Energy Regions in Transition

Report on US tour of European energy leaders

September 2016

Renewables Grid Initiative

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1. Introduction

Since 2013 the Renewables Grid Initiative (RGI) has been in very regular dialogue and knowledge exchange with energy experts from the United States. This dialogue was triggered by Dave Olsen, member of the Board of Governors of the California ISO (CAISO), visiting Brussels and Berlin in December 2013 upon RGI's invitation and presented the Californian integrated grid and renewables generation planning at different events, including RGI's 3rd European Grid Conference. Subsequently, a delegation of California energy experts and regulatory leaders came to Germany in March 2014 to meet with many of their European counterparts. This led to RGI creating its work stream 'Energy Regions in Transition', which aims to bring together energy experts from countries that are currently going through or preparing for an energy transition. Under this banner, RGI first journeyed to California in October 2015 with a high-level European delegation and an agenda that was built around the California Independent System Operator's (CAISO) Annual Stakeholder Symposium. In 2016, we again organised an 'Energy Regions in Transition' tour to America, this time with an agenda spanning both New York and California, the leading states of the American energy transition. At the same time, their energy sectors need to provide power for the country's biggest cities. Still, they have set ambitious targets for the expansion of renewables, reduction of CO2 emissions and energy efficiency by 2030. This report is meant to give an overview of the discussions we had with the New York Public Service Commission, ConEdison, National Grid, the Nature Conservancy, Bloomberg New Energy Finance, CAISO, Tesla and many others.

> *"Our journey compared to a top level think-tank on cutting-edge subjects. Very good team spirit and plenty of insights… a nice cocktail to go forward."*
> **Enrico Carlini, Director of Grid Planning and Interconnection, Terna SpA**

> *"First hand experience is the best way to learn! The different perspectives provided from industry, officials and NGOs gave a broad perspective of the challenges ahead to successfully manage the energy transition emphasising that we need innovative approaches and sound engineering."*
> **Gerald Kaendler, Vice President Asset Management, Amprion**

We strongly believe that this sort of mutual exchange is a fundamental contribution to a comprehensive learning exercise with the objective of improving reliability, reducing costs and limiting the environmental impacts during the energy transition. We are convinced that the energy transition will hugely benefit from many of its most involved players having looked beyond their own horizon with respect to technical, financial, regulatory and societal solutions for the energy transition and deepened their understanding of the transferability of solutions to and from another regional context.

1. US Energy Policy

New York

1. In 2014, Governor Andrew M. Cuomo launched New York's signature energy policy, Reforming the Energy Vision (REV). REV will build an integrated energy network able to harness the combined benefits of the central grid with clean, locally generated power.
2. The State Energy Plan is a comprehensive roadmap to build a clean, resilient, and affordable energy system for all New Yorkers. The Plan coordinates every State agency and authority that touches energy to advance the REV agenda, unleashing groundbreaking regulatory reform to integrate clean energy into the core of the power grid, redesigning programs to unlock private capital, and actively deploying innovative energy solutions across the State's own public facilities and operations.
3. The Plan, as a roadmap for REV, fosters economic prosperity and environmental stewardship—government and industry working together through public-private partnerships to achieve the shared goal of a healthier and stronger New York economy.
4. The initiatives outlined in the State Energy Plan, along with private sector innovation and investment fueled by REV, will put New York State on a path to achieving the following clean energy goals by 2030:
   - 40% reduction in greenhouse gas emissions from 1990 levels (80% by 2050)
   - 50% of energy generation from renewable energy sources
   - 23% decrease in energy consumption in buildings from 2012 levels (600 trillion British thermal units (Btu) increase in statewide energy efficiency
5. New York State Public Service Commission (PSC) ordered the New York State Energy Research and Development Authority (NYSERDA) to develop a proposal for the Clean Energy Fund, which NYSERDA submitted in September 2014. The proposed Clean Energy Fund is a 10-year program to invest $5 billion in New York's clean energy economy through 2025.

More information:
http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

Basic facts:

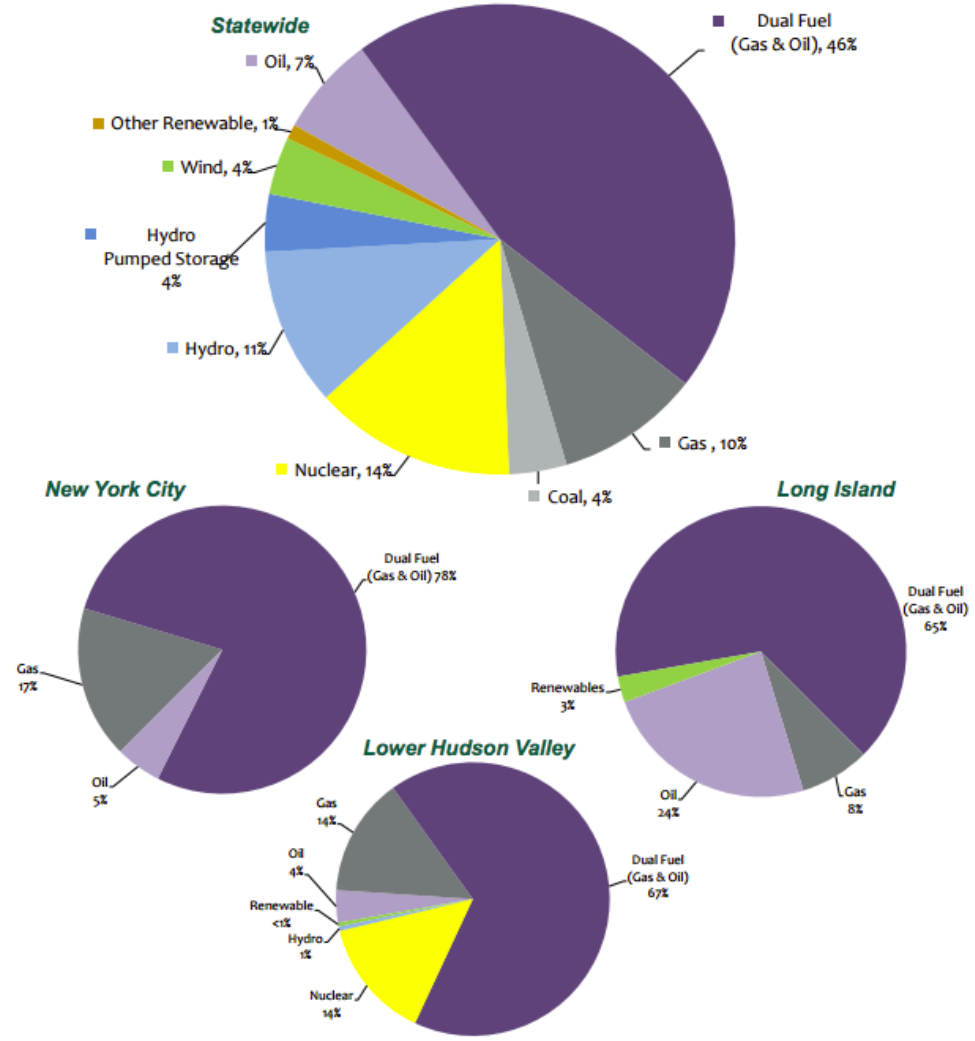
- In 1882, Thomas Edison built the world's first electrical grid in New York City.
- The 2.4-gigawatt Robert Moses Niagara hydroelectric power plant is the fourth-largest hydroelectric power plant in the United States. In 2015, New York produced more hydroelectric power than any other state east of the Rocky Mountains.
- In 2015, New York had the seventh-highest average electricity prices in the United States, down from the third-highest price in 2014.
- To curb air pollution, in 2012 New York became the first North-eastern state to require that all heating oil be ultra-low sulphur diesel.

- To ensure reliability, New York regulators require electricity-generating units that can burn either fuel oil or natural gas to be ready to switch to fuel oil if natural gas supply is constrained.
- The NY-Sun initiative aims to install 3,000 megawatts of small-scale (less than 200 kilowatts) solar photovoltaic facilities by 2023, and more than 15% of that target was installed by the end of 2015.

