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The "Cal-ISO Duck" appears to not value DCPP

The attached set of three documents merged into a single PDF raises the "Loading Order" question regarding California's current renewable energy portfolio policy that excludes, among other generation sources, nuclear power from the portfolio. Diablo Canyon Power Plant (DCPP) is California's largest electric power generator, producing about 18,000 GWh of reliable, emissions-free, low-cost electric power. DCPP's annual capacity factor (CF) is around 95%. DCPP provides excellent voltage-control and frequency-control to the California power grid.

The December, 2014 analysis from North American Windpower Magazine appears to endorse taking DCPP off-line to reduce the curtailment of low-CF solar and wind power generators that lack frequency control. The trade would reduce the curtailment of 4,637 GWh of this lower-quality power in exchange for the loss of DCPP's 18,000 GWh of high-quality electric power (about 388.3% of the curtailment.) This proposed policy change would sacrifice California grid stability and reliability and should not be pursued in its present form.

Instead, large wind and solar projects should be required to include significant energy storage capability to increase their CFs from the current 20-25% range to at least 80%. This change would facilitate a more accurate equivalence with the emissions-free nature of nuclear power. (However, the already-high capital expenditures associated with wind and solar projects would likely at least double with a requirement to include energy storage.)

The second document is the Cal-ISO document regarding the "Cal ISO Duck." The third document provides a profile of the Oakland, California firm MRW & Associates, LLC whose authors were authors of the December, 2014 North American Windpower Magazine article. The inclusion of the firm profile does not in any way imply an endorsement of the firm.

Additional submitted attachment is included below.

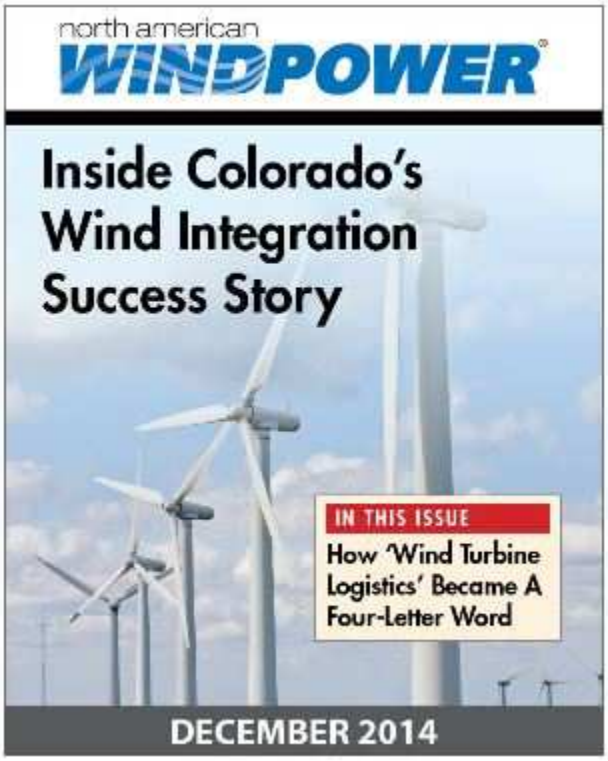
Industry At Large: Wind Farm Operations

Renewable Energy Faces Daytime Curtailment In California

An oversupply of renewable energy and gas-fired generation is causing major headaches for the California Independent System Operator.

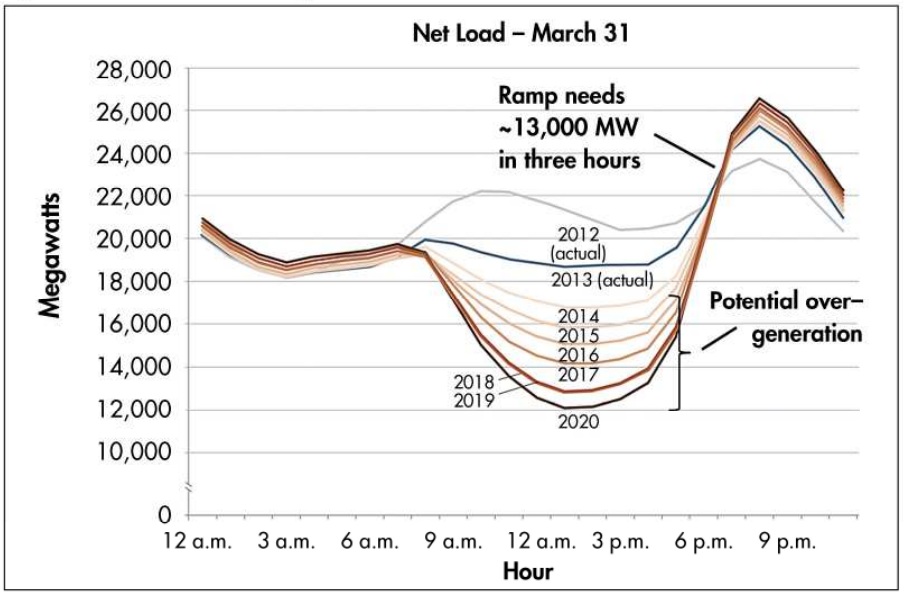
By David Howarth & Bill Monsen

North American Windpower, Volume 11, Number 12 December, 2014
Archived by Gene A. Nelson, Ph.D. 06 June 2015



http://www.nawindpower.com/issues/NAW1412/FEAT_04_Renewable-Energy-Faces-Daytime-Curtailment-In-California.html

