission facilities included in the plan; and
• Organizes all these elements into an annual comprehensive plan that accommodates the 33 percent renewable energy portfolios.

Generation changes

The installed capacity of renewable generation will increase dramatically in the next several years. The conventional power plant fleet will also grow. An estimated 3,500 MW is likely to come on line by 2013. These mainly gas-fired plants will need to be more flexible, with faster start times and quicker ramping essential to balancing the variable nature of renewables.

Many older power plants in California are essential for local reliability because they are located in areas deficient in generation and transmission capacity. For economic reasons, however, these plants may close down just when they are needed to smooth out the variability of intermittent resources. Revenue for conventional power generation is declining as renewable resources gain more competitive footing in the energy marketplace.

In the near future, the ISO expects the state will have policies in place for long-term procurement that will address flexible generation needs.
2010/2011 Transmission Plan

The transmission plan describes the infrastructure upgrades necessary to meet reliability and public policy goals. Key analysis of the plan include:

- Identifying transmission needed to support meeting the 33 percent RPS goals over a diverse range of renewable generation portfolio scenarios, which are based on plausible forecasts of the type and location of renewable resources in energy-rich areas most likely to be developed over the 10 year planning horizon;
- Analyzing transmission infrastructure under development but not yet permitted is found reasonable under a number of scenarios, as well as policy-driven elements that might be needed to deliver energy from the resources in these portfolios to the ISO grid;

Planning Results

The ISO identified 32 transmission projects worth $1.2 billion in the 2010/2011 planning cycle as needed for system reliability, as well as one policy-driven project that provides access to renewable resources located in Imperial County. The ISO Board approved four projects over $50 million as shown in figure 9.

Figure 9 — Approved reliability projects over $50 million

- Evaluating the need for 41 transmission projects submitted into the 2008 and 2009 transmission planning request windows;
- Identifying transmission upgrades and additions needed to reliably operate the network and comply with applicable planning standards and reliability requirements; and
- Performing economic analysis that considers whether transmission upgrades or additions could provide additional ratepayer benefits.
Transmission to meet 33 percent RPS

Table 2 lists the already approved projects with a combined capacity that is sufficient at this time to meet the 33 percent RPS. This determination is based on the following:

- The major transmission projects already approved by the ISO accommodate a diverse range of conditions for meeting the RPS; and
- Existing inter-state transmission will have capacity made available as renewable resources displace energy from traditional resources.

Annually, the ISO will reexamine what transmission is needed to support the 33 percent RPS.

One of the challenges in meeting renewables goals is seeing “steel in the ground”. The process of final siting and permitting for approved transmission projects is often met with regulatory hurdles and uncertainty, as seen in Figure 10.

Table 2 — Major upgrades to meet 33% RPS

<table>
<thead>
<tr>
<th>Transmission upgrade</th>
<th>Approval status</th>
<th>Renewable Potential</th>
<th>Online</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ISO</td>
<td>CPUC</td>
<td>MW</td>
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<tr>
<td>Carrizo-Midway</td>
<td>Pending LGIA</td>
<td>Not yet filed</td>
<td>900</td>
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<tr>
<td>Sunrise Powerlink</td>
<td>Approved</td>
<td>Approved</td>
<td>1,700</td>
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<tr>
<td>Eldorado-Ivanpah</td>
<td>LGIA</td>
<td>Approved</td>
<td>1,400</td>
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<tr>
<td>Pisgah-Lugo</td>
<td>LGIA</td>
<td>Not yet filed*</td>
<td>1,750</td>
</tr>
<tr>
<td>Valley-Colorado River</td>
<td>Approved</td>
<td>Approved°</td>
<td>4,700</td>
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<tr>
<td>West of Devers</td>
<td>LGIA</td>
<td>Not yet filed</td>
<td></td>
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<tr>
<td>Tehachapi</td>
<td>Approved</td>
<td>Approved</td>
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<td>Tehachapi Wind/Solar Diversity</td>
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<td>Cool Water-Lugo</td>
<td>Pending LGIA</td>
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<tr>
<td>South Contra Costa</td>
<td>LGIA</td>
<td>Not yet filed</td>
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<tr>
<td>Borden-Gregg</td>
<td>LGIA</td>
<td>Not yet filed</td>
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<tr>
<td>Path 42</td>
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<tr>
<td>Other — Outside of ISO Grid</td>
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<tr>
<td>Total</td>
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<td>22,350</td>
</tr>
</tbody>
</table>

TWh/year needed in ISO area to meet 33% goal: 44

* Large Generator Interconnection Agreement  ° Petition to modify CPCN pending.