More information: http://www.eia.gov/state/?sid=NY

Power mix

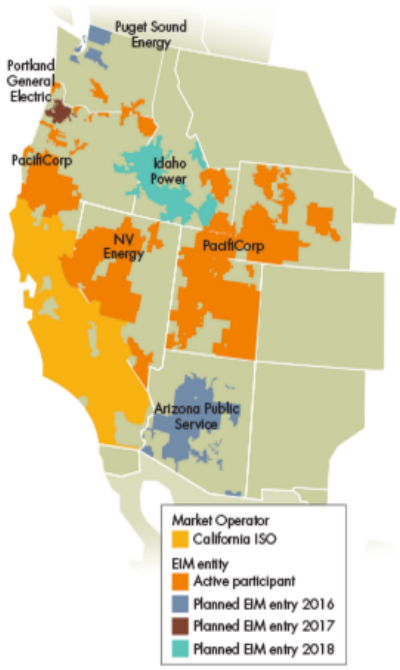
Figure 15 - Generating Capability in New York State by Fuel Source – Statewide, New York City, Long Island and Lower Hudson Valley: 2015



http://www.nyiso.com/public/webdocs/media_room/press_releases/2015/Child_Power_Trends_2015/ptrends2015_FINAL.pdf

California

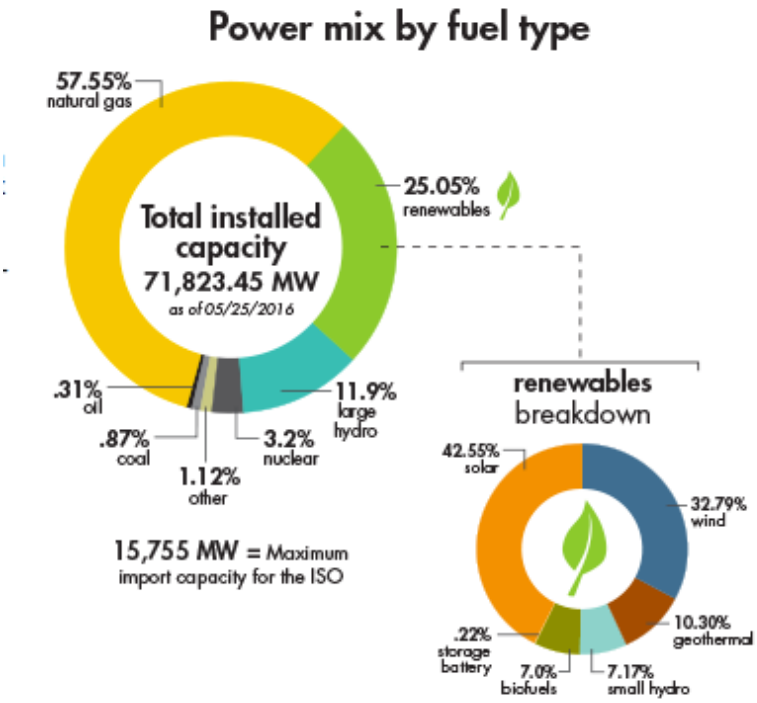
- Senate Bill 350, the Clean Energy and Pollution Reduction Act of 2015, was signed into law by Gov. Edmund G. Brown Jr. on Oct. 7 2015
    - It calls for California to get half its energy from renewables by 2030.
    - It requires new buildings to double energy efficiency.
    - It outlines a path for the California ISO to become a multi-state, regional grid. The ISO is responsible for developing policy to change the market's governance structure, economic and environmental impact studies and public workshops in the next two years.
- Expansion of the Energy Imbalance Market – The automated real-time market was launched in November 2014 with PacifiCorp, based in Portland, OR. Since then, Nevada-based NV Energy, joined in Nov. 1, 2015. The EIM now operates in California, Oregon, Washington, Idaho, Utah, Wyoming and Nevada.
- Four additional participants – Puget Sound Energy in Washington state, Arizona Public Service, Portland General Electric and Idaho Power Co. -- have announced plans to join the market.



The EIM is an automated, real-time energy wholesale market matching the lowest-cost electricity supply with demand every 15 minutes, and dispatches that energy every five minutes. The voluntary market allows participants to use the existing ISO marketplace platform and state-of-the-art grid operation. It expands the pool of balancing resources, which boosts flexibility and reserve levels, creates economies of scale and lowers costs. This allows more opportunities to integrate and manage cleaner sources of energy, including variable output generation, such as wind and solar, that may be produced in one area but needed in another.

Power mix

RENEWABLES AT-A-GLANCE (updated solar peak record)



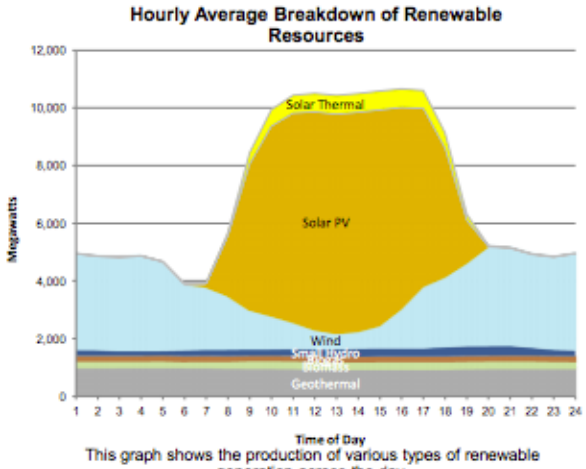
Data for Monday, August 29, 2016

24-Hour Renewables Production

Renewable Resources	Peak Production Time	Peak Production (MW)	Daily Production (MWh)
Solar Thermal	14:45	662	6,418
Solar	13:00	7,582	70,121
Wind	19:45	3,522	54,082
Small Hydro	18:10	367	6,349
Biogas	21:00	183	4,230
Biomass	10:36	270	6,116
Geothermal	6:18	985	23,038
Total Renewables			**170,353**
Total 24-Hour System Demand (MWh):			*746,862*

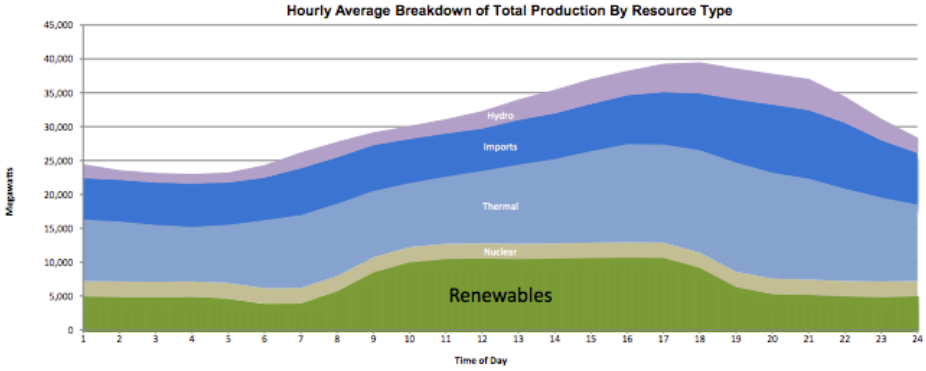
This table gives numeric values related to the production from the various types of renewable resources for the reporting day. All values are hourly average unless otherwise stated. Peak Production is an average over one minute. The total renewable production in megawatt-hours is compared to the total energy demand for the ISO system for the day.

Previous Renewables Watch reports and data are available at http://www.caiso.com/green/renewableswatch.html



This graph shows the production of various types of renewable generation across the day.

System Peak Demand (MW) *one minute average	39,530
Time:	17:28



This graph depicts the production of various generating resources across the day.

2. Programme

Brattle Introduction Talk

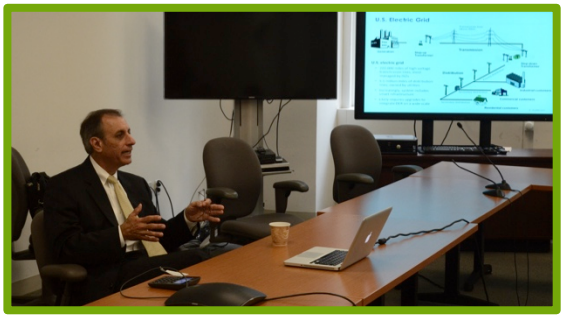
The economics consulting firm Brattle welcomed the delegation on Tuesday, providing an introduction to the U.S. Energy market.

Supply and demand

1.1 GW of installed capacity today generates 4 million GWh annually. The observable trend of recent years is an economy driven shift from coal to natural gas which is considered a bridging fuel. The US green power plan targeting the reduction of carbon pollution from power plants is currently stalled at the US Supreme Court.

With the level of generation from wind and solar standing at 5% and narrowly over 3%, renewables still play a relatively minor role.

The subject of distributed versus centralised generation of renewables is the topic of ongoing debate regarding whether load should be relocated closer to the wind itself, however the resolution of such issues is the role of the market. The subject of offshore wind generation is a contentious topic; this exemplifies the fact that thus far there exists merely one offshore development in the US.



Generally, most renewables are produced by distributed resources and the majority of these are actually demand resources with energy efficiency/demand response considered the largest. Demand response reduces peak demand by approximately 6%, the impact of energy efficiency is not quantified but perceived to be substantial.

Electricity demand per capita has been declining since the 1950's. This is the case on an individual basis, because despite the increase in devices, less electricity is being consumed overall owing to efficiency gains. The primary driver of the decline however, is the structural change of energy intensive industry, this decrease in demand affects utility revenues.

The introduction of smart meters as means to provide price signals is a development in progress, one which will eventually be a service rolled out to all customers. However, there is concern from some about the ethical implications in relation to the privacy of users and ambiguity as to how to effectively enable customers to understand markets and make use of price signals.

The grid

There are 3,306 power providers across the US, more than 50% of these are small and owned by municipalities. Approximately 100 large investor owned utilities (IOUs) serve the majority of customers. IOUs and non-utility generators produce the majority

of the power; with IOUs delivering most power that is generated by merchant producers.

The grid network is comprised of more than 400 000 miles of transmission lines that are largely managed by Independent System Operators that undertake grid planning and make decisions regarding upgrades. There are currently 5.5 million miles of distribution lines in the ownership of utilities at the distribution level, while vertical integration is still common efforts are on-going to disassemble this system.

The peak of distribution system infrastructure development took place in the 1950s/1960s, therefore the average age of substations is 50 years. Incidences of major outages as a result of large storms accentuated the need to increase the resilience of the system by responding with according investment.

The markets

There are organised wholesale markets and retail electricity markets, although they are not present throughout all states of the US. Wholesale markets are either operated as competitive markets for power by Regional Transmission Organizations or by the ISO. In all regions where no such market exists, wholesale purchases are bilateral. With regards to retail markets, most states have vertically integrated utilities, but restructuring efforts are continuing to stimulate increased competition by separating power generation from distribution.