Figure 1: Net load on the CAISO system



Source: CAISO

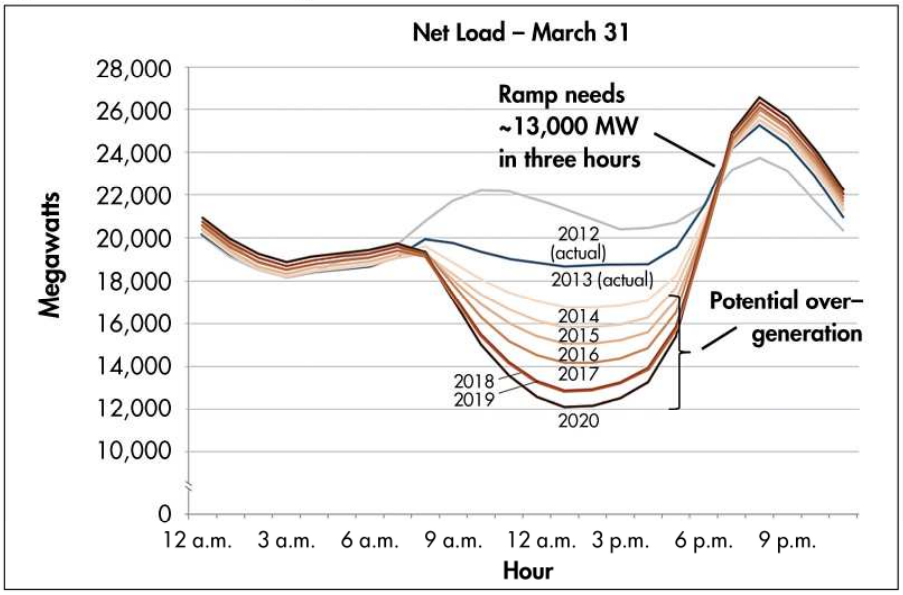
CAPTION: The California Independent System Operator (CAISO) is concerned that there may be times when there is so much variable wind, solar and other renewable energy being scheduled onto its system that the other generators that have to adjust to accommodate it will not have the flexibility needed to do so.

As California marches toward fulfilling – and probably exceeding – a renewable portfolio standard (RPS) that requires 33% of its electricity to come from renewable energy sources by 2020, grid operators are beginning to face operational challenges that could have implications for existing renewable and non-renewable generators and that will shape opportunities for future projects.

For example, existing renewable generators might be curtailed more than in the past. If the system operator curtails renewables, then the generator might not receive full compensation for curtailed energy. Existing gas-fired generators might need to increase their flexibility to allow for more starts, faster ramping and lower minimum levels of operation.

New projects – both renewable and conventional – may need to provide greater levels of flexibility or accept greater levels of curtailment

Figure 1: Net load on the CAISO system

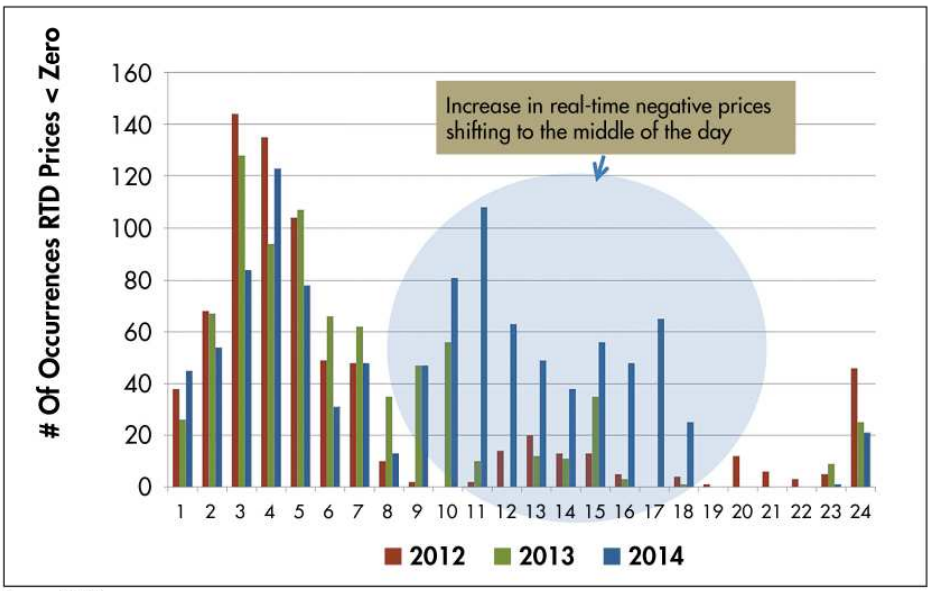


Source: CAISO

The California Independent System Operator (CAISO) is concerned that there may be times when there is so much variable wind, solar and other renewable energy being scheduled onto its system that the other generators that have to adjust to accommodate it will not have the flexibility needed to do so.

When scheduled generation exceeds scheduled demand in the hour-ahead market, the price of energy falls below zero in an attempt to balance supply and demand. In other words, when prices are negative, generators must pay others to take the electricity they produce. After accounting for changes in generation and load between the hour-ahead and real-time markets, if generation still exceeds load and there are no more generators willing to be paid to reduce their output, then the CAISO must order generators to curtail output in order to maintain system frequency.

Figure 2: Distribution of negative prices – March, April & May 2012, 2013 & 2014



Source: CAISO

Why would generation exceed load? Some generators, such as nuclear, small hydroelectric, and most geothermal and combined heat and power plants, need to run and have little ability to shut down because they have limited flexibility. A certain amount of gas-fired power plant capacity must also be operated at minimum levels to provide upward ramping needed later in the day or to provide ancillary services, such as regulation and load following. If the combination of must-run generation and gas-fired generation needed for system operations exceeds demand (particularly in low-load hours), then the CAISO must take action.

Growing curtailments

The CAISO is already beginning to see these types of overgeneration events. In February through April (2014,) the CAISO had to curtail wind and solar generation four times for a total of six hours to balance supply and demand on its system. On one occasion, the maximum curtailment reached 485 MW of wind and 657 MW of solar. The impact on individual generators depends on the terms of their power purchase agreements, but typically, there is no compensation for curtailment that is ordered by the grid operator.

In the absence of any changes to address the underlying issues, the CAISO forecasts overgeneration and renewable energy curtailment to increase in the future as more renewable energy is added to the system.

Looking ahead to 2024, the CAISO expects curtailment to remain relatively modest if RPS energy levels remain at 33%. Total curtailment is forecast to be less than two-tenths of 1% of the total RPS supply. However, if RPS energy levels increase to 40% (which has been proposed by California Gov. Jerry Brown, D-Calif., as an achievable goal), then the CAISO

forecast of renewable curtailment jumps to more than 2.5% of RPS supply. This means that a significant portion (15%) of the incremental renewable energy added to move from a 33% RPS to 40% would be curtailed.

Figure 3: CAISO forecast assumptions for 2024

Scenario	Number Of Hours Curtailed	Maximum Curtailed (MW)	RPS Energy Curtailed (GWh)	RPS Actually Achieved
Trajectory (33% RPS)	96	5,927	153	32.9%
Trajectory Without Diablo Canyon	24	3,383	26	33.0%
High Load	87	5,841	136	32.9%
40% RPS	822	13,402	2,825	38.7%
Expanded Preferred Resources	1,165	14,599	4,637	37.5%

Source: CAISO

GAN Note: Diablo Canyon's annual production is 18,000 GWh, or 388.2% of the above "worst case" RPS energy curtailment.