The ISO has determined the projects it has already approved, as listed in the table above, can accommodate the integration of 33 percent renewables, under current conditions.
Interconnection reform

Revised interconnection procedures implemented in 2010 offer small generators three interconnection options for study: the cluster process, fast track and independent study process. Also, small generators have the option to meet deliverability requirements to provide resource adequacy capacity. More refinements are planned for the interconnection procedures. A stakeholder process is underway to consider 12 topics, including:

- Refining the economic test and cost allocation for network upgrades;
- Determining the cost and credit requirements when proposed network upgrades are changed during the transmission planning process;
- Establishing triggers for financial security posting deadlines; and
- Considering partial deliverability as an interconnection option.

Stimulus projects

The ISO was able to leverage its new planning flexibility by accelerating the review and approval of proposed interconnection projects seeking stimulus funding under the American Recovery and Reinvestment Act (ARRA), the bulk of which are renewable projects. As of September 2010, 46 projects in the ISO interconnection study queue totaling 10,749 MW were candidates for funding.

Although the funding deadline for projects seeking tax incentives and direct grants was pushed out from its original December 31, 2010 date into 2011, the extra efforts by the ISO reduced the study timetable for cluster projects by four months, thus enabling 16 cluster projects representing 3,601 MW to meet the eligibility criteria. In all, 41 projects, representing 10,169 MW, had studies completed to meet the original ARRA deadline. This amount includes both cluster and serial projects seeking ARRA funding.

As part of the ISO efforts to streamline the study process, the ISO asked for and was granted approval from federal regulators to temporarily waive financial security deposits for ARRA projects in cases where participating transmission owners agree to upfront fund transmission upgrades for developers.

The current interconnection study queue (as of June 1, 2011) has nearly 85,000 MW of proposed generation, as noted in figure 11. About 72,500 MW are renewable projects.

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19 FERC agreed in Docket No. ER10-1401 to exempt network upgrades associated with ARRA projects from having to go through further evaluation in the RTTP process and allowed them instead to be determined within the large generator interconnection process, which is quicker, http://www.ferc.gov.
## Interconnection queue by county

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Projects</th>
<th>Renewables MW</th>
<th>Conventional MW</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humboldt</td>
<td>1</td>
<td>50</td>
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<tr>
<td>Shasta</td>
<td>2</td>
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<td>Butte, Glenn, Tehama</td>
<td>5</td>
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<td>Lake, Colusa</td>
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<td>Sutter, Yuba</td>
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<td>20</td>
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<td>Placer</td>
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<td>5</td>
<td>587</td>
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<td>Marin, Sonoma</td>
<td>3</td>
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<td>Solano</td>
<td>11</td>
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<td>Amador</td>
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<td>Alameda, Contra Costa, Santa Clara</td>
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<td>1,110</td>
<td>1,698</td>
<td>2,808</td>
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<td>San Joaquin</td>
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<td>325</td>
<td>1,020</td>
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<td>Stanislaus, Tuolumne</td>
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<td>Merced</td>
<td>7</td>
<td>612</td>
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<td>Fresno, Madera</td>
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<td>Monterey, San Benito</td>
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<td>1,550</td>
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<tr>
<td>Kings</td>
<td>38</td>
<td>4,614</td>
<td>625</td>
<td>5,239</td>
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<td>Inyo, Tulare</td>
<td>13</td>
<td>625</td>
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<td>San Luis Obispo, Santa Barbara</td>
<td>6</td>
<td>896</td>
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<tr>
<td>Kern</td>
<td>109</td>
<td>13,802</td>
<td>1,100</td>
<td>14,902</td>
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<td>San Bernardino</td>
<td>21</td>
<td>4,395</td>
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<td>50</td>
<td>2,390</td>
<td>2,650</td>
<td>5,040</td>
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<td>Riverside</td>
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<td>10,667</td>
<td>1,420</td>
<td>12,087</td>
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<tr>
<td>San Diego</td>
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<td>1,453</td>
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<td>Imperial</td>
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<td>In-state Totals</td>
<td>481</td>
<td>56,787</td>
<td>11,159</td>
<td>67,947</td>
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<td>Wyoming</td>
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<td>3,000</td>
<td></td>
<td>3,000</td>
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<tr>
<td>Nevada</td>
<td>18</td>
<td>5,252</td>
<td></td>
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<tr>
<td>Arizona, New Mexico</td>
<td>10</td>
<td>5,878</td>
<td>1,250</td>
<td>7,128</td>
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<tr>
<td>Mexico</td>
<td>3</td>
<td>1,628</td>
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<tr>
<td>Out-of-state Totals</td>
<td>32</td>
<td>15,758</td>
<td>1,250</td>
<td>17,008</td>
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<tr>
<td>TOTAL ALL PROJECTS</td>
<td>513</td>
<td>72,545</td>
<td>12,409</td>
<td>84,955</td>
</tr>
</tbody>
</table>