The New York's Reforming the Energy Vision initiative and the 'Utility of the Future'

The Reforming the Energy Vision (REV) is a high profile initiative to reorient both the electric industry and the paradigm towards a consumer-centred and market-mediated approach, with a particular focus on integrating distributed energy resources. It aims to develop and implement a market approach to integrated distributed resources. The utility is foreseen as a monopoly provider of a platform, but not of the services enabled and provided over the platform. Through this platform DER (distributed energy resources) providers innovate to meet unrealized market demands while utilities realize transaction-based revenues. Connectivity as such is not being doubted and shall be provided by the utility – however, the question of how to secure the financial viability of this remains as yet unclear.

Discussion with New York State Energy Research & Development Agency

This session introduced a competition targeted at understanding how to create a market for the vision of the 'distributed utilities'. Currently, electricity generated via decentralised PV 'floats' through the system without being measured or controlled.

This does not pose any issues at a currently installed capacity of 300MW, however it is foreseeable that this will present problems in future in response to an increase in installed capacity.

For this reason, the specific programme focuses on the micro-grid level. The concept involves customers switching position from 'taker' to 'giver', assuming a role in the management of voltage, frequency and power flows.

The competition attempts to incentivise communities to consider how to create their own micro grids to achieve the integration of electricity from distributed resources and secure resilience of the system. The latter point has received an increasing level of interest following Hurricane Sandy hitting the East Coast in 2012. The event posed questions regarding how best to maintain critical infrastructure such as hospitals and guaranteeing their capacity to be fully functional and possess the capability to operate disconnected from any other grid for a minimum of one week, however, this varies among individual proposals with some designed to operate independently for a longer timeframe (2-3 weeks).

The competition has attracted in excess of 150 singular proposals, all developed by separate teams in which utilities take part as equal partners amongst others. 83 of these have been selected to enter a design and feasibility phase. The intention is that upon the closing of this phase, 5-6 winning teams will be selected with the outcome of each possessing one actual project up and running in each utility area 1-2 years from now.

The selected projects must convince on the level of technical design and include a business commercialisation plan and a Cost-Benefit-Analysis. They are required to inform on aspects such as technical, regulatory, economics and legal barriers of implementing such solutions, in addition to shedding light on the possible co-existence of separate micro-grid designs. While none of the projects possess business cases at this time, the desired criterion is precisely that: a replicable business model. The decision to investigate a large number of cases is therefore driven by the wish for some statistical significance.

Discussion with New York Public Service Commission

Commissioner Zibelman explained that in her previous position as Chief Operating Officer of PJM (a regional transmission organisation) the ‘list of concerns’ included the following topics.

- The need to maximise the resilience of an aging infrastructure, in combination with the question of how to better utilise distributed energy
- The combination of an increase in peak load (primarily due to an increased penetration of air conditioning) with a simultaneous decrease in overall demand
- Global warming

- The increasingly prevalent phenomenon of people going off the grid while those who do not need to balance this out

In the recognition that they are to a large extent regulatory, not technical issues, she 'changed sides' and took the opportunity to view these challenges from a position where RES penetration remains low and will continue to consider the optimal policies to achieve a reliable, safe and cost-effective system.

Commissioner Zibelman explains that the proposition of the REV is to install a future orientated regulation and to overcome the current situation in which there is no incentive for utilities to integrate renewables into the system. Instead, new policy shall alter the earnings of utilities to lead them to consider distributed resources as an actual resource, as opposed to as a problem. This includes the idea that investment into demand-based resources instead of building new substations will provide utilities with more flexibility without the need for major investment.

Some of the activities that should be enabled by such a platform include:

- sharing of information which is related to the most suitable connection points as a service to society which could be remunerated
- allow for load shaping instead of only doing peak generation shaping

Highlight the monetary values of different services, allowing for prices which are differentiated locally and are calculated following the same set of principles.

Commissioner Zibelman also shares some thoughts about perceived future game changers. The list includes:

- Storage (electric as well as geothermal) as one of the major game changers of the years to come. The Commission is quite convinced of the geothermal technology but sees that many are still opposed.
- Electrification of transport (encompassing both EV but also using the batteries of city bikes.

She finally confirms that the State of New York has decided to subsidise nuclear power, as they wish to avoid a situation in which the cease in production by these plants is replaced by gas.

Discussion with ConEdison

Con Edison has been constructing the energy and infrastructure needed to fuel and sustain New York City's growth for the past 190 years. It runs a complex gas, steam, and electric power system with service to more than 3 million customers in New York City and Westchester County. Con Edison is the primary electric utility in the city, providing electric distribution services to all five boroughs.

ConEdison welcomed our delegation with an extensive team, allowing an exchange with the manager of state regulatory affairs, the stakeholder ombudsman and a representative of the 'Utility of the future' team.

For ConEdison, classifying its role in the REV (see previous session with Commissioner Zibelman) is of primary importance, a task which the 'Utility of the Future' team deals with. It encompasses resolving questions such as: how the

organisation can embrace customer sided solutions, how to help the proliferation of distributed resources, how to organise stakeholder engagement, but also how to deal with push-back against the programme and how to set up the interface with the policy team of Commissioner Zibelman.

However, due to its particular geography (carrying out work in Manhattan is always very expensive) ConEdison has been exploring demand response solutions which would allow the deference of the need for capital intensive investments for a long time. The Brooklyn Queens Demand Management Programme is one of the ConEdison initiatives on this (see below). Today, ConEdison perceives they are in an improved position towards becoming a 'Utility of the Future' as a result of not owning any generation.

Con Edison supports the wish for a market-based solution that triggers private investment, increases system efficiency and the asset utilisation rate of the sector. The large underlying question that needs to be resolved on this matter is to find out what the customer actually wants and which are the best ways to engage them.

Con Edison intends to begin the necessary upgrade of the metering system in 2017. Old meters are often still limiting more creative solutions for some customers. Overall, the organisation will have to install three million meters, planning to introduce 5,000 meters a day for five years.

Already today, many of the larger customers are on-demand based systems and have batteries installed. There is a demand charge in place for 10kW and above, pricing takes place on an hourly basis for those customers with 500kW and beyond. ConEdison is aware that the process of supplying this to residential customers will have to be a careful one. There is already a voluntary opt-in time-of-use rate which encourages customers to reduce electricity use during peak hours, by tying electricity rates to the times at which you use it. A reduced rate is being paid during designated off-peak periods and an increased rate during peak times (see http://www.coned.com/customercentral/energyresvoluntary.asp). However, the adoption rate of this offer has been very slow so far.

Con Edison is expecting further benefits from an upgrade of the smart meters including better outage detection, increased ability to tune systems on different voltage levels and improved theft detection.

While the meter costs will increase, savings are expected in spite of this due to the fact that less movement of trucks will be required to deal with outages. Morever, it is possible to reduce the voltage level, leading to savings of 1.5-2%. Overall, this will result in benefits for the customer.

Data privacy and cybersecurity are both considered a significant issue, therefore those who do not wish to share their data will be able to ensure that it remains private through use of an opt out option.

As previously stated, Con Edison is always eager to find ways to defer substantial asset investment needs to later years. In the Brooklyn/Queens Demand Management Program, Con Edison works in parts of Brooklyn and Queens to team up with customers, community organizations and energy-solution providers to save energy for more sustainable neighbourhoods. By helping to conserve energy, customers are lowering their utility bills and helping to defer the need to build new utility infrastructure. With $200million funding, 11MW utility sided solutions such as batteries in substations were being built, 41MW are customer-sided, including demand response, energy efficiency, energy storage and improved management/optimisation/control amongst various others. Con Edison states that DSR measures are only paid for if they function correctly and penalised if this is not the case, therefore there is a need to overbuy because not all are going to perform. The development of the programme included a request for ideas from the stakeholders, which then included 78 responses having been condensed into 12 concrete potential measures.

Distributional justice is a concern. There are now 4,000MW of distributed generation with a 90% profit margin. All infeed is put into the grid and meters actually count backwards during these periods. Germany is twice mentioned as a reference for mistakes that shouldn't be repeated – once with regards to a much too high share of the return on investment with the distributed customers and secondly with regards to a premature phase out of nuclear power plants.

Discussion with IBM

The discussions with IBM were focused on energy balancing and the different solutions IBM offers to allow for uncertainty management, which enables the enhanced usage of distributed energy resources. IBM states that to successfully compete and thrive in the environment of today, energy companies need to assume the role of an energy integrator, deliver a 360-degree 'customer-of-one' experience and take their role in implementing disruptively innovative business processes through analytics driven operational excellence.

As energy integrators, organisations need systems that optimally balance supply and demand, which in itself requires three areas of competency. First, the 'Data Lake' is fed e.g. by data from advanced metering, from enterprise asset management, from weather models and social media, demographics and alike. Second, forecasting deals

with uncertainties regarding demand, renewables supply, supply availability, supply cost, transmission cost vs. congestion and market price and constraints. Thirdly, multi-stage stochastic optimisation helps to manage matters such as generation scheduling (including curtailment and demand response); storage, spinning reserves and ancillary services scheduling; planned maintenance schedules and the analytics of capital expenditures and contracts.