Under this scenario, which assumes a solar-dominated renewable energy portfolio, California would fall short of 40% renewable supply unless even more renewables were added to make up for the curtailed RPS energy – at considerable extra expense and with diminishing returns.

The CAISO has made certain market changes designed to improve the management of overgeneration through economic dispatch, as well as to require utilities to procure enough flexible capacity to ensure reliable operation under a range of conditions. On May 1, (2014) the CAISO reduced its bid floor from -$30/MWh to -$150/MWh, with provisions to reduce it further to -$300/MWh after a year.

In other words, if the market-clearing bids are at the floor price, then generators will have to pay $150/MWh to deliver their electricity to the system.

By reducing the bid floor, the CAISO hopes to provide an additional incentive for renewable generators and less flexible conventional generators to provide market bids rather than simply operate as must-take resources. The CAISO has also implemented a 15-minute market to allow for intra-hour scheduling and to provide another opportunity for renewable generators to submit economic bids and adjust schedules close to real time, thereby reducing the likelihood of overgeneration.

The CAISO is proposing to establish a flexible capacity requirement to ensure that utilities have enough ramping capability. The CAISO is also proposing to procure backstop flexible capacity to meet any system-level deficiencies. The Federal Energy Regulatory Commission approved both proposals on Oct. 16, (2014).

The specter of overgeneration may dampen demand for new renewable generation that would contribute to excess supply during certain hours. This appears to be especially true for solar photovoltaics that have dominated recent RPS procurements as a low-cost resource and are driving down "net load" (which is equal to sales plus losses less must-take renewables) during the middle of the day. **Baseload renewable generators, such as geothermal and biomass, should not necessarily expect a boost, however, because they also contribute to the problem of minimum generation levels**. To the extent that such generators can be made dispatchable, they should be more valuable going forward.

Potential opportunities

There may be an opportunity for existing gas-fired generators to be part of the solution by improving their operating flexibility. However, it remains to be seen whether procurement mechanisms will develop that allow such generators to recover the costs of making flexibility improvements to their existing plants. When utilities procure new capacity resources – and with little or no load growth being forecast in California, it might be awhile before they add to the procurement pipeline – flexibility characteristics could factor into procurement decisions. **Projects that are able to ramp quickly and start multiple times per day will be preferred.**

Storage facilities should also benefit from the situation because they can increase demand by charging during periods of potential overgeneration – while getting paid to store the excess electricity – and then use that stored energy to meet peak demand and provide ancillary services, thereby reducing the amount of gas-fired generation needed to operate at minimum levels to provide reserves.

Demand response may also be able to meet some of those peak ramping needs and reduce minimum generation levels.

It is likely that changes in rate design – with an emphasis on getting better price signals – would encourage customers to shift loads in times of surplus generation, which might be in the middle of the day. This would be a reversal of historic conservation efforts designed to reduce consumption during historic peak periods, such as noon to 6 p.m. in the summer months.

An unknown factor in addressing overgeneration is whether excess generation in California can be exported to other areas. The CAISO says that there has never been less than 2 GW of net imports into California, and therefore, it has assumed zero net exports from California in its modeling. With greater regional coordination, grid operators may be better able to dispatch resources across larger geographic areas, which should reduce the likelihood of overgeneration

and curtailment**. A first step in this direction was the creation of the energy imbalance market between the CAISO and PacifiCorp that began operating on Oct. 1, (2014); this new market is expected to expand to include Nevada Power in 2015. The CAISO has indicated that it is open to greater cooperation, but the grid operator will move slowly and only in collaboration with other balancing authorities in the West.**

Given this attention and the various tools available to regulators and grid operators to address the underlying causes of overgeneration, it is not a given that the CAISO's forecasted curtailment levels will actually occur during the 10-year time horizon that was modeled.

In fact, preliminary results from the California 2030 low-carbon grid study being performed by the National Renewable Energy Laboratory – and sponsored by a group of clean energy companies, foundations and trade associations – suggest that with substantial increases in energy efficiency, demand response and storage, and greater cooperation across the West, California's electrical system in 2030 would be able to accommodate a portfolio of incremental renewable generation equivalent to a 50% RPS, with minimal renewable curtailment to address overgeneration. w

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A Duck Sighting

To illustrate the challenge posed by increasing levels of variable renewable generation, the California Independent System Operator (CAISO) has produced what has become known as the "duck chart." **The duck chart shows the net load on the system – that is, the electricity demand to be served by generation after subtracting the variable generation over which the CAISO does not have dispatch control – on a spring day with relatively high hydroelectric generation and low demand.**

As shown in the Figure 1 chart, the "belly of the duck" grows in each successive year with the addition of solar resources that reduce the net electricity demand during the daytime. Already, the CAISO sees utility-scale solar on its system approaching 5 GW, plus an additional 2 GW of solar resources on the customer side of the meter. These solar additions have the effect of shifting the minimum net load from early morning to the middle of the afternoon (that is, from 3 a.m. to around 2 p.m.). **The growing belly also contributes to the steep ramp to meet peak net demand after the sun sets. By 2020, the three-hour ramp (from 4 p.m. to 7 p.m.) is expected to reach 13 GW.**

The effect of solar additions can also be observed in the changing distribution of negative real-time energy prices, which provide an indication of the risk of overgeneration. As shown in Figure 2, the incidence of negative real-time prices in 2014 increased significantly during the

middle of the day compared to prior years. However, there was no significant change in negative real-time prices during other periods.

The overgeneration events that occurred in 2014 are also consistent with the duck-like shape of the net load curve. Only one event occurred at night (at 3:44 a.m.). The other three involved solar curtailments and occurred starting at 8:40 a.m., 11:11 a.m. and 12:40 p.m., respectively. On one of those days, April 12, energy prices were negative during 43% of the five-minute real-time dispatch intervals. **Based on observations of negative prices and curtailment in 2014, Brad Bouillon, CAISO director of day-ahead operations and real-time operations support, reported to the Federal Energy Regulatory Commission that "the belly of the duck has already arrived."**

Forecasting Curtailment In 2024

The California Independent System Operator (CAISO) submitted testimony to the California Public Utility Commission (CPUC) in August based on the modeling it performed of the electrical system in 2024.

The forecast assumptions were largely determined in advance by the CPUC with input from the California Energy Commission. There were five scenarios specified by the CPUC: the current policy trajectory with a 33% renewable portfolio standard (RPS); the current trajectory without the Diablo Canyon nuclear plant; high loads; a 40% RPS; and an expanded slate of preferred resources, such as energy efficiency and distributed generation.