as of 06/01/2011
The California ISO is committed to providing the generation and transmission infrastructure that accommodates the state’s 33 percent renewables portfolio standard and other public environmental policies.
V. RENEWABLE INTEGRATION

Renewable growth
Under California law, utilities must supply 20 percent of all electricity retail sales from eligible renewable resources in the next couple of years and 33 percent by 2020. Wind and solar technologies will provide the bulk of additional generation needed to meet the renewables portfolio standard, but their output variability introduces new operating challenges for system operators. Figure 12 roughly shows the expected mix of renewable resource capacity assuming the 20 percent RPS is achieved in 2013 and compares it to the renewable resources in 2010.

Figure 12 – Renewable generation capacity buildout

Ramp forecasting
Greater amounts of variable generation interconnected to the grid increase the magnitude of forecasting errors. Cloud cover, moisture or dust in the air, sand storms and wind conditions impact solar and wind generation output, which can cause production to swing by several thousand megawatts in a short period of time.20

In the absence of storage, demand response or curtailable renewable resources, conventional generation must be ramped up or down to cover the variability of renewable generators. Inaccurate load forecasts substantially increase the difficulty for grid operators to respond appropriately. The ISO was able to work with its weather forecast vendor in 2009 to improve its accuracy rates by 20 percent.21

Promising enhancements include short-term event predictor and ramp forecasting tools that will allow grid operators to anticipate major events by recognizing correlated meteorological and system events.

Renewables integration market and product review
Renewable resources do create additional operational issues for managing the traditional fleet, such as:

- Increased frequency and magnitude of ramps;
- Increased procurement of regulation up and regulation down energy;
- Increased load-following requirements, perhaps leading to the need for additional reserves; and
- Increased frequency and magnitude of overgeneration conditions.

To begin addressing these concerns, among other related issues, the ISO initiated the Renewables Integration Market and Product Review.22 Variable generation requires system flexibility, especially when it comes to ramping capability. In the absence of storage and demand response, the ability to ramp down is limited. The need exists to create incentives for ramping resources to bid into the market.

The market needs more flexibility from the conventional generators, existing or new, that include higher ramp rates, lower minimum operating levels and the ability to provide ancillary services. Meanwhile, variable energy resources need more flexibility as well to help dampen their impact on operations.

Solar resources are expected to expand quickly between 2012 and 2020. The rough estimates show more renewable energy than needed to meet the 33 percent RPS in 2020.

It is vital for ISO operators to have as keen an awareness of grid conditions as possible. To this end, the ISO is seeking to develop forecast tools to predict the output capabilities of renewable resources in the two- to five-hour range. Additional tools will predict and display in real-time the intra-hour capacity and ramping requirements needed to integrate variable generation. Work is also underway to estimate the hourly regulation requirements for the next day operation factoring into consideration the impact of variable resources.

22 http://www.caiso.com/informed/Pages/StakeholderProcesses/RenewablesIntegrationMarketProductReviewPhase1.aspx
The Renewables Integration Market and Product Review initiative is addressing a number of near-term incremental changes to market design to improve operational capabilities to support integration of renewables. This includes reforming the ISO Participating Intermittent Resource Program, lowering the energy bid floor and adopting regulation energy management enhancements.

This initiative is also looking at longer-term changes to the market, including new reserve products that will enable the ISO to procure needed ramping capabilities and compensate the resources providing these services.