The need for energy balancing is driven by a multitude of factors, including the increase in intermittent, non-dispatchable renewables generation, the increased usage of natural gas which is volatile both in price and availability, increased uncertainty with regard to line congestion as renewables generation is often placed in locations with limited transmission options; a growing number of demand response solutions that respond to volatility becomes available together with a multitude of energy products and hedges, finally a further market liberalisation increasing the sophistication and complexity of energy sales and trading. All this provides ample opportunity for 'market makers' to arbitrage relative to uncertainties. IBM perceives TSOs to be in a good starting position to be such a market maker and grasp upcoming opportunities of a changing market.

The purpose of IBM products is to enable clients to run a future system by gathering often unstructured data, to deduce how to organise all this information and make it useful at a later stage, e.g. via forecasting tools or visualisation to provide appropriate decision bases.

For TSOs, the ambition to establish such a platform implies a major investment decision and one of the big questions which requires an answer is whether in the future it will be they themselves whom manage these large platforms. Alternatively, it may be wiser to wait until a standard set of criteria emerges. In this context, IBM referred to the times when airlines had to decide about developing a system for airline ticketing where clearly the ones who moved first were also the ones to shape and drive how a future joint platform would look.

Discussion with National Grid

National Grid confirmed that these are times where everything from how energy is being generated, transported and used is undergoing change. Similar to Con Edison, National Grid has to find an answer to the highly pertinent question of how to stay relevant to shareholders and how to continue to deliver services to customers.

As part of an effort to answer these questions, National Grid has done some future scenario development, which has led to concluding the three following aspects:

- National Grid's future role will be to provide a robust and resilient grid in the 21st century, which enables public policy
- Customers will have to be put in charge – by giving them the right tools, information and incentives to make informed choices
- National Grid should play an active role in delivering a cleaner energy future by making the right investment choices.

In National Grid's view, transmission will remain the backbone for large scale RES development, but there is also a lot to come on the distributed level making a parallel modernisation of the transmission and distribution system necessary.

The New York REV and its implications

National Grid describes that the New York REV (Reforming the Energy Vision) forces utilities and other market participants to understand how to operate in this envisaged new world. Each utility is legally required to file a Distributed System Implementation Plan (DSIP) presenting their respective view of the future in regards to how to enable customers and the market to deliver solutions. National Grid asked their stakeholders what they are really aiming to achieve, what they wish to derive from this and how to empower residential and commercial customers. Ultimately, the ambition is to provide information to Energy Service Companies (ESCOs) that are interested in usage patterns to develop better products by gaining an improved understanding of how their customers behave.

Traditionally utilities are not incentivised to share data but conversely to guard it. However, the state of NY has come to conclude it is of much more value to share it to the benefit of the customers. Nonetheless, some important questions still await answers, including to what extent should utilities be permitted to earn money with the data of others and how to share more data without dangerously increasing risks related to cyber security.

Generally National Grid perceives that it is unclear what comes beyond the REV and its related policy programmes. While current pilot programmes under the REV are all driven by a regulator, the open question is what else will develop simply because there is a business case.

Wind power production and transportation in the US

Offshore wind is only in its infancy in the US; the Deepwater Wind developments are the first US offshore wind farms. On the East coast, most offshore potential is outside highly attractive real estate, making development of both on- and offshore generation a challenge. On the West Coast in California, development is almost impossible as environmental restrictions are too high. In addition, the fact that offshore

developments are more expensive than some of the alternatives is an important part of the overall discussion.

Harnessing and transporting onshore wind from a scarcely populated centre of the country to its rims presents a number of challenges, as this implies having to build transmission that traverses a number of states. Some of the benefits that can be offered to these states are to connect into their respective systems and help them to stabilise it. In any case, there are roughly 900 miles of transmission lines that have not yet been built, leading to a chicken and egg situation between developers of generation and utilities. There is no political decision or legislative approach which would promote the development of such lines, meaning that in the absence of a business case, developers are not obliged to develop anything. Investment decisions are hence made on the basis of current needs and not tailored toward the attainment of a future vision and related future needs.

NGO/academia roundtable discussion, incl. Nature Conservancy, Environmental Defense Fund and others

The delegation also met with a number of NGO representatives in New York to reflect on EU and New York/US energy policy, explain the idea behind an organisation like RGI and pass on information about how we successfully collaborate as transmission system operators and environmental groups and deal with the cultural and structural challenges in the energy sector.

Representatives from the Nature Conservancy, the Environmental Defense Fund, the Open Space Institute, Riverkeeper, Pace University Energy and Climate Center; NYU School of Law and Albany Law School joined the discussion.

What makes RGI work is that these diverse actors (NGOs and TSOs) have come together under one roof for one common cause – to enable timely, environmentally friendly and socially responsible grid development for the integration of renewables. Working together towards this goal, does not at the same time mean that there is no room for disagreement or independence, be it on this issue or any other issue. On the other hand, being such a diverse interest group that has one common voice often gives us more credibility, when we go public with an issue.

One of the core activities of RGI's work is identifying and sharing best practices, especially with regard to public acceptance. This can for example be community benefit programmes that create local jobs or other value. However, we always also have to deal with regulatory barriers when trying to practically implement best practice stories. So, it's not only TSOs but also regulators who have to look at cultural change in the course of the energy transition. The same is true for technological innovation. National regulation is often very outdated with regard to these challenges, and while TSOs start to work across borders more and more, regulation stops at borders and a pan-European regulation is missing.

And while the RGI partners might disagree on some issues, they agree on the fundamental issue that they want to expand renewables and that this expansion needs new grids. However, experts still have to become smarter at finding out, which lines are really needed and become better in analysing costs and benefits of different scenarios. And the distributed level cannot be disregarded. More decentralisation may mean that the system becomes a little more insecure, but it may also mean less need for new infrastructure. But from climate perspective, we need to make sure that we have a better information basis very soon. Maybe new data platform and distribution utility concepts can be a start here.

Discussion with Bloomberg New Energy Finance

Bloomberg specialises in data, hence this encounter was all about data. It encompassed a global clean energy overview, how China is 'pumping the brakes', effects of the merit-order in the US, outlooks on solar and storage and development of green bonds to finance clean energy.

Bloomberg foresees that globally installed RES capacity will more than double from 6,418GW today to 13,460 by 2040. Of this 54% will be hydro (12%), wind (13%) and solar (29%), a large contrast to the total today which is a sum of 29%. This added capacity will require $11.3trillion of investment, of these 81% zero-carbon investment, including $3.4trn in solar and $3.1trn in wind.

By far the largest generation capacity additions will be happening in Asia Pacific (plus 4.4TW), of these 70% are renewables. While absolute capacity additions are expected to be much lower both in the Americas (1.4TW) and Europe (0.9TW), the share of renewables as part of the investment are even higher (82% and 91% respectively).

On the topic of the US market, the session illustrated how the combined effect of falling fuel prices, intermittent RES with near-zero short-run marginal costs, a combination of societal changes and efficiency investments, in addition to demand-side solutions which increase load's sensitivity to price spike events all contribute to lowering wholesale power prices. More detailed data shows how the increase in solar generation during the course of the day lowers the mid-day power prices, and that PV prices on the wholesale market are below both the purchase price allocation prices and the subsidised levelised costs for new utility-scale solar. Similarly, realised prices for Texas wind fell to record lows.

With regards to storage, Bloomberg foresees that by the end of 2016, global commissioned storage capacity will reach 740 MW, up from 466 MW at the end of

2015 and 66 MW in 2009. The observed application mix of commissioned storage in H1 2016 sees 54% for frequency regulation, 31% for renewables integration and 4% for other ancillary services. 91% of this commissioned storage is lithium-ion batteries. Between 2015 and 2024, Bloomberg foresees a significant shift in shares of utility-scale versus behind-the-meter storage with 84% of utility scale and 2015/2016 dropping to 34% by 2024. The expectation is that the growth in lithium-ion batteries will by and large come from consumer applications (mobile, laptop) and further growth in electric vehicles, while stationary energy storage will experience a significant increase but at much lower absolute values.

Bloomberg forecasts 82.2GW of new build PV in 2018 globally (in comparison to 7.7GW in 2009 and 56GW in 2015) as a conservative scenario, almost 90GW in 2018 as an optimistic scenario.

For the US, Bloomberg anticipates 12GW of PV capacity coming online in 2016, 8 of these at utility scale, slightly lower values for 2017/2018 and values between 13 and 14GW from 2019 to 2022. As of 2016, the project pipeline for assets targeting completion in late 2017, 2018 and 2019 is fullest for the state of California, closely followed by the Southwest and Southeast. More than half of the forecast build PV is foreseen to be utility-scale with only California, Southwest and PCJ having fostered growth also across residential, commercial and industrial segments.

Green Bonds

A “green bond” can be differentiated from a regular bond by its label, which signifies a commitment to exclusively use the funds raised to finance or re-finance “green” projects, assets or business activities. Green bonds are being clustered into Asset Backed Securities, Project, US Municipal, Corporate and Supranational, Sovereign & Agency Bonds (SSA). Of these, Bloomberg observes that rates of issuance have begun to increase significantly in 2014. Between the years 2014 and 2015 EMEA was clearly leading, at the current stage in 2016 issuance volumes for EMEA and AMER are on an even level, closely followed by APAC with SSA issuers from China in particular squeezing the previously high market share from traditional European development banks. The first half of 2016 was actually the busiest year on record for green bond issues, with TenneT as a corporate issuer for the offshore grids playing a major role in this. US municipal issuance is on the rise and 2016 figures are, as of quarter 3, higher than the total for the entirety of the year 2015. By dollar volume, most of these use proceeds for water and sewage management, wind and solar play a negligible role.