The CAISO's curtailment forecasts for each of these scenarios are summarized in Figure 3.

Given a 33% RPS, the CAISO forecasts 96 hours of renewable curtailment, with a maximum curtailment of almost 6 GW. Total curtailed RPS energy is expected to be 153 GWh. Under a 40% RPS scenario, curtailments are forecast to increase to 822 hours with a maximum curtailment of over 13 GW. At 2,825 GWh, the amount of curtailed renewable energy in the 40% RPS scenario is forecast to increase by almost 20 times compared to the 33% RPS scenario.

The highest level of curtailment occurs in the expanded preferred resources scenario, which relies on energy efficiency and customer distributed generation to reduce net electricity demand significantly.

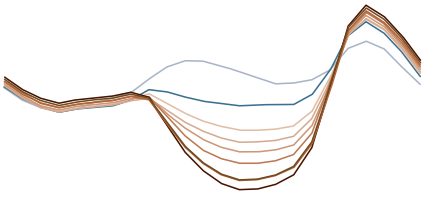
In this scenario, renewable energy curtailments would occur during almost 1,200 hours (13% of all the hours in a year), with a maximum curtailment of almost 15 GW. **Curtailments are lower in the scenario without Diablo Canyon because minimum generation levels would be reduced**

by removal of this baseload nuclear resource. (Emphasis added by GAN) There is relatively little difference in curtailments between the high load and trajectory scenarios because the renewable generation and loads both increase in proportion to each other.

Because the CAISO analysis does not include all of the capacity resources currently being procured to ensure local reliability in Southern California (following the modeling instructions provided by the CPUC), the CAISO's assessment probably overestimates curtailment. This is because the approximately 2 GW of new capacity not included in the analysis are likely to be more flexible than much of the existing fleet and will reduce the minimum generation needed to be operating at a given time. However, with forecasted curtailments of up to 15 GW in the 40% RPS scenario, the CAISO will still need additional tools to address overgeneration in the future.

California ISO
Shaping a Renewed Future

FAST FACTS



What the duck curve tells us about managing a green grid

The electric grid and the requirements to manage it are changing. Renewable resources increasingly satisfy the state's electricity demand. Existing and emerging technology enables consumer control of electricity consumption. These factors lead to different operating conditions that require flexible resource capabilities to ensure green grid reliability. The ISO created future scenarios of net load curves to illustrate these changing conditions. Net load is the difference between forecasted load and expected electricity production from variable generation resources. In certain times of the year, these curves produce a "belly" appearance in the mid-afternoon that quickly ramps up to produce an "arch" similar to the neck of a duck—hence the industry moniker of "The Duck Chart".

Energy and environmental goals drive change

In California, energy and environmental policy initiatives are driving electric grid changes. Key initiatives include the following:

- 33 percent of retail electricity from renewable power by 2020;
- greenhouse gas emissions reduction goal to 1990 levels by 2020;
- regulations in the next 4-9 years requiring power plants that use coastal water for cooling to either repower, retrofit or retire;
- policies to increase distributed generation; and
- an executive order for 1.5 million zero emission vehicles by 2025.

New operating conditions emerge

The ISO performed detailed analysis for every day of the year from 2012 to 2020 to understand changing grid conditions. The analysis shows how real-time electricity net demand changes as policy initiatives are realized. In particular, several conditions emerge that will require specific resource operational capabilities. The conditions include the following:

- **short, steep ramps** – when the ISO must bring on or shut down generation resources to meet an increasing or decreasing electricity demand quickly, over a short period of time;
- **overgeneration risk** – when more electricity is supplied than is needed to satisfy real-time electricity requirements; and
- **decreased frequency response** – when less resources are operating and available to automatically adjust electricity production to maintain grid reliability.

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Green grid reliability requires flexible resource capabilities

To reliably operate in these conditions, the ISO requires flexible resources defined by their operating capabilities. These characteristics include the ability to perform the following functions:

- sustain upward or downward ramp;
- respond for a defined period of time;
- change ramp directions quickly;
- store energy or modify use;
- react quickly and meet expected operating levels;
- start with short notice from a zero or low-electricity operating level;
- start and stop multiple times per day; and
- accurately forecast operating capability.

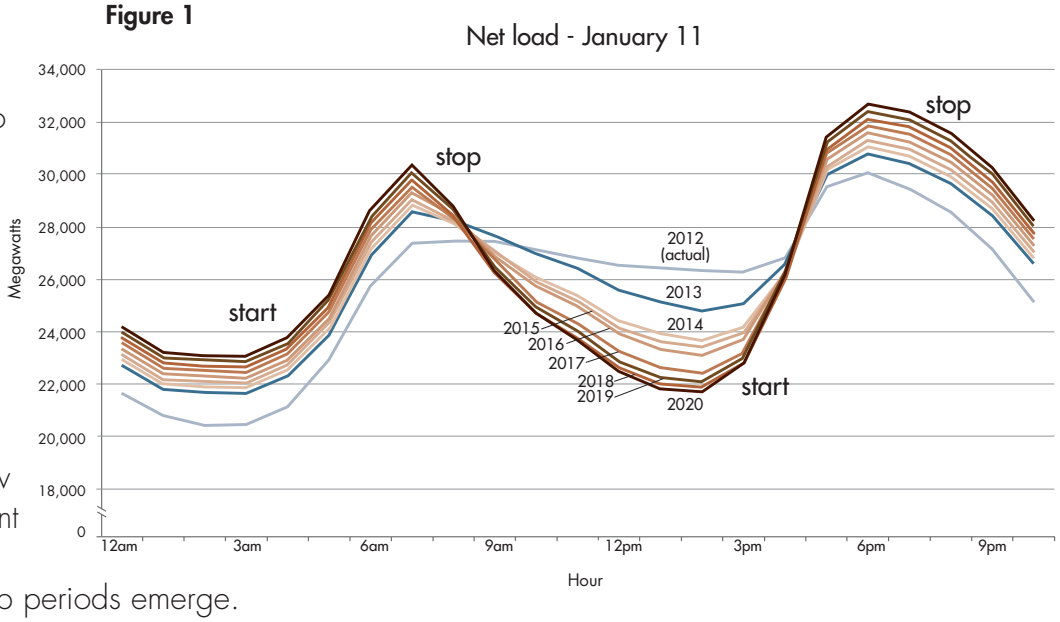
Reliability requires balancing supply and demand

The net load curves represent the variable portion that ISO must meet in real time. To maintain reliability the ISO must continuously match the demand for electricity with supply on a second-by-second basis. Historically, the ISO directed conventional, controllable power plant units to move up or down with the instantaneous or variable demand. With the growing penetration of renewables on the grid, there are higher levels of non-controllable, variable generation resources. Because of that, the ISO must direct controllable resources to match both variable demand and variable supply. The net load curves best illustrate this variability. The net load is calculated by taking the forecasted load and subtracting the forecasted electricity production from variable generation resources, wind and solar. These curves capture the forecast variability. The daily net load curves capture one aspect of forecasted variability. There will also be variability intra-hour and day-to-day that must be managed. The ISO created curves for every day of the year from 2012 to 2020 to illustrate how the net load following need varies with changing grid conditions.