**Pseudo-tie pilots**

Extending the pseudo-tie pilots to renewable resources is further enhancing the ISO understanding of how renewables interact with the grid. Pseudo-tie pilots are arrangements that treat out-of-state or out-of-ISO generation as if it is in-state or directly connected to the ISO-controlled grid. The ISO has three important pseudo-tie pilots now underway as noted in table 3, one of which is a solar project.

The lessons learned from the pseudo-tie pilots will feed into the ISO dynamic transfers initiative, which is addressing the permanent rules on how to import and export variable resources while enhancing grid efficiency and reliability.23

<table>
<thead>
<tr>
<th>Table 3 — Current pseudo-tie pilots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Mountain Solar (Sempra Generation)</td>
</tr>
<tr>
<td>Sutter Energy Center (Calpine)</td>
</tr>
<tr>
<td>New Melones hydro-electric plant (federal Bureau of Reclamation)</td>
</tr>
</tbody>
</table>

Source: California ISO

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The grid and its market is a dynamic and complex system that requires highly qualified and competent operators. The new headquarters features one of the few operator–in–training centers in the country — a simulator training room that is a scaled-down version of the control center. The hands-on training allows operators to execute their roles and responsibilities better and with more confidence. It is used to keep experienced operators current on their training and is serving as an important tool in recruiting and shaping the grid operators of tomorrow.
VI. OPERATIONS

Greening the grid
As the largest portfolio of renewable power in the country enters the California grid, successful operations will necessitate changes in the generation fleet.

In 2011, we have already begun to see the impact of renewable generation variability as new record production peaks are established, as shown in figure 13. Conventional generation starts and stops are increasing and the variability of wind generation is increasingly apparent as more and more wind generation comes on line. The ISO control center is already tracking 800 MW drops in wind generation in a short time span.

Unpredicted, significant changes in generation output can result in wholesale market price extremes as the market systems dispatch generation to quickly compensate for the unexpected gaps. By 2013, these swings will be much larger — perhaps as much as thousands of megawatts in an hour.

Figure 13 – Record wind and solar peaks
ISO grid sets new record peak production as more renewable power comes on line.

Ramping challenges
In California, wind energy production typically peaks at night and falls off as the day progresses. Solar ramping is the inverse, as it peaks in the afternoon. Essentially, the two resources can offset each other — but not entirely. That is where conventional power plants come in. The fast ramping capabilities (quick start ups and slow downs) of gas-fired generation aid in mitigating the fluctuations of renewable resources. However, it takes advanced forecasting tools to predict when fast ramping will be needed and typically the lead time is less than an hour.

Exceptional dispatching can be used to add ramping capability. It is used to procure out-of-market energy under limited situations. In the future, market systems will anticipate these ramping events and commit resources to ensure enough ramping capability is available. Figure 14 shows a simulated output profile for wind and solar resources under a 20 percent RPS and highlights the ramping challenges.

Figure 14 – Ramping extremes under 20% RPS conditions
The variability of wind and solar generation somewhat offset each other, but production of both resources can swing dramatically.
2011 Summer assessment

With the continued growth of diverse grid resources, predicting supply and demand over the peak summer months will become more challenging. For summer 2011, the ISO assessment\(^{24}\) projects that an adequate supply will be available to handle a broad range of expected operating conditions.

It also projects a very low probability of involuntary load curtailments, as shown in figure 15. These favorable findings are primarily attributable to the cumulative addition over the past decade of approximately 21,200 MW net dependable capacity of new generation.

Figure 15 – Probabilities of 3% or less operating reserve margin

![Figure 15](2011 Summer Loads and Resources Assessment)

2011 continues a trend in which the probabilities of the ISO reserve supply dropping below the 3 percent load shedding threshold are less than 1 percent.

The summer imports are projected to be healthy and vary from 8,500 MW to 11,400 MW for the ISO, as shown in table 4.

An estimated 2,357 MW of retail demand response and interruptible load programs will be available to deploy by the utilities during summer 2011, which is about the same amount as available in 2010.

Overall, 2011 reliability needs remain consistent with 2010 levels.