California ISO Symposium

The delegation was cordially welcomed back by CAISO when joining the second day of their Annual Stakeholder Symposium in Sacramento.

Keynote conversation

The day began with a keynote conversation between Norman Bay, Chairman, Federal Energy Regulatory Commission and Michael Picker, President, California Public Utilities Commission as speakers.

The conversation on distributed energy resources began with Ashutosh Bhagwat, from the California ISO Board of Governors, introducing the role of the consumer. He described that as of today, California has more than 16000 MW of utility-scale distributed resources. In addition to this, there are now 4435 MW of distributed solar resources, an increase of 43% within the last five years. At this rate of growth, the 10.000 MW is expected to be reached quite soon.

While this is a massive technical challenge, the ISO perceives this also as a great opportunity as distributed resources can help to balance other renewables. However, barriers to participation such as the installation of distributed storage, learning how to dispatch distributed generation and resolve the distribution/ transmission interface and regulatory issues have to be tackled and remedied.

Michael Picker describes that in this widely changing landscape, policy has evolved from assuming the role of a more or less static player to one driving change to allow these new resources to play a role in providing reliability and ancillary services.

Indeed, Norman Bay from FERC perceives the ongoing changes as having a transformative effect, including for their own organisation. To stay ahead of such developments, within FERC the Office of Energy Policy and Innovation has been established, the Office for market oversight is tasked with tracking and monitoring the big changes in the markets and in the industry and FERC is in a continuous dialogue with their stakeholders about on-going changes and the necessary market adjustments.

Although examining distributed resources is naturally a more 'inward looking' perspective, this change is perceived to happen across the United States with the recurring themes being the drive for greater economic efficiency and an optimistic valuation of renewables with public policies working to stimulate their increase. Costs of renewables are foreseen to decrease further and some parties predict that by 2020 the cost of storage will have declined by 50%. In addition to all this, consumer preferences for clean energy are perceived to play an increasingly significant role in transition, all this cumulatively leading to the phenomenon of distributed resources playing an increasingly larger role.

Michael Picker and Norman Bay also agreed that in a setting with thousands of transactions in the distribution system, new players and new services, who monitor that markets are indeed functioning and delivering what is needed, as well as authorities possessing the ability to enforce this, will indeed be crucial.

You can find the full conversation between the two gentlemen at: https://www.caiso.com/informed/Pages/MeetingsEvents/StakeholderSymposium/Default.aspx

Panel on Distributed Energy Resources and the Transmission/Distribution Interface

This panel was moderated by David Olsen, California ISO Board of Governors with the panelists being Lorraine Akiba, Commissioner, Hawaii Public Utilities Commission, Luigi Michi, Head of Strategy and Development, Terna, Italian Grid Operator, Ron Nichols, President, Southern California Edison, Jon Wellinghoff, Chief Policy Officer, Solar City and Lorenzo Kristov, Principal, Market and Infrastructure Policy, California ISO.

Luigi Michi, from the Italian TSO Terna, in an introductory note pointed out that in sight of both European climate goals and the actual development of renewables there is no doubt that renewables are here to stay. He explains that while distributed resources create 'a lot of trouble' for TSOs, Terna has reached the point at which people wish to talk about the opportunities they bring. He underlines that to access these

opportunities, flexibility and visibility are key and that it is time to move beyond old-fashioned and hierarchical systems.

Lorraine Akiba Commissioner, Hawaii Public Utilities Commission introduces the idea of looking at Hawaii as receiving postcards from the future. Hawaii is the state with the most ambitious renewables targets in the US, if not worldwide, aiming to achieve 100% of renewables by 2045. Hawaii has six separate island grids; meaning it possesses separate energy ecosystems that must all solve their issues and innovate. Lorraine describes that this actually allows Hawaii to be considered as a test laboratory wherein new schemes can be piloted and cutting-edge technologies tested. Giving customers choices and empowering them lies at the heart of Hawaiian initiatives. To provide the basis for this, a very clear regulatory framework has been defined, one that recognises energy efficiency, demand response and storage as the to-be-used toolkit of distributed resources. Renewables served by a reliable grid with in a reasonable timeframe and at reasonable rates summaries with '4 Rs' what Hawaii is striving to achieve.

Ron Nichols, President of Southern California Edison underlines that while his organisation embraces distributed energy resources, one has to be aware that the scale and pace of their growth is phenomenal and implies that many questions still need to be resolved. This includes compensation models associated with such growth, to highlight the various types of transactions that must be dealt with, how to allocate costs in the future and also how to provide the necessary data. Ron describes that the commission has done, and is still doing a great job in their endeavour to find answers, pointing to a wide range of joint workshops in which various issues have been discussed to determine how best to establish the value of DER in the distributed system, as well as how to make sure that an adequate grid infrastructure is in place. He underlines that with 22000 interventions into the shorter and longer term configuration of the distribution system to increase reliability it is also essential to find ways that acknowledge the new level of complexity in providing value to the grid and the customers while simultaneously reducing green house gas emissions.

Lorenzo Kristov, Principal, Market and Infrastructure Policy, California ISO, describes the transmission and distribution interface as a very technical topic, but also acknowledges that it is possible to perceive it as a reverse funnel that opens up to show how the entire industry works and operates. He points towards the two different dimensions of distributed energy resources. One is the roof top solar system installed by a customer with devices that have no interest in the market and are as such not of interest for the ISO, but as their numbers increase do cause an impact which flows up onto the ISO level; second, those resources which explicitly do wish to participate in the ISO market. The latter are attempting to respond to ISO requirements, unfortunately with no visibility whatsoever for the distribution company.

Lorenzo also explains that the future of distributed companies in this setting is still very ambiguous. The selection of available options is wide, ranging from a solution in which todays distributed companies have some more planning and operations capabilities to where they take over a substantial portfolio of operations tasks, market coordination and balancing obligations. As of today, there is no clear idea yet of which way to go and a broad range of possibilities that remain to be explored.

Jon Wellinghoff, Chief Policy Officer, Solar City, underlines that he can discuss the topic from the consumer perspective that has been mentioned by the other speakers so frequently. He states that his company is currently carrying out up to 100 installations per day, leading to a very high potential of distributed resources that can be used. He remarks that the past has already demonstrated that this is possible, pointing to the PJM capacity market where 10GW demand response via distributed resources have already been integrated; he is strongly convinced that the future lies with the distributed utility. He confirms that the best way to optimise resources, both for the distributed system and the large system, is as yet unclear, but that initiatives are being developed to aid better understanding of this, including a pilot which Solar City is collaborating with PG&E to combine solar PV, storage, advanced inverters and software controls with the objective of it being utilised by distribution utilities to aggregate and make the resources accessible also for the ISO.

You can view the further discussion between the panellists here: https://www.caiso.com/informed/Pages/MeetingsEvents/StakeholderSymposium/Default.aspx

Featured Presentation: California's Integrated Resource Plan

In his introductory note Mark Ferron (California ISO Board of Governors) credits the amazing pace of change and the degree of complexity with regards to technology, markets, price signals, financing, customer choices, operations and jurisdictional issues in the electricity sector. He underlines that, in his view, policy is what holds this together and gives it direction, he points toward the SB-350 Clean Energy and Pollution Reduction Act aiming for 50% of electricity from renewables, 50% of improvement of energy efficiency in the building stock and a 50% reduction of petroleum use by 2030 as one particular piece of legislation that will have a significant impact.

Furthermore, he praises that the ISO has received the authorisation of investigating the possibilities and benefits of having a Western-US ISO and the decision to task CPUC to adopt a process around integrated resource planning with a focus on disadvantaged communities in decision-making processes.

Liane Randolph, Commissioner at the California Public Utilities Commission underlines in her next presentation that SB-350 on the one hand does build upon initiatives of the past yet also provides guidance for the future by taking on new challenges such as the Integrated Resource Planning Procedure (IRP).

According to Liane, SB 350 is the result of recognising that policies of the past have assisted in the reduction of California's emissions, but that more is needed to achieve the position that California wishes to be in. In the past, the Californian investor-owned

utilities followed a resource-loading order when procuring resources which has been instrumental for cost effectiveness. SB 350 now adds a new priority that classifies the achievement of aspired emissions reductions as a cornerstone-goal. In order to reach this, the integrated planning of resources to identify a diverse and balanced resource portfolio that ensures a reliable, clean and cost effective electricity supply is an essential element.

While the loading order will continue to exist, it must be operationalised in a different way so that clean energy resources compete against each other to provide attributes needed by the grid and demanded by customers.

The Integrated Resource Planning procedure will look into several elements that are complex to formalise, including a new technical model, new scenarios and assumptions to contemplate. All the while processes between different institutional players such as the ISO, the energy commission or the air resources board are reasonably aligned.

Liane Randolph already envisages that an IRP 2.0 will soon follow the IRP 1.0, as it will be impossible to perfect all aspects during the initial cycle. She visualises an extremely challenging and complex process ahead where transparency and regulatory certainty will be imperative issues to include in order to avoid unnecessary anxiety about what is to come.

Attention to disadvantaged communities will be a significant focus of the process. This will also include identifying and reducing barriers for those communities to access renewables or energy efficiency.