Ramping flexibility

The ISO needs a resource mix that can react quickly to adjust electricity production to meet the sharp changes in electricity net demand. Figure 1 shows a net load curve for the January 11 study day for years 2012 through 2020. This curve shows the megawatt (MW) amounts the ISO must follow on the y axis over the different hours of the day shown on the x axis. Four distinct ramp periods emerge.

Figure 1



The first ramp of 8,000 MW in the upward direction (duck's tail) occurs in the morning starting around 4:00 a.m. as people get up and go about their daily routine. The second, in the downward direction, occurs after the sun comes up around 7:00 a.m. when on-line conventional generation is replaced by supply from solar generation resources (producing the belly of the duck). As the sun sets starting around 4:00 p.m., and solar generation ends, the ISO must dispatch resources that can meet the third and most significant daily ramp (the arch of the duck's neck). Immediately following this steep 11,000 MW ramp up, as demand on the system deceases into the evening hours, the ISO must reduce or shut down that generation to meet the final downward ramp.

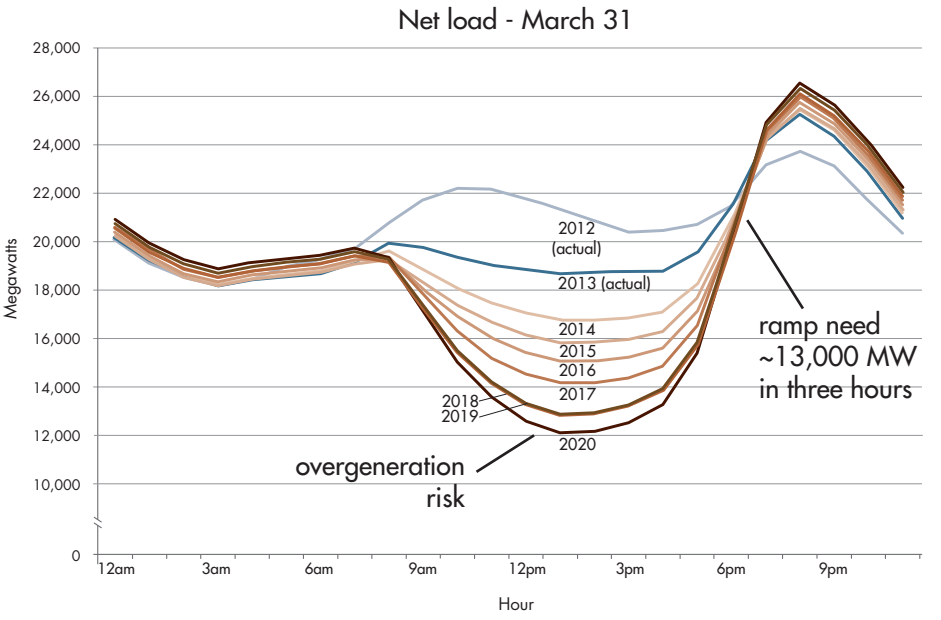
Flexible resources needed

To ensure reliability under changing grid conditions, the ISO needs resources with ramping flexibility and the ability to start and stop multiple times per day. To ensure supply and demand match at all times, controllable resources will need the flexibility to change output levels and start and stop as dictated by real-time grid conditions. Grid ramping conditions will vary through the year. The net load curve or duck chart in **Figure 2** illustrates the steepening ramps expected during the spring. The duck chart shows the system requirement to supply an additional 13,000 MW, all within approximately three hours, to replace the electricity lost by solar power as the sun sets.

Overgeneration mitigation

Overgeneration happens when more electricity is supplied than is needed to satisfy real-time electricity requirements. The ISO experiences overgeneration in two main operating conditions. The first occurs as the ISO prepares to meet the upcoming upward ramps that occur in the morning and in the late afternoon. The existing fleet includes many long-start resources that need time to come on line before they can support upcoming ramps. Therefore, they must produce at some minimum power output levels in times when this electricity is not needed. The second occurs when output from any non-dispatchable/must-take resource further increases supply in times of low electricity need, typically in the nighttime hours. Historically, this condition was most likely to occur in the early morning hours when low demand combines with electricity and generation brought on line to prepare for the morning ramp. The duck curve in **Figure 2** shows that overgeneration is expected to occur during the middle of the day as well.

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



Because the ISO must continuously balance supply and demand, steps must be taken to mitigate over generation risk. These steps include increasing exports, expanding resource capabilities, and requiring renewable generation curtailment. The ability to export power depends on the needs of neighboring entities and balancing agreements. The available resources must evolve to include capabilities to start and stop multiple times per day and start with short notice from a zero or low electricity operating levels. The resource mix would also benefit from resources with energy storage capabilities and demand side response capabilities to help meet real-time system conditions.

Reliable grids have automated frequency response

System frequency measures the extent to which supply and demand are in balance. To ensure reliability, system frequency must be managed in a very tight band around 60 hertz. When an unexpected event occurs that disrupts the supply-demand balance, such as a loss of a generator or transmission line, frequency is impacted. These events do not allow time for manual response and balance is maintained through automated equipment. Conventional generation resources include frequency-sensing equipment, or governors, that automatically adjust electricity output within seconds in response to frequency to correct out-of-balance conditions.

Part of the renewable integration analysis conducted by the ISO uncovered concerns about frequency response capabilities due to the displacement of conventional generators on the system. The 2020 33% studies show that in times of low load and high renewable generation, as much as 60% of the energy production would come from renewable generators that displace conventional generation and frequency response capability. Under these operating conditions, the grid may not be able to prevent frequency decline following the loss of a large conventional generator or transmission asset. This situation arises because renewable generators are not currently required to include automated frequency response capability and are operated at full output (they can not increase power). Without this automated capability, the system becomes increasingly exposed to blackouts when generation or transmission outages occur.