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The ISO Advanced Grid Center illustrates the technologies that are transforming the way the ISO operates the wholesale energy markets and manages the transmission grid.
Smart grid

Efforts to modernize the grid should help the ISO manage a greater supply of renewable and distributed energy resources. The evolution in the industry is blurring the definition of what constitutes traditional supply resources. New distributed energy resources present unique integration challenges, yet offer new capabilities and flexibility to the resource portfolio the ISO will rely upon to meet our objectives.

The smart grid is the application of technologies to all aspects of the energy transmission and delivery system that provide better monitoring, control and efficient use of the system. The ISO goal is to enable and integrate all applicable smart technologies while operating the grid reliably, securely and efficiently. This will facilitate effective open markets that engage and empower consumers while meeting state environmental and energy policies.

The Smart Grid Roadmap and Architecture is the ISO vision of a 2020 grid, which includes putting in place an infrastructure that uses widely accepted interface standards. Also important is a flexible technology infrastructure that supports demand response, advanced storage and distributed energy resources. The other major thrust for smart grid technologies is to support the ability to provide price signals to customers that allow them to adjust their electricity use.

Synchrophasor technology

Some smart grid technologies are mature and ready to be deployed. They will allow us to better manage the grid within reliable limits and allow us to get more out of the transmission infrastructure already in place. For instance, the rapid deployment of synchrophasor technologies holds the promise to detect small signal oscillations in real-time, allowing us to operate closer to reliability-based limits.

The ISO is participating in the partially federally funded Western Electricity Coordinating Council synchrophasor project. This leverages the existing technology to enable grid operators to see grid conditions in multiple readings per second, which increases the ability to respond much quicker to potential system instabilities.

Additional smart grid technologies including smart meters and smart substations will help the local distribution system, owned and operated by utilities, to match the sophistication of the high-voltage transmission system. These specialized functions, if developed, could communicate demand levels as well as output from distributed generation.

ISO READINESS

Smart Grid

- Conduct pilots with the utilities and aggregators to refine our technology, test connectivity and dispatch protocols, and enable further load participation in the market.
- Identify telemetry solutions to better measure distributed resources and demand to enable more effective awareness of the grid.
- Update ISO market model to reflect the capabilities of additional resource types, such as storage and demand response.
- Use near real-time synchrophasor information for increased wide-area situational awareness as the data measurement and collection devices are rolled out through the system.
- Work with the investor-owned utilities to implement dynamic line ratings to more efficiently use the transmission system.

The ISO is participating in the partially federally funded Western Electricity Coordinating Council synchrophasor project. This leverages the existing technology to enable grid operators to see grid conditions in multiple readings per second, which increases the ability to respond much quicker to potential system instabilities.
Advanced forecasting

The ISO determines the resources needed to serve demand based on load forecasts and reserve requirement forecasts. The variability of solar and wind resources makes it critical to have highly accurate forecasts of renewable output 24 hours in advance to ensure adequate resources are available the next day.

Incentive-based demand response, plug-in electric vehicles and distribution-level rooftop solar will affect forecasted load. The ISO is focused on using smart grid technologies and advanced forecasting tools to predict resource, load and grid conditions in order to produce the most reliable and efficient system operation.

Distributed resources

Distributed generation resources are mostly small generation facilities and storage systems typically located at or very near the location where the energy is used. The impact of these resources is being studied and taken into account in system operations. For the ISO, the challenge will be largely associated with forecasting the output of distributed resources and its effect on net demand because the expectation is that these resources will be mostly not visible to the ISO. Operators in the control center, in other words, will not be able to see, through telemetry, how these resources are effecting supply and demand.

The ISO expects the impact in the near term to remain fairly limited, but ISO will be in a position to support the changes through its process and forecasting capability, no matter the levels.

WHEELING ELECTRIC VEHICLES

While it is too early for the grid to feel the effects of electric vehicles, the ISO and its stakeholders are proactively looking ahead for a time when their impact will be felt. In an independent study, Pike Research forecasts the annual plug-in electric vehicle market to reach 359,000 vehicles by 2017 — the majority in California and New York City.¹

The largest electric vehicle market expected is in the Southern California Edison service territory. Most current research on the topic does not provide enough data on which to base grid planning.

The Energy Commission reports that by 2020, electric vehicles are expected to increase annual electricity demand on a statewide basis by roughly 4,400 gigawatt hours (approximately 1.4 percent), and peak demand by roughly 190 megawatts (approximately 0.3 percent).² The Commission’s electricity demand forecast, which the ISO uses in its planning process, accounts for these increases.