As a final remark, Liane Randolph steers the attention to the perspective of implementing time-of-use-rates for customers and the necessity to undertake ample communication work to ensure people are aware of how it functions and are able to react to it in an appropriate, informed manner.

Panel on New Directions in Energy Supply – The Consumer's Perspective

This panel was moderated by Steve Chadima, Sr. VP, External Affairs, Advanced Energy Economy. The panelists Elizabeth Echols, Director, Office of Ratepayer Advocates, Sean Gallagher, VP State Affairs, Solar Energy Industries Association, Sam Harper, Regional Energy Manager, Gerdau Steel, Susan Kennedy, CEO & Board Member, Advanced Microgrid Solutions, Mike Petouhoff, Global Energy Team Leader, Apple Inc. were invited to share their views on what regionalisation and the acceleration of distributed resources mean for the consumer, including large industrial and commercial customers, as well as individual homeowners.

Elizabeth Echols, Director, Office of Ratepayer Advocates (ORA) began by chronicling the company as the 'voice' of millions of rate paying small businesses, striving to procure the lowest possible rates for customers consistent with safety, reliability and the state's environmental goals. It is explained that the changes taking place in regards to the locations in which energy is produced are an opportunity to form a renewed conception of the manner in which the customer interacts with the grid and the utility. The primary goal is to ensure that everyone benefits from the changes of modernisation, taking into account the wide-ranging needs of different consumer groups and ensuring that no person is left behind.

Sean Gallagher, VP State Affairs, Solar Energy Industries Association illustrated the accelerating trend across the US of adoption of residential installation of PV solar, and highlighted projections that anticipate a continual increase throughout the US. California currently boasts 50% of the US Solar market possessing 4GW of installed rooftop solar and culminating in a reduction in system peak. It is proposed that a crucial element of successfully aligning customer behaviour with system needs is the employment of time-use rates, empowering the consumer to respond to price signals using a menu approach, thus permitting their own contributions to be made to system needs. He expands by detailing that a high peak to off-peak differential encourages the use of batteries by those with the financial means to establish storage on the system, thus reinforcing the concept of advancing the alignment of customer needs with system needs.

Sam Harper, Regional Energy Manager at Gerdau Steel, offered his perspective as an incredibly energy intensive and price sensitive industrial customer. Two principal elements were highlighted: the first is concerned with the fact that the cost of electricity for industry in California is two times that of their competition elsewhere, resulting in a vast import of materials from global sources. This exemplifies the necessity of paying close attention to the intent of a policy and ensuring that it doesn't pose inadvertent outcomes that can actually result in increased emissions. The latter point refers to the use of dynamic price signals to emphasise load shifting and ensure that the correct signals are sent through the wholesale market or a proxy to generate the optimal response from the consumer at the most suitable time. This eliminates the lengthy process of monitoring loads to identify specific hours of the day, instead presenting a natural method of observing when loads respond, eradicating the risk of errors in prediction. He reinforced that dynamic price signals can therefore have extensive benefits for the system as they forge reliability, Furthermore, the shift in

power from peak to off-peak aids the overall reduction of emissions and induces reduced costs for all.

Susan Kennedy, CEO & Board Member, Advanced Microgrid Solutions pioneered a technology that integrates the customer aspect with the grid through use of advanced energy storage. The technology presented here performs as a single integrated system that operates behind meters at large industrial loads. According to Susan, when applied appropriately storage can provide a fundamental load control technology that resolves a multitude of problems at a time. Harnessing the customer's load with storage allows to curtail the load, thus avoiding high costs that would otherwise be incurred. These costs result from two factors. First, solar energy is consumed until the sun is not present and demand switches back to the grid. This is increasingly co-inciding with times of system peaks when times-of-use rates are high. Consumers who for a long-time were encouraged via a variety of incentives to install solar panels are now being told that they contribute to problems in the grid and have to pay for it, a phenomenon which is leading to frustration for the consumer. Next, the necessity to have a secondary distribution system in reserve to deal with the additional renewables intake is expected to cost $100 billion dollars annually over the coming decade which again is ultimately costs to the customer. With storage once information is visible to the distribution operator it becomes possible to plan the system around expectations of the load.

Mike Petouhoff, Global Energy Team Leader at Apple Inc, exhibited the ambitious goal of attainting 100% renewables worldwide, emphasizing the attainable reality of achieving this across countries/states and regulatory models. A spotlight was placed upon the efforts made on the new campus in California in regards to dealing with issues of grid integration as a microgrid that is both dispatchable and a 100% renewable solution. This particular system boasts the characteristic of not simply being a current of information that flows in a single direction from the utility to the load, but rather features bytes of information flowing in both directions, a 'two way conversation'. In light of this, the microgrid is viewed as a step in the right direction toward not solely securing a higher penetration of renewable energy but also making progress in the areas of intermittency and dispatchability.

The full discussion between the panelists can be viewed here:

https://www.caiso.com/informed/Pages/MeetingsEvents/StakeholderSymposium/Default.aspx

Lunch with CAISO Senior Executives

After the final session of the symposium, CAISO organised a joint lunch attended by the CAISO board of governors and tour participants. The conversation touched upon a wide variety of topics, reflecting on the fact that CAISO deals in part with challenges that Europe is facing as well while also combating those specific to the situation in California and across the United States. Across a well-set table, the conversation flowed from the significance of enhanced communication with stakeholders on to which measures can be taken to contribute to higher acceptance levels. Obtaining appropriate access and solutions for low-income customers and the dilemma produced by the fact that an increase in decentralised solutions can prompt both an increased democratisation of the electricity system, but also manifest into a form of diminishing societal solidarity in which some profit while others pay the bill, are perceived as joint challenges. Europe and California are united in a need to sort out the future governance across voltage levels, while the political barriers to a more regional approach in which California forms an alliance with its neighbouring countries is certainly a more US specific issue, together with the uncertainty CAISO faces in regards to what comes next and which windows of opportunity may (remain) open or closed following the elections.

In the spirit of the entire tour, the interest of continuously exchanging best practices was underlined, reinforced by a proposition to think about the development of a cross Atlantic vision and narrative for a renewables-based electricity sector of the future.

Discussion with California Public Utilities Commission

The California Public Utilities Commission regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies.

According to CPUC, Californian CO2 emissions are derived 20% from electricity, 40% from transportation and 30% from heat. Therefore, while a shift of the electricity sector to 100% renewables is considered technically viable, this would not result in the achievement of the allocated greenhouse gas emission targets. As a result, the commission is more interested in achieving an 80% renewables target, while in parallel simultaneously pushing for the electrification of transport. This would require improved transmission grid infrastructure and regionalisation, connecting California with neighbouring states so as to make best use of the complementing generation fleets. This presents a major political challenge, amongst others due to the fact that neighbouring states wish to protect their older thermal generation fleets.

For the distributed system, CPUC emphasises the need to enhance visibility of ongoings at community level. Customers are making the decision at an accelerating frequency to install solar PV or have an electric vehicle, but thus far this represents an uncoordinated effort as it forces the distribution grid level to react at short notice. The process of securing much higher distribution system value in the future will be extremely data intensive.

CPUC policy-making includes the facilitation of the deployment of electric vehicles (zero-emission vehicles – ZEV) and the supporting infrastructure. This states that the following milestones shall be achieved:

- Coordinating the build-up of infrastructure to charge 1 million ZEVs by 2020;
- Encouraging vehicle adoption with the aim of having 1.5 million ZEVs on the road by 2025;
- Designing rates and incentives for low carbon fuels to halve petroleum use by 2030; and
- Utilising Vehicle-Grid Integration technologies to use transportation energy as a resource that facilitates a 50% renewable electricity system by 2030.

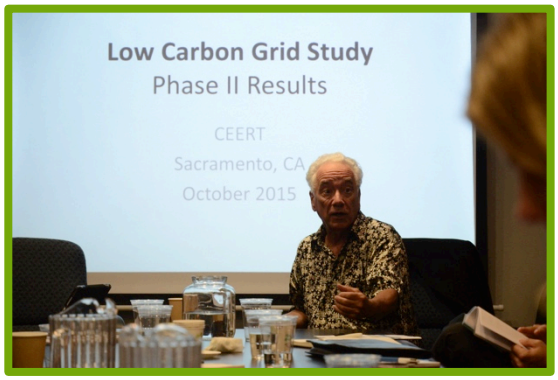
On the topic of storage, the 2010 Assembly Bill 2514 was designed to encourage California to incorporate energy storage into the electricity grid. This required CPUC to consider establishing storage procurement targets for investor-owned utilities (IOUs) and required municipally owned utilities to consider the same. IOUs had to demonstrate that their storage procurement would support integration of renewables, or contribute to GHG reductions or grid optimisation. Meanwhile, the CPUC had to consider storage policy and regulatory barriers in proceedings. In 2012, this led to the establishment of IOU targets of 1,325MW of storage by 2020, being split between Pacific Gas & Electric (580MW), Southern California Edison (580MW) and San Diego Gas & Electric (165MW). The targets are divided into three storage grid domains, specifically transmission-connected, distribution level and customer side/behind the meter applications. Customer programmes that have been launched to encourage the establishment of these behind the meter solutions are the Self-Generation Inventive Program (SGIP), the Demand Response Auction Mechanism (DRAM) and the Permanent Load Shifting (PLS).

A remaining key regulatory policy issue is concerned with how to enable multiple uses of storage that are capable of providing a variety of services to various stakeholder groups while counting services only once and paying for them only once.

