Renewables Grid Initiative

# Energy Regions in Transition

## Report on California tour of European energy leaders
## October 2015


March 2015

Renewables Grid Initiative

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# 1. Introduction

## 1.1. Background & Purpose

Last year, a most relevant dialogue and knowledge exchange between California and Europe has started which showed both sides how much they can learn from each other. Dave Olsen, member of the Board of Governors of the California ISO (CAISO), visited Brussels and Berlin in December 2013 upon invitation from the Renewables Grid Initiative (RGI) 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, facilitated by the Renewable 100 Policy Institute, came to Germany in March 2014 to meet with many of their European counterparts.

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. To continue and deepen this exchange between California and Europe, the Renewables 100 Policy Institute and the Renewables Grid Initiative organised a tour through the US state under the banner of "Energy Regions in Transition" between the 19th and the 24th of October 2015. A delegation of European grid operators, energy policy leaders, regulators and NGO representatives visited California to exchange experiences in decarbonising the electricity system and learn about how America's clean energy front runner is handling its transition to 50+% renewable electricity.

"Given Germany and California's roles as front-runners, the exchange of experiences and best-practices will help both sides to find the optimal solutions."
**Jörn Rauhut, Deputy Head of Division International Energy Policy, Federal Ministry for Economic Affairs and Energy**

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.

## 1.2. Organisation

RGI and Renewables 100 have worked intensely on developing a programme that would benefit all participants equally and leave both sides with satisfactory new lessons, ideas and relationships. The agenda (see chapter 3) was built around the California Independent System Operator's (CAISO) Annual Stakeholder Symposium, the premier West Coast event for all energy and grid operator executives. It also included visits at the Tesla factory, Stanford University, the California Public Utilities Commission, Bloomberg New Energy Finance and the CAISO Control Centre.

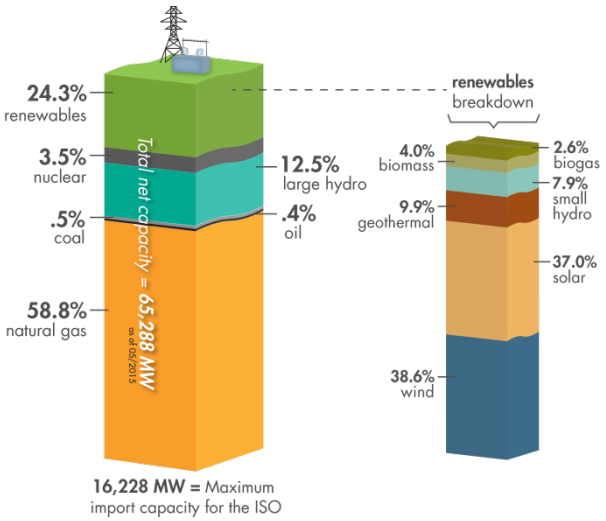
## 2. Starting point

### 2.1. European and Californian energy policy

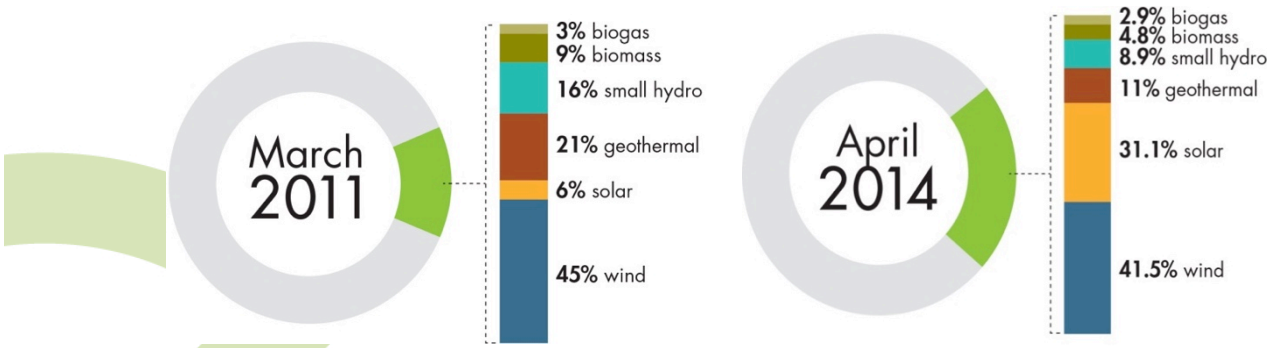
## California

**The California investor owned electricity sector includes:**
11.5 million customers - 32,698 miles (~52,622 km) of transmission lines - 239,112 miles (~ 384,813km) of distribution lines - more than 200 electric generation units - $23.7 billion in revenue