While the direct impact of electric vehicles on the ISO high-voltage network will need to be studied, the impact on the local distribution level will be more of an issue in the short term. The ISO is beginning to consider this in its activities, which include coordination with local utilities.

² http://www.energy.ca.gov/2010publications/CEC-600-2010-001/CEC-600-2010-001-CMF.PDF

Distributed resources are showcased at the new ISO headquarters. Photovoltaic panels on the roof of the control center and in the parking lot can generate 742 kW of electricity at any one time.

Non-generation alternatives
The ISO now has a regulation energy management tariff enhancement that removes barriers restricting the full participation of limited energy resources in the ISO regulation market. Passed by the ISO Board of Governors in February 2011, the enhancement enables new types of storage resources, such as batteries and flywheels, to provide regulation capacity for the power grid. These resources offer flexibility and fast on and off capabilities that are expected to provide significant operational benefits.

The ISO will closely monitor the performance of new technologies and adapt market rules as necessary to maximize the benefits they provide. The enhancement also supplies an important compliance step with FERC Order No. 890 requiring ISOs to enable these resources to participate in the ancillary services market.

ISO READINESS
Distributed Resources

- **Implement a process** to track distributed energy resources including their capacity and location.
- **Establish requirements** for equipment to support distributed solar generation forecasting.
- **Modify load forecasting process** to adjust for electric vehicle impact to load forecasts.
- **Define role of microgrids and virtual power plants** in system reliability and its load shaping impacts.

Storage
The ISO believes that storage could supply ancillary services products such as regulation capacity, which is critical in maintaining system frequency. In addition, storing energy for later use could play a major role in managing the uncertainty of wind and solar resources. Stored energy could fill in the supply gaps on the grid. Yet, utility grade storage is a nascent technology and requires more testing to fully understand its application and operational characteristics, which will guide the policies to fully utilize its capabilities.

An estimated 5 MW–10 MW of storage is expected to begin bidding into the market once the Federal Energy Regulatory Commission approves the tariff changes submitted by the ISO and needed software modifications are made.

Meanwhile, the U.S. Department of Energy awarded $186 million to eight California smart grid and storage demonstration projects on November 24, 2010. This was in addition to the $230 million awarded to California projects through the smart grid investment grants on October 27, 2010. Among the projects were the following:

- **Southern California Edison: Irvine Smart Grid Demonstration** ($40 million) integrated, scalable end-to-end smart grid system from transmission to consumer applications — the ISO is actively engaged in this project to further our understanding of the potential impact of distributed energy resources and develop deep situational awareness.

- **Pacific Gas and Electric: Underground Compressed Air Energy Storage** ($25 million), 300 MW plant in Kern County — the ISO is participating on the advisory committee for this project.

- **Southern California Edison: Tehachapi Wind Energy Storage Project** ($25 million), 8 MW utility-scale lithium ion battery technology — the ISO is an advisor to this project and is supporting it by bringing this battery into the ISO market.
Demand response

Through enabling technologies, common data exchange standards and price signals that reflect grid conditions, consumers can make smart choices about their electricity use by having the capability and understanding to adjust their consumption based on economic and reliability conditions.

Grid reliability will be enhanced when dynamic pricing is widely deployed, thus incenting large numbers of consumers to automatically respond to price signals and explicit instructions from utilities, aggregators and the ISO. This will contribute to a more efficient market and responsive grid. Price responsive and dispatchable demand resources are essential to maintaining grid reliability as California’s energy supply incorporates more renewable, variable energy and distributed energy resources.

Demand response success relies on consumers and their willingness to leverage the tools available to shift and curtail power use. That includes participating in air conditioning cycling programs, subscribing to price responsive load curtailment programs and responding to ISO calls for conservation during system events. Utility retail demand response programs include 2,400 MW available for the summer of 2011 to help offset load peaks and provide grid operators with additional system flexibility when needed.27

The ISO and stakeholders have designed two new products that will enable dispatchable demand resources to participate in the wholesale market.

Proxy demand resource

The proxy demand resource product, which launched in 2010, enables utilities and third party aggregators to bid a demand response into the ISO markets just like conventional generation. Along with it, the ISO deployed a demand response system and released software updates for the market results interface and the scheduling and logging system. A settlements and market-clearing configuration that supports proxy demand resource functionality was also put in place. This enables pre-qualified entities to aggregate loads that are measurable and verifiable in reducing demand.