Policy needed for flexible resources

To reliably manage the green grid, the ISO needs flexible resources with the right operational characteristics in the right location. The ISO is actively engaged in policy efforts to build awareness of the new grid needs. Working with the industry and policymakers, the ISO is collaborating on rules and new market mechanisms that support and encourage the development of flexible resources to ensure a reliable future grid.

CommPR/HS/10.2013

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About MRW & Associates, LLC

MRW & Associates, LLC is internationally recognized for its broad expertise in electric power and fuel markets. We combine an in-depth knowledge of these markets with rigorous economic and technical analysis to help our clients assess market opportunities, develop business strategies, and address regulatory issues.

MRW offers its clients a comprehensive portfolio of consulting services in the areas of power market analysis, regulatory and litigation support, natural gas market analysis, and retail market support. Because we maintain a singular focus on the energy industry, our industry expertise is both deeper and broader than many other consulting firms. We understand the strategic implications of evolving regulatory models, emerging technologies, and changing market dynamics and we put this knowledge to use to serve our clients' interests. Practical research, qualitative and quantitative analysis, and industry expertise underpin all of MRW's work and ensure that our client recommendations are sound.

Established in Oakland, California in 1986, MRW early-on built a solid reputation for delivering local insights on power and fuel markets in the western United States as well as intervening successfully in legislative and regulatory proceedings on our clients' behalf. Over this time, MRW has been involved in landmark developments such as the emergence of the independent power industry and the deregulation of California's electricity and natural gas industries.

Today, MRW continues to deliver high quality, superior market insights, analysis, and client support on a national and international level. The company has undertaken engagements in more than twenty different states, including nearly every state in the western U.S. Internationally, MRW has advised clients on projects in Argentina, Bolivia, Canada, China, India, Indonesia, Korea, Mexico, and Vietnam.

Our client base includes major financial institutions, private power developers, power marketers, municipalities, Fortune 500 industrial companies, commercial end-users, natural gas pipelines and storage service providers, regulatory agencies, and other strategic players in the energy sector. MRW's team of professionals, with an average of ten years of industry experience, include specialists in power market modeling, financial analysis, regulatory processes, utility rate design, legislative analysis, commodity procurement, energy use analysis, contract negotiations, transmission planning and pricing, and strategic planning.

For more information about MRW, please visit our website at www.mrwassoc.com.

Regulatory & Litigation Support

Industry restructuring in electricity and natural gas markets has brought market forces to bear on these traditionally regulated industries. The emerging model at the federal and state levels is the creation of competitive markets through the unbundling of formerly regulated monopoly services. The move to deregulate some segments of electricity and gas markets has led many regulatory agencies to open inquiries into stranded cost estimation, asset divestiture, consumer protection in competitive markets, and market power mitigation. At the same time, many facets of electricity and natural gas markets remain subject to some form of regulation by various agencies at the state and federal level.

The firm combines its expertise in finance, economics, and policy with its extensive knowledge of the energy industry's evolution to provide invaluable insights as the regulatory process unfolds. MRW provides a full range of services associated with regulatory intervention before federal and state regulatory agencies, including:

- preparing discovery requests;
- sponsoring expert testimony;
- developing or evaluating settlement scenarios;
- supporting cross examination efforts; and
- writing and submitting briefs.

MRW has actively participated in regulatory proceedings at the state and federal level dealing with stranded cost estimation, asset divestiture, performance-based ratemaking, marginal costs and revenue allocation, rate design and unbundling, utility mergers, and market power.

In addition to supporting our clients' participation in regulatory proceedings, MRW also provides support in commercial litigation cases. MRW assists law firms with litigation, mediation, and arbitration related to antitrust, commercial damage claims, and other legal matters. These cases often involve the presentation of complex economic issues related to profitability, market competition, and fair business conduct. MRW assists in all phases of the litigation process, working with attorneys to develop case strategy, conduct discovery, prepare depositions, submit expert testimony, and analyze settlement scenarios and estimate damages.

Power Market Analysis

Deregulated power markets present industry players with a range of new business opportunities. Competitive wholesale electricity markets, direct retail sales to end-users, and ancillary services markets are several aspects of the new electric power market that industry participants must consider in order to position a project for maximum profitability and minimal risk. In this environment, industry players need to stay abreast of a wide range of issues, including changes in regulatory policy, competitors' operations, fuel market trends, and wholesale power market trends. Sound project and market evaluations also play a crucial role in the successful development and financing of power projects. The emergence of merchant power projects, which are not backed by contracts for guaranteed power sales, underlines the need for solid analysis of the viability of projects.

MRW employs a variety of analytical tools to help clients make informed decisions about business opportunities within a local or regional power market. MRW provides sophisticated modeling to create forecasts of wholesale power prices, avoided costs, and retail electric rates. MRW also maintains a complete database of historical power prices posted at the California Power Exchange. At the same time, MRW's analyses, shaped by a deep appreciation for the regulatory and market environment, offer a comprehensive view of a particular power market. MRW offers a range of services in this area, including:

- forecasting wholesale power prices using power market simulation models;
- analyzing power market bidding dynamics;
- developing marketing strategies for power sales;
- reviewing transmission access issues;
- valuing ancillary services;
- identifying potential development or acquisition opportunities; and
- assessing the regulatory and policy environment.

MRW has substantial experience evaluating the viability of power projects on behalf of project developers, equity investors, and the investment banking community. MRW is often called upon to assess the impact of contract terms, transmission interconnection, and fuel supply arrangements on a project's future revenue stream.

Internationally, many countries are moving toward restructured or privatized power markets. Although the issues or business opportunities may differ from those in deregulated U.S. markets, the analytical approach to evaluating a power market is often similar. MRW has completed analyses of local and regional power markets in Bolivia, Canada, China, India, Indonesia, Korea, Mexico, and Vietnam.

Natural Gas Market Analysis

North American natural gas markets are experiencing robust growth, spurred in large part by significant increases in demand from power generators. At the same time, industry players and consumers are confronting several other market issues: new pipeline capacity is continually changing basis differentials among markets; several states continue to push for further regulatory reform and unbundling; and corporate mergers are changing business strategies.