*Key figures*




*Net capacity April 2015*




*Previous renewable net dependable capacity as a % of the fuel mix*

*Legislative background and targets*

In October 2015, Governor Brown signed the Clean Energy and Pollution Reduction Act. It calls for ambitious targets:

- **Greenhouse gas emissions**: 40% reduction below 1990 levels by 2030. The state also has a policy target of reducing emissions 80% below 1990 levels by 2050.
- **Renewable Portfolio Standard (RSP)**: 33% by 2020, 50 % by 2030. Utilities are currently on track to achieve these targets.
- **Energy efficiency**: new buildings need to double energy efficiency
- **Regional integration**: the Act outlines a path for the California ISO to become a multi-state, regional grid. The ISO is responsible for developing policies to change the market's governance structure, economic and environmental impact studies and public workshops in the next two years.

"It was astonishing to see how advanced the Californian energy transition is already 'on the ground' and that reality goes ahead without waiting for regulation. It was a very encouraging, refreshing and mind-opening trip."
**Henrik Maatsch, Policy Advisor Climate & Energy, WWF Germany**

The Smart Grid Vision includes integrating digital technologies, smart meters, sensors and automation, advanced communications, interactive/real-time information, and an integrated network of distributed generation, plug-in vehicles and storage.

California is a frontrunner on energy storage policy and adoption. In 2013, the state mandated a target of 1,323 MW for utilities and other load serving entities to build, buy or contract for energy storage by 2020.

*Regional integration – the Energy Imbalance Market (EIM)*

The automated real-time market was launched in November 2014 with PacifiCorp, based in Portland, Oregon. Since then, the CAISO and PacifiCorp have saved a combined $21.4 million through high levels of flexibility and coordination. CAISO has admitted its second participant, Nevada-based NV Energy, in November 2015. Since then, the EIM operates in California, Oregon, Washington, Idaho, Utah, Wyoming and Nevada. 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.

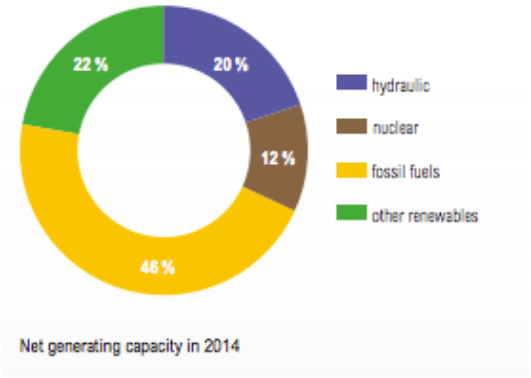
*The California ISO*

The ISO manages the flow of electricity across the high-voltage power lines that make up 80 per cent of California's and a small part of Nevada's power grid. It is a non-profit public benefit corporation with 30 million customers. As the only independent grid operator in the western U.S., the ISO grants equal access to 26,000 circuit miles of power lines and reduces barriers to diverse resources competing to bring power to customers. It also facilitates a competitive wholesale power market designed to diversify resources and lower prices.

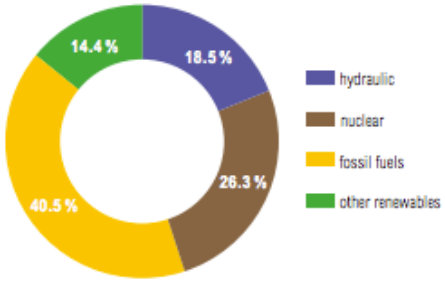
## Europe

**The European electricity market includes:**
525 million customers - 828 GW generation capacity - 305,000 km of transmission lines - 3,400 TWh total demand/year - Electricity trade volume: 400 TWh/year

*Facts and Figures*



Net generating capacity in 2014



Energy net generation in 2014

*Legislative background and targets*
In 2014, all members of the European Union agreed on a 2030 Framework for Climate and Energy. It sets three targets to be achieved by 2030:

- a 40% cut in greenhouse gas emissions compared to 1990 levels
- at least a 27% share of renewable energy consumption
- at least 27% energy savings compared with the business-as-usual scenario

Moreover, the EU has set itself a long-term goal of reducing greenhouse gas emissions by 80-95% when compared to 1990 levels by 2050.

In February 2015, the European Commission adopted "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy". The concept of the Energy Union consists of five pillars: security of supply, a fully-integrated internal energy market, energy efficiency, climate action and emission reduction, and research and innovation.