Discussion with Center for Energy Efficiency and Renewable Technologies and National Renewable Energy Laboratory (CEERT)

The Center for Energy Efficiency and Renewable Technologies and National Renewable Energy Laboratory (CEERT) introduced its Low Carbon Grid Study (http://lowcarbongrid2030.org/). This study aims to educate the public and lead thinkers about the risks and opportunities associated with and presented by a better integrated Western regional grid, both within the electrical system and as support for greater electrification of transportation and energy use in buildings.

The inaugural stage of this effort was the development of a multi-stakeholder exercise that comprised a scenario/set of assumptions and a model designed to simulate the hourly and sub-hourly operations of the grid throughout the year. Following a series of initial runs the group began to adjust parameters and the assumed generation portfolio to explore what could be achieved with regards to reductions of CO2 emissions. The study would include analysis of how flexibility and diversity of technology would affect the system.



In Summer 2014, phase I of the study concluded that a target case would achieve more than 50% reduction between the years 2012 and 2030, an accelerated case could achieve even more substantial reductions. The study proposed a $55bn investment plan between 2020 and 2030, which would essentially be funded by fuel and emission cost savings and increased efficiency.

Phase II of the study would then add 23 scenarios and sensitivities, including examining a range of varying gas and carbon prices, capital costs for renewables and a range of economic conditions. The study would assume an Energy Imbalance Market (EIM) with day-ahead-market for the area of the Western Electricity Coordinating Council (WECC), it would assume the retirement of one-third of the coal fleet, of the Diablo Canyon nuclear power plant and over-the-counter gas fleet, settlement of combined heat and power, significant addition of transmission capacities to the WECC-backbone, significant rooftop solar, build-out of the CPUC storage mandate, an increase in gas prices and 3.3 million electric vehicles.

The study concludes that climate and clean energy goals are technically feasible without significant electricity rate impacts, implying that the Californian electricity sector is capable of a reduction of 40-50MM tons/Co2 annually by 2030. This contribution of achieving a level 40% below the 1990 greenhouse gas levels is significant, as is the 50% reduction in commercial and industrial energy use in buildings which can also be accommodated, in addition to the increased energy load from 3.3 million electric vehicles being absorbed.

Getting there requires a number of critical components of enhanced flexibility, such as:

- Real-time carbon accounting for dispatch, unit commitment as well as procurement and planning
- Technologically and geographically diverse renewable energy portfolio including: grid-scale PV solar, rooftop solar, regional wind, geothermal, biomass, and concentrating solar power with thermal storage
- Bulk storage benefits shared across multiple balancing authorities and utilities, including both new projects and an optimized, state-wide use of existing non-IOU pumped hydro
- Strategic dispatch of natural gas resources, staggered quick starts to prevent idling, ramping
- Increased flexibility in unbundled REC accounting, enabling optimal sub-hourly dispatch

According to CEERT this backward planning approach and the results found are providing policy makers with a higher certainty that the achievement of more ambitious

targets is possible. However, clearly, this requires a shift in the attitudes and behaviour of all players and CEERT concludes that the flexibility we are most short of is 'the six inches between our ears'.

Discussion with Pacific Gas & Electric

Pacific Gas and Electric provides natural gas & electricity to 16 million people in Northern and Central California.

PG&E owns and operates 18,500 miles of transmission lines, 854 substations and 141,000 miles of distribution lines. The company owns 7,684 MW of electricity generation capacity in hydro power (50%), nuclear power (30%), fossil fuel based (18%) and solar PV (2%). In addition to electricity generated from its own plants, PG&E procures electricity from external generation sources. Approximately 40% of PG&E's electric portfolio originates from own generation, 60% derives from the procurement business.

Combined, the electric generation portfolio mix of the bundled retail sales in 2015 consisted of 42% of fossil fuel based generation, 30% renewables, 6% hydro and 23% nuclear. In 2002 the renewables share remained at 11%, for 2020 the forecast projects 43% of total bundled retail sales, the target set for 2030 is 50%.

This development is driven by a variety of renewable energy programmes, both at utility and customer level, including a self-generation incentive programme, green tariff shared renewables programme at the community level, feed-in tariffs, renewable auction mechanisms or renewables requests for offers.

PG&E observes that the growing share of renewables in the system is becoming an increasing challenge. A 2020 projection of load, wind and solar profiles displays what is referred to as the 'duck curve effect', a situation in which net load (total load – (wind + solar generation)) peaks twice a day at ±7am and 7pm and the interim daylight hours experience excess supply. A key question at this time for PG&E is concerned with what action to take in medium and long term power system planning when this duck curve becomes a reality.

With regard to the medium term scale (months to years), the objective is to ensure the availability of existing resources to the California ISO in times of need. Flexible resource adequacy products, moving of peak and Effective Load Carrying Capacity (ELCC) for counting wind and solar are identified as the appropriate responses to this need.

Across a longer timeframe (10 years and beyond), the ambition is to construct a flexible and diverse resource portfolio, meaning also that differing time zones and weather patterns should be integrated. This clearly requires a process of regional expansion followed by a subsequent extension of the transmission balancing area. At this stage the real-time imbalancing market shall become accessible to external resources.

The establishment of a full partnership between a number of neighbouring transmission areas involving shared transmission costs and a surrender of some control will necessitate complex political conversation upfront. Over time, this would also imply the need for additional grid infrastructure, however PG&E is convinced that even with the existing system substantial benefits will be reaped.

The geographic area covered by PG&E is experiencing rapid growth in rooftop solar. Between the years 2010 and 2014 the cumulative annual growth rate for retail solar capacity was at 34%, PG&E currently has 240,000 solar customers, with an additional 6,000 new customers added each month. This augmentation is driven by decreasing costs of technology (module prices have dropped in excess of 50% during the previous five years), strong political support and business model innovations, e.g. via leasing or solar and storage or solar and load control products. Furthermore, the Net Energy Metering programme allows customers to export excess generation to the grid at the full retail rate, while ensuring a constant

supply of electricity 24/7, eliminating the need for batteries. PG&E perceives it as highly unlikely that private customers will go off-grid in the next 10-15 years as the systems facilitating this would be costly (±100,000$) while still being less reliable than remaining connected to the grid.

Meanwhile, business and commercial customers do pay demand charges, so that for them batteries can be a means to flatten their load.

PG&E have coined the Term 'Grid of Things' to refer to its efforts in enabling customers to access new products and services that are desirable to them, while integrating significantly higher shares of renewables both from large-scale plants and extremely distributed resources. PG&E's Demand Side Management Program then attempts to seek the growing amount of distributed resources in order to secure a double-benefit between the customer and PG&E. This is carried out by offering targeted energy efficiency and demand response programmes in locations in which the system needs upgrades. In these locations, PG&E identifies high impact customers, matches these customers with suitable EE and DR programmes and through this achieves the combined benefit of lowering customer bills while being able to defer investments.

PG&E, upon request of the California Public Utilities Commission (CPUC) is also implementing change concerning electric rates for residential customers. In the system of residential tiered rates, each customer is assigned a monthly baseline quantity, which varies by season, end-uses and the climate zone. An example to illustrate this is the baseline quantity in San Francisco that is 215 kWh, while in Bakersfield it is 515 kWh. The tiers are then defined in terms of baseline quantities, with tier one applying for a consumption of zero to 100% of the baseline, tier 2 with 100% - 200% and so on; each tier has a different price per kWh.

On account of the Californian energy crisis, supplementary new tiers had been added and whenever there was a need for a revenue increase, this was taken only by the upper tiers.

The CPUC rate reform decision is now pursuing action with the aim of levelling some of this out once more, requesting a reduced number of tiers and rate differentials over a four-year transition period, also gradually reducing the discounts that are provided to low-income households. CPUC keeps the door open for a fixed monthly charge and has in the meantime approved an increase of the minimum bill amount from $4,50 to $10. Once the transition period reaches completion, default times-of-use rates shall be implemented.

Tesla

This year's visit to Tesla was comprised of a meeting with Tesla Energy Group and a factory visit.

Tesla Energy Group was launched in 2015 with the aim of systematically looking beyond transport when striving toward the fulfilment of Tesla's mission: 'To accelerate the world's transition to sustainable energy.' A year before ground was broken for the Gigafactory, which is perceived as elementary in moving forward with the ambitions of the Tesla Energy Group. The Gigafactory is foreseen to produce 50Gh in annual batteries by 2020, which is sufficient for 500,000 cars. The production will be powered by renewable energy leading to the classification of the Gigafactory as a net zero energy factory.

All of Tesla's battery architecture is built from modules consisting of several dozens of cylindrical cells bearing a large similarity to the batteries we find in remote controls back home. Tesla's commercial battery products such as battery packs for cars – the Powerwall and now the PowerPack – are being assembled in line with this anatomy. The Powerwall stores 6.4kWh, one Powerpack holds 100kWh, but multiple Powerpacks can be combined into larger units. As of today, approximately 120Mwh of storage is installed via the Powerpacks and Powerwalls.

Powerwalls target customers who do not have solar, but who do work with net-metering. Tesla notes that the level of understanding possessed by customers is comparatively low, therefore as a means to tackle this Tesla also runs a customer education programme. Powerpacks are used to provide a range of services, namely peak shaving, load shifting, demand response, microgrid solutions, emergency backup, ancillary services, capacity firming, in addition to transmission and distribution support.