MRW offers a wide range of analytical and advisory services designed to provide information about and insight into the competitive and regulatory forces shaping the natural gas industry. MRW assists its clients in reviewing gas supply and transportation options and choosing the options best-suited for their circumstances. On behalf of lenders, MRW will evaluate the economic soundness of a project's fuel supply arrangements relative to the evolving natural gas and power markets. MRW also provides economic and market analysis in support of clients' efforts in regulatory proceedings before state and federal agencies or in commercial litigation. MRW's services in this area include the following:

- evaluating gas supply procurement and transportation strategies;
- soliciting and negotiating gas supply procurement and transportation agreements;
- representing clients' interests in regulatory proceedings;
- providing economic and market analysis in support of commercial litigation;
- tracking industry developments that affect future natural gas supplies and prices; and
- forecasting short- and long-term natural gas prices.

Finally, because of our corporate expertise in electricity markets, MRW is qualified to assist clients in understanding the interplay of natural gas and electricity markets. In many regions of the United States, natural gas-fired power plants are becoming the marginal price-setting units. MRW helps its clients to assess the merit order of dispatch in a regional power market through an evaluation of short-term gas price trends and basis differentials.

Retail Market Support

The advent of retail competition in gas and electricity markets has fundamentally altered energy markets. For the first time, retail customers have the opportunity to choose their energy providers and can base their energy supply decisions on their unique situations. In response, many new players have entered the market and traditional utilities are transforming their operations to respond to the competitive marketplace. To win customers and increase market share, energy providers are expanding their product offerings to include not only commodity supply but also a broad array of energy management and value-added services, ranging from energy efficiency upgrades to providing detailed load and billing data via the Internet.

In this new environment, a retail customer must understand how much energy a facility uses and the manner in which it is used. With this information, a company will be able to identify opportunities for obtaining competitive energy commodities, optimizing energy use and maximizing energy savings. MRW provides expert analysis and strategic counseling to retail energy customers throughout the energy procurement process, from developing an overall energy supply strategy to analyzing energy consumption patterns, and to finalizing supply agreements. MRW offers the following services in this area:

- developing energy procurement strategies;
- implementing energy procurement strategies, including negotiating power purchase contracts, writing requests for proposals, and evaluating responses;
- analyzing energy usage data and facility operations;
- evaluating energy objectives;
- monitoring policy developments that affect the retail market;
- integrating electric power and fuel supply contracts; and
- developing risk management strategies.

MRW has worked with small and large commercial, institutional, and industrial clients in all of these capacities. For example, MRW assisted a large California municipality to procure commodity power and specialized services by preparing an RFP, analyzing the proposals, and advising the city officials throughout negotiations.

Selected Engagements

This select list of representative engagements illustrates MRW's capabilities in each of the firm's four main practice areas.

Regulatory and Litigation Support

- For a coalition of energy service providers, MRW submitted testimony before the California Public Utilities Commission concerning billing credits customers receive when they choose non-utility energy providers, such as credits for metering and billing services. To substantiate our testimony, MRW analyzed the embedded short-run and long-run marginal costs of the three major California utilities for providing theses services.

- On behalf of a major power marketer, MRW submitted testimony in the 1999 General Rate Case for Pacific Gas & Electric (PG&E). MRW staff testified in the areas of regulatory policy, administrative and general expense, distribution operations and maintenance, distribution and transmission capital additions, customer information systems, and customer records and accounting. MRW presented testimony on the level of allowable costs as well as policy issues associated with recovery of such costs. PG&E requested an increase in revenues in excess of $1 billion; the California Public Utilities Commission ultimately authorized an increase of only $452 million.

- On behalf of a non-profit health industry organization, MRW submitted testimony in the proceedings before the Pennsylvania Public Utilities Commission regarding stranded cost estimates for Penelec, Duquesne Light Company, and West Penn Power Company. MRW assessed the policy implications of securitization, evaluated how to maximize the benefits to ratepayers, and analyzed the potential impacts of large cash infusions to the utilities.

- MRW provided technical expertise and economic analysis to the legal counsel of one party to a commercial litigation dispute. The dispute centered on claims of breach of contract between the owner of several power production facilities and the utility purchasing the energy and capacity under long-term contracts. MRW analyzed short- and long-term power prices, reviewed power purchase contract terms, and contributed expert advice on historical market activity. MRW also advised the attorneys on deposition content, data requests, and expert witnesses, as well as overall legal strategy for the case.

Selected Engagements (cont.)

Power Market Analysis

- MRW was selected to be the power market consultant to a merchant power plant constructed in the Western United States. MRW developed a detailed market simulation model to forecast market-clearing power prices in the California market. Our power price forecast enabled the lead lender to evaluate the project's ability to repay the debt financing in a competitive wholesale market environment. Based on our overall power market assessment, the project became the first true merchant power plant to be financed successfully on a project finance basis. MRW played a similar role in the re-financing of several cogeneration projects and the divestiture of power plants by California's investor-owned utilities.

- MRW evaluated fuel supply and transmission interconnection issues and made a preliminary assessment of energy revenues for a 520 MW natural gas-fired combined cycle greenfield power project located in the Western United States. Specifically, MRW analyzed natural gas supply reserves and transportation options to supply the facility with natural gas. MRW also estimated the costs of natural gas for the facility over the life of the project. MRW evaluated the existing transmission system in the area and the potential for transmission congestion to affect the project's ability to deliver power into key markets. Finally, MRW developed power price forecasts under a base case and alternative scenarios. This plant is scheduled to enter commercial operation in 2001.

- MRW advised the international lenders considering financing a proposed 2x300 MW coal-fired power plant located in Hubei Province in the People's Republic of China. For this engagement, MRW analyzed national and provincial economic trends, regulatory reforms, and the future development of natural gas for power generation in China. MRW built a data set to simulate the Hubei power market to understand the project's competitiveness vis -à-vis other generating resources in the region. Our analysis of the project accounted for the impact of the Three Gorges Dam.

- MRW developed forecasts of future hourly power prices in the Pacific Gas & Electric service territory in California for an owner of a Qualified Facility. The forecasted prices provided the plant owner with a proxy for the day-ahead zonal Power Exchange (PX) price that the plant would receive if it were to exercise its one-time option to switch from the current formula-based short-run avoided cost pricing mechanism to market-based pricing. MRW also analyzed the regulatory risks arising from the potential need to reconcile an interim pricing mechanism used by the PX and a future mechanism that could be set by the California Public Utilities Commission whereby some portion of the PX price may be considered a capacity payment.

Selected Engagements (cont.)