*Regional integration*
The European Commission has repeatedly stated that creating a single EU-wide electricity market is essential to achieve its targets of affordable and secure energy supplies while tackling climate change.
Market integration is already well advanced in several areas of Europe, especially in day-ahead markets.
Price Coupling of Regions (PCR) is the initiative of seven European Power Exchanges to develop a single price coupling solution to be used to calculate electricity prices across Europe, and allocate cross-border capacity on a

> "… learning about the challenges of regional cooperation in the Western states made me realise how advanced we actually are in Europe. Sometimes you need an outsider perspective, enabled by such trips, to see the progresses we are making in Europe."
> **Ben Voorhorst, COO, TenneT**

day-ahead basis. It is based on three main principles: one single algorithm, decentralized operation and decentralized governance.
PCR is used to couple the following countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK.

## 2.2. Challenges

Before travelling to California, we asked the members of our delegation to share what they perceived as the most pressing challenges in the electricity sector today and in the coming years. Many recurring themes were identified in the experts' assessments. Most prominently among them were questions of market integration and market design, regional cooperation, digitalisation and public acceptance of grid projects. Specific challenges perceived included the necessity for a continuously improved stakeholder process that closely involves citizens and expert groups in the planning and implementation of grid development. They further span the many unanswered questions that arise with the more and more intense digitalisation of electricity. How do we deal with the exchange, management and protection of data? And do we kae sure that we all have a joint understanding of the topic when we talk about smart grids? Closely connected to these questions are issues of the stronger positioning of customers in the electricity system, as they are transforming from simply being consumers into being prosumers taking an active part in the market. How can they be better enabled to offer their flexibility to the market and dynamically shape the future of renewables? The topic of flexibility was also raised with regard to load and generation management, it proved to emerge as a frequently debated issue during our delegations' time in California. Very fittingly the delegation members also named market integration and international cooperation as important issues that require more attention on both sides of the Atlantic. Another challenge noted was the speed of development of storage and battery technology and the impact of their development on the network development necessary.

Jointly moving forward on the way towards finding solutions to these challenges shaped the discussions during our Californian week. Grid operators on both sides of the Atlantic recognised their fundamental role as enablers of the energy transition. Despite the differences across EU Member States and US States operational challenges proved to have many similarities. Building on the challenges identified by the European experts, three main areas of interventions have jointly been identified during the week: system operation with increasing shares of renewables, markets and public acceptance. Read more about where discussions on these issues led in the lessons learned (chapter 4).

"This initiative helped me deepen valuable relationships with people who have now become close allies in further developing our efforts in ecological corridor management or the handling of the marine environment in connection with offshore grid projects."
**Olivier Feix, Chairman of the RGI Board & Head of Communications and Public Affairs, 50Hertz**

# 3. Programme

## 3.1. NGO Round Table

The meeting brought together representatives of environmental and climate action NGOs from Europe and California to exchange views on the current status of the electricity systems and challenges and opportunities when it comes to coping with rising shares of renewable energy in the system. Discussions focused both on technological solutions and on the economic design that will encourage further deployment of renewables.

*Market design*
Participants agreed that there is a need for renewables to start participating in the market and providing ancillary services. For this to happen, new products that come closer to real-time trading are needed as well as products that are not related to a certain technology. This way, a provider combining different sources, such as batteries and wind energy, could bid in the market. Both in California and in Europe, there is still scepticism towards renewables providing these services. However, pilot projects have been started. In some countries in Europe, such as the Netherlands, renewables are already active market participants. In California, the ISO is currently investigating the opportunities of a solar service market.

*Flexibility*
Both Europe and California are heavily discussing flexibility options for the system. While California launched a big programme on storage with the target of procuring 1,325 MW by the end of 2020, European counterparts were more hesitant and shared experiences of up to 50% renewables in the system without the need for big scale storage facilities. NGOs agreed that there is still a big potential for energy efficiency measures and demand response that has neither been fully tapped in Europe nor California.

*Best practice: the solar eclipse in Europe*
European delegates reported about the solar eclipse that happened in March 2015. TSOs had prepared for this incident for months since they did not have the experience of what would happen when shares of solar energy in the system would rise very rapidly after the eclipse. During the day, generation dropped by 13.7 GW within 70 minutes. After the eclipse, about 25 GW of solar generation had to be reintegrated. The eclipse was handled successfully. Success factors included functioning markets and enough flexibility in the system. TSOs came to the conclusion that flexible tools, such as demand-side response are already available, but need to be activated.