Some of these services, such as peak shaving, are of interest only for a handful of hours per year. The fundamental question therefore lies in how to simultaneously make the batteries available for merchant use while also combining 2-3 compatible applications for the same piece of hardware. The attainment of this requires the resolution of regulatory issues, amongst others. An example to illustrate this can be seen in the requisite of an individual definition for storage, this is essential to avoid it being penalised from a regulatory perspective.

Tesla does ensure the deliverability of firm capacity (kW) and energy (kWh) over the lifespan of maintenance agreements through adding hardware to their systems on a periodic basis. As retrofitting is perceived as too expensive (especially because the

hardware is not expected to work with modern control equipment), Tesla recycles the batteries for secondary use.

Siemens Digital Grid

The visit at Siemens covered a global industry trend briefing, as well as information about their Spectrum Power control center for Independent System Operators and the SWS-Market Transaction manager for Transmission System Operators.

In the industry trend briefing, Siemens' Chris Fisher introduced four different forces that push utilities towards future scenarios. Regulatory forces which can make for more efficient grid operations and energy markets and emission reductions; technology forces with new products and services at decreasing costs; business innovation forces including new business models and new ways of customer engagement and customer forces meaning the new expectations and new level of power of customers. Each of these forces brings along a range of implications for utilities. A shift to performance based incentives, the expansion of markets to new participants or rate design developments from the regulatory side imply that capabilities of utilities need to evolve. Declining costs of DER, storage with onsite generation and microgrids, cloud-based services, cybersecurity threats and the development of new platforms for customer and third party market participations require utilities to come up with dynamic, two-way grids. The bundling of services such as communication, home security and energy management, aggregation and the participation of DER in different energy markets mean that also utilities need to find new roles and business models. Customers who exercise economic and

environmental choices, take more control and expect more online data and applications as well as focus on lifestyle choices require a new level of customer engagement. As a consequence, in addition to its traditional roles in customer operations, distribution and transmission and energy trading, utilities now have to adopt a whole new set of added roles, covering areas from energy service provision to distribution and transmission, and energy trading.

What Siemens technology is offering here is to mange variability in the electricity system and react more flexible by looking ahead. Whenever a dispatch is being run, it is possible to look multiple intervals ahead (two hours ahead at 5 minutes intervals). This enables operators to try to come up with a dispatch that is optimal globally. If operators are able to look ahead, there is more time to ramp up cheaper generation when the forecast needs changing.

Advanced Microgrid Solutions

Advanced Microgrid Solutions (AMS) is an energy development and software company that uses energy storage, load control technologies and data analytics to design, build and operate customised fleets of energy storage for large commercial and industrial users and utilities.

The Rocky Mountain Institute, in their work on 'The Economics of Battery Energy Storage' have depicted that storage can provide 13 different services to grid operators, utilities and electricity customers – according to AMS, it is necessary to tap at least two, but not more than four, of the related value streams to make the application of storage economically viable. At the heart of AMS lays the question of how this can be done within the respective context of each individual client.

In order to do so, AMS has built an energy analytics platform that identifies the cost and value of each kilowatt hour of energy consumed by a facility in order to design an optimised energy profile. The platform uses energy consumption data, retail and wholesale energy prices, carbon intensity and efficiency metrics to formulate a diagnostic energy profile for each building. They model optimised resource scenarios using best-in-class energy storage, on-site generation, load control technologies and various utility tariffs to identify maximum efficiency, savings and revenue opportunities. The platform then optimises energy resources in real time at the building level, the fleet level and across portfolios.

AMS has a large contract with Tesla to avoid the potential risk of supply issues with regards to the batteries they install within the homes of clients.

It is possible to examine AMS case studies for example, on how grid independence for the Inland Empire Utilities Agency was achieved, how peak energy costs of California State University could be reduced by more than $3.3 million while providing storage capacity to 2,000 homes or how Southern California Edison obtains 50MW of dispatchable demand reduction via AMS on the website at http://advmicrogrid.com/projects.html.

3. Lessons Learned

Our lessons learned during this journey mirror and complement many of the lessons we described in our 2015 'Energy Regions in Transition' report. Here they are:

1. California and European countries are facing many common challenges in decarbonising the electricity sector and increasing shares of renewable energy. Grid operators on both sides of the Atlantic recognised their fundamental role as enablers of the energy transition as well as the need to explore synergies and share experiences to speed up transformative processes. In order to make this process as smooth as possible, we must not forget to find a common vocabulary which ensures that everyone understands each other in all nuances. Terms like 'Distributed renewable Resources' and 'Clean Energy', for example, have a much broader meaning in the US as than they have in Europe as they encompass renewable energy sources, storage and DSM (demand side management).
2. Strong regional cooperation is needed to successfully implement the energy transition. This is an area that proves equally or even more challenging for the Western United States than Europe. Both regions strive to increase collaboration across borders, regional grid integration, collaboration across voltage levels and market coupling as the most economical and efficient way to integrate increasing shares of variable renewable energy sources. However, the structure with regard to utilities, regulation and politics is much more heterogeneous between the different states in the US, which is one of the main reasons for establishing an Independent System Operator (or Regional Operation Center) concept. On one side vertical integrated utilities still own the transmission grid and on the other side there are no harmonised targets in terms of CO2 reductions, renewables etc. in the US.

> *"The trip was a great opportunity to see the US power markets, systems and their approach to the transition for real. No theory there, learning by doing prevails: many initiatives from start-ups to regulatory authorities compete with, but also complete, each other and build a very dynamic scene. Most surprising to me: historical utilities were marginally altered by deregulation in the US, where unbundling is stricter in Europe."*
> **Sebastien Lepy, Deputy Director European Affairs at RTE, Chair of System Development Committee at ENTSO-E**

3. Public acceptance is fundamental. Strong alliances across sectors are needed to gain the necessary public support for the energy transition. Opposition to grid infrastructure is common across the Atlantic as well as in Europe. Huge efforts should be made to understand how to bring people along in the process of decarbonising the electricity sector, to address the needs and wants of citizens. The experience made by RGI in Europe was considered to be an important example that could inspire US stakeholders to develop a similar partnership between grid operators and NGOs. Both European and American energy experts feel that it is important to properly explain the need for grids to stakeholders and citizens in order to build the grids needed for the integration of renewables in a timely manner. Developing a joint cross-Atlantic vision and narrative for the

renewables-based electricity sector of the future could be worth working together on closely.

4. Business models are changing. Further collaboration is needed to identify, track, and strengthen business models of the future, which will require greater horizontal and vertical integration. Integration and coordination on the grid are going to be increasingly important on a horizontal (further regionalisation), as well as a vertical (entire supply chain of the distribution networks down to the consumer's meter) level, as new customer-owned technologies installed on the distribution system have a growing ripple effect on transmission grid operations. Consumers will assume increasingly prominent roles in the management of voltage, frequency and power flows. Smart meters and the development of micro-grids, a growing industry in the US, enables customers to take on this new role and develop into prosumers. Challenges that come with this also include organisational change for grid operators and utilities, an increase in research and development programmes on the topic and additional demonstration programmes that establish a baseline to encourage follow-on investments in a smart grid infrastructure.
5. With regard to the growing importance of the distribution level, there is also a need to enhance visibility of what is happening at community level. Currently, there is rather little coordination, which often forces the distribution grid level to react to increases in customers installing PV or buying electric vehicles at short notice. This future process of securing much higher distribution system value will be extremely data intensive.

> *"The regulatory systems in the US are much more forward-looking: grid operators are incentivised for establishing IT platforms and promoting DSM where it is useful."*
> **Carsten Lehmköster, Senior Manager Regulatory Management, Amprion**

6. Storage plays a much bigger role in the American discussion than it does in the European one. In particular in California, the PV feed-in is highly correlated with the consumption, in which the use of air conditioning plays a significant role. As a consequence, challenges arising from that, e.g. the duck curve, are quite different compared to Europe. Storage devices constitute a proper solution to manage this effect.
7. Data privacy and cyber security are both considered significant issues especially with regard to acceptance. In the US, grid operators are incentivised not only by building and operating assets but also for establishing IT platforms and promoting DSM where it is useful. In this context the following questions still need to be discussed: How can more data be shared without dangerously increasing risks related to cyber security? Will those who do not wish to share their data be able to ensure that it remains private through use of an opt-out option? To which extent should utilities be permitted to earn money with the data of others? Have the right communications measures towards the customers been taken? Are they aware of the level of data sharing, and also are they aware of how time-of-use-rates function and are able to react to it in an appropriate, informed manner?

8. Obtaining appropriate access and solutions for low-income customers and the dilemma produced by the fact that an increase in decentralised solutions can prompt both a better democratisation of the electricity system, but also manifest into a form of diminishing societal solidarity in which some profit while others pay the bill, are perceived as joint challenges.
9. Regulators and policymakers around the world must strengthen their capacity to respond to rapidly developing clean electricity technologies and consumer demand. As we implement the grid of the future, the political and regulatory frameworks will either make or break this effort. Creating frameworks that support rather than inhibit the energy transition being executed by all stakeholders, including consumers and local communities, is one of the biggest challenges in every region around the world. Policy can and should be a driver for change that allows new resources and players to take on a role in providing reliability and ancillary services. Within the American Federal Energy Regulatory Commission (FERC) for example, an Office of Energy Policy and Innovation has been established, and the Office for market oversight is tasked with tracking and monitoring the big changes in the markets and in the industry and FERC is in a continuous dialogue with their stakeholders about on-going changes and the necessary market adjustments.