Natural Gas Market Analysis

- On behalf of a natural gas storage services provider, MRW assessed the reasonableness of a gas storage pricing mechanism proposed by a power marketer seeking a price discount for its gas storage requirements. The proposed pricing mechanism was defined in terms of a spark spread, which was to be a function of future gas and electricity prices in the local market. MRW investigated the linkage between the daily city gate gas price and the zonal power price by performing regression analyses on the historic data. Based on this statistical analysis and our assessment of future gas and electric prices, we recommended to our client that it seek an alternative and more favorable pricing mechanism.

- MRW advised the majority equity owner of a cogeneration project on the acquisition of long-term natural gas supplies for the 26 MW plant. On behalf of the owner, MRW issued a Request for Proposals, evaluated the responses, and developed a short list of recommended suppliers for the investor to review. MRW provided an independent review of all of the proposals, resulting ultimately in substantial savings to the project and its owner.

- On behalf of a major gas marketer and shipper, MRW provided expert witness testimony at FERC responding to Pacific Gas Transmission's (PGT) request for rolled-in transportation rates. In addition to providing a comprehensive review of federal and California state pipeline rate design policy, MRW testified on the validity of sophisticated gas price models that purported to demonstrate the impact of the PGT Expansion on California natural gas prices.

Retail Market Support

- MRW assisted a national hospital chain in reviewing its electricity and gas costs on an aggregated and facility-by-facility basis. MRW compiled various types of facility-specific data, including electric consumption and demand levels. Using this information, MRW explored energy cost savings options such as energy efficiency improvements and fuel switching, switching electric tariffs, renegotiating existing fuel supply contracts, building cogeneration units, and obtaining discounts off the cost of bundled utility service by taking service from a power marketer. Ultimately, MRW helped our client to issue requests for proposals for demand-side management services and for energy commodity services at its California facilities and assisted with the evaluation of the subsequent responses and final selection of a supplier.

Selected Engagements (cont.)

- MRW developed a decision analysis process to assist a large Midwestern university in its evaluation of cogeneration and the expansion of the campus' chilled water system. MRW identified the major threshold issues the university needed to consider in each case and created a process for the university to follow in making a decision. MRW also analyzed the cost-effectiveness of various solutions and facilitated discussions between university personnel and the local utility, an energy service provider, and engineering firms.

- MRW assisted the City of San Diego in developing a comprehensive strategy to take advantage of the opportunities presented by energy industry restructuring. An important part of the strategy involved outsourcing some of the city's energy management functions to a third party. MRW combined an historical energy use analysis with the city's development plan to prepare a complete profile of the city's energy procurement needs. After these initial steps, MRW helped the city to prepare an RFQ and subsequently an RFP for energy services. MRW evaluated the responses based on various criteria and then assisted the city in negotiating and selecting a provider.

- On behalf of a northern California city, MRW evaluated proposals from several energy service providers seeking to serve as the city's agent at a former military base after the city established a public municipal utility and assumed control of the electrical distribution system following the base's closure. MRW performed a financial analysis of the proposals on behalf of the city and supported negotiations with the selected agent. MRW also assisted the city in assessing the feasibility of purchasing fuel cells for installation at a new city hall. MRW evaluated the costs of installing and operating the fuel cell cogeneration units compared to the alternative cost of purchasing electricity and natural gas. MRW's assessment also identified qualitative benefits and risks of installing fuel cells, including an assessment of air emission reductions, and presented these findings along with the financial analysis for evaluation by city staff.

MRW & Associates, LLC
Principals and Associates

WILLIAM A. MONSEN - Principal

- Expert witness in numerous regulatory proceedings and litigation support
- Specialist in competitive bidding systems for electric resources
- Expertise in modeling utility financial and operational systems
- Specialist in least-cost planning and demand-side management analysis
- Former Energy Economist and Decision Support Coordinator for Pacific Gas & Electric Company
- Former Staff member of University of Wisconsin-Madison Solar Energy Laboratory

MARK FULMER - Principal

- Experienced professional in energy technical,economic and policy analysis
- Expert witness in numerous regulatory proceedings in U.S. and Canada
- Experienced in least-cost planning and demand-side management analysis
- Experienced in power supply and energy efficiency technology assessment
- Experienced in utility cost allocation and rate design
- Former Research Assistant at Princeton University's Center for Energy and Environmental Studies

DAVID N. HOWARTH - Principal

- Interdisciplinary energy specialist, including quantitative and qualitative analysis of economic, technical and policy issues in the electric and natural gas industry
- Expertise in performing project due diligence, financial analysis, and valuation for independent power projects, including renewable energy facilities
- Experienced with renewable energy and greenhouse gas policy development and implementation
- Experienced with distributed generation and utility rate analysis for end use customers

LAURA NORIN – Senior Project Manager

- Expertise in quantitative and qualitative analysis of electricity and natural gas markets, regulation, and policy
- Experienced with California energy policy and regulatory processes, with an emphasis on nuclear energy policy and retail energy rates
- Expertise in building and analyzing spreadsheet models
- Background in the physics, economics, and policy of the energy industry
- Former Research Associate at Lawrence Berkeley National Lab's Environmental Energy Technology Division

KENNETH SOSNICK – Senior Project Manager

- Expert on a wide range of utility ratemaking issues (including Cost of Service, Rate Design, Cost Allocation)
- Testified and/or filed testimony before the Federal Energy Regulatory Commission in major interstate gas and oil pipeline and electric utility rate proceedings
- Extensive knowledge of major interstate natural gas and oil/product pipelines and Regional Transmission Organizations/Independent Service Operators
- Former Staff Analyst and expert witness for the FERC

MRW & Associates, LLC
Principals and Associates

JULIA GETCHELL – Senior Associate

- Experience in economic and statistical analysis; infrastructure and land use planning, and policy-making in relation to these fields
- Background in environmental planning, land use planning, and environmental economics
- Former Teaching Assistant for a masters-level quantitative analysis course at The University of Texas at Austin

BRIANA KOBOR – Senior Associate

- Experienced in California energy and regulatory policy with an emphasis on utility rate design and greenhouse gas policy
- Expertise in developing and analyzing models for exploring energy-related questions including electric and natural gas rate forecasting; policy implication analysis; electric production; and financial analysis
- Background in Resource Economics and Policy
- Former positions with large international energy research firm and U.S. Environmental Protection Agency

NAINA GUPTA – Associate

- Experience in California energy and regulatory policy
- Background in engineering and energy studies, including qualitative and quantitative analysis of energy-related issues
- Former Graduate Student Researcher at the University of California, Berkeley and Lawrence Berkeley National Lab