In the near term, most proxy demand resource capacity is expected to come from existing utility programs. Utility filings in March 2011 indicated that as much as 10 percent of their demand response capacity may be offered as proxy demand resources. This would represent more than 200 MW of demand response during peak summer months.28

Reliability demand response resource

Another market feature completed in early 2011 and sent to federal regulators for approval is the reliability demand response resource product. The product was created in a multi-party, cross-industry settlement approved by the Public Utilities Commission as a means to convert traditional interruptible demand programs into market based products that can be dispatched through the ISO market. Its design features include compatibility with interruptible load programs and residential air-conditioning cycling.

If these technologies do not develop in expected time frames and enabling policies are not in place, there will be an increased reliance on conventional generation to balance the variabilities of renewables generation.

ISO READINESS
Demand Response

- Engage with the investor-owned utilities and PUC on potential dynamic pricing approaches.
- Evolve Proxy Demand Response Product to make it more effective.
- Coordinate with WECC to change reliability standards to support non-generating resources.

Visitors and employees enter the new ISO campus through a security access point that enables low profile, high safeguard measures.
VIII. ORGANIZATIONAL EFFECTIVENESS

Budget and grid management charge

The ISO reached a new level of organizational efficiency in 2010 that led to reducing the 2011 budget by $5.3 million. These savings were realized even with the additional workload that integrating renewables is placing upon ISO staff and resources. The 2011 revenue requirement is $189.8 million with the grid management charge set at 79 cents per megawatt hour. This is nearly unchanged from 2010 even though the sluggish economy is reducing the volume of electricity entering the grid. The budget assumes 240 terawatt-hours of volume in 2011, which is 2.4 percent lower than in 2010.

As with most corporations, the ISO is watching costs closely while improving services by ensuring efficient staffing levels. The ISO budget uses an activity-based costing approach that directly ties division budgets with the goals contained in the 2011-2015 Five-Year Strategic Plan.

Reforming cost allocation guiding principles was a major element in reforming the grid management charge in 2011. The ISO changed its approach by separating the cost of its activities into three main categories: market services, system operations and congestion revenue rights services. Associated with these cost categories are four transaction charges: bid segment fee, inter-scheduling coordinator trade fee, congestion revenue rights bid fee and the scheduling coordinator identification fee.

This approach offers significant improvements to the current grid management charge structure by:

- Increasing the amount of direct allocations of costs to buckets;
- Reducing forecasting errors through rate simplification;
- Reducing the number of charge codes; and
- Simplifying the calculations of these charge codes.

The primary purpose of the new grid management charge design is to base each participant’s charges on the use of ISO services. The benefits include:

- **Transparency** – Costs and billing determinants will be clear, visible and understandable to all market participants.
- **Predictability** – Market participants will be able to determine in advance what their grid management charge costs will be depending on their activity.
- **Flexibility** – The new grid management charge structure will easily accommodate future market enhancements without excessive complexity or disruption to the overall structure.

The new rate structure, once it gains FERC approval, will go into effect January 1, 2012.

Facility management

Efficient campus operation was an important objective in the design of the new ISO headquarters. The ISO decreased energy usage by more than 70 percent compared to the energy usage at its former leased headquarters, as seen in figure 16. This is just one of the sustainable attributes of the new building that helped earn it a Platinum rating through the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) program.

LEED is the nationally recognized benchmark for the design, construction and operation of high performance sustainable buildings. Buildings that earn Platinum demonstrate environmental stewardship and social responsibility.

The ISO headquarters exemplifies California’s commitment to the environment and the hope is that it serves as a model to encourage other sustainable building construction.

**Figure 16 – New building energy savings**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Electricity usage per sq. foot</th>
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</thead>
<tbody>
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<td>previous leased space</td>
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<tr>
<td>standard building</td>
<td>23 kWh</td>
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<tr>
<td>new headquarters</td>
<td>19 kWh</td>
</tr>
<tr>
<td>reduction</td>
<td>72%</td>
</tr>
</tbody>
</table>

---

Xeriscaping at the ISO headquarters is 100% irrigated by building graywater. Overall, water use is 30% less than at the former campus.