## 3.2. Tesla Factory Tour

A packed Tuesday started with a Tesla factory tour. The group was taken trough the factory and could observe the entire manufacturing process of the Silicon Valley-based e-mobility company. Aside from the manufacturing process, the tour also included a discussion with a Tesla representative about innovation in battery

technologies, balancing options for the system, user data patterns and the (dis)advantages of electric vehicles and hydrogen-powered cars.
Part of the reason the facility was chosen as part of the tour was that it is a good example of the energy transition from the old system to the new. Underscoring that the energy transition is a job creator, Tesla's growth trajectory over the last 6 ½ years has seen employee numbers increasing from a few hundred to 11,000 worldwide. Tesla also demonstrated that digital and information technologies can inform the new energy system in new ways as many employees at the factory notably are culled from Silicon Valley rather than the automotive industry.


### 3.3. Lunch with the Silicon Valley Leadership Group

The delegation met with representatives of Sunpower (provider of distributed and large-scale PV), Google and linear generator innovator Etagen. During the lunch three points of interest dominated the discussion:

- digitalisation of the electricity sector and its implications for business models, data privacy and regulation;
- reasons for Google's interest in renewable energy;
- regulatory framework needed to integrate more and more renewables into electricity grids;

*Digitalisation*

Digitalisation is the next big revolution in the electricity sector. Changes are very fast and bring new actors in the once very traditional and conservative sector. Digitalisation will enable generation consumption and distribution to be optimised, costs (especially transition costs) to be reduced and, ideally, transparency to be increased. With digitalisation, however, new actors will enter the market and de facto completely change the current business models of both transmission grid and distribution grid operators. The question on how to deal with data privacy and data ownership remains a hot one and huge effort is needed to develop the governance that reassures consumers and policy makers. One challenge that was shared by European grid operators and Californian delegates was the insufficient data that is currently available for all actors, in particular grid operators.

> "Silicon Valley has been and will continue to be instrumental in developing new business models connected to battery technology and the digitalisation of the energy sector. We have definitely taken some lessons home in these fields, that now enrich our discussions and our innovative thinking at 50Hertz."
>
> **Boris Schucht, CEO, 50Hertz**

*Google's interest in renewable energy*

Google's energy strategy affects three areas: energy consumption of its own facilities, investment in renewables and development of consumer products.

1. Energy consumption

The company has reached procuring 37% of its power from renewable sources, making Google the largest corporate purchaser of renewable power in the world. Google committed to triple the purchases of renewable energy by 2025.

2. Investment in renewable projects

Google has committed to invest more than 2 billion in renewable energy projects worldwide, including Solar City and some of the largest wind power projects.

Reasons for the investment are not only due to an ideological support for renewables and the related projects, but also because they make a good business case.

3. Consumer products

The Project SunRoof uses existing Google imagery to help customers identify whether their roof has good potential for solar energy. This is done by analysing the shade on the roof and the costs of solar installations. The Project is currently tested in three markets in the US – the Bay Area and Fresno in California and Boston in Massachusetts.

## 3.4. Stanford Meeting

After meeting with the SVLG, the delegation visited Stanford University, which has a renowned electrical engineering programme working very closely with many of the Silicon Valley IT and energy companies. The Stanford scholars hosted a three-hour roundtable discussion attended by the university's top energy experts and used the opportunity to introduce the European group to their new "Bits & Watts" initiative that essentially pursues a cloud-based brain to balance and cost-minimise the electricity system. In addition to Stanford researchers, representatives from Google, AutoGrid, SLAC National Accelerator Laboratory, the Precourt Institute for Energy, the National Science Board, the California Energy Commission, California Public Utilities Commission and the National Renewable Energy Laboratory (NREL) joined the event.

The discussion that followed the Stanford presentations focussed on the greatest challenges for innovation in technology, policy and markets. Attendees discussed how these areas could be aligned so that they collectively amplify each other and accelerate the energy transition. The following are some of the key discussion points:

*Transmission vs. distribution grid*
There is a debate in many regions on whether the future needs the transmission grid "backbone" or a system almost completely handled by the distribution grid. Most participants appeared to agree that this is not a question of either/or, and that transmission grids will remain necessary to guarantee quality, adequacy, resiliency, and security. Transmission grid operators and distribution grid operators, however, need to have clear roles. According to the laws of physics, noted one participant, voltage control is easier on higher levels, whereas lower voltage levels can steer electricity and interact with certain ancillary services.

*Too much of a good thing*
How to manage over-generation while minimising curtailment is a challenge that will grow as more renewables enter the grid. In this line, we are approaching a world where there is so much renewable generation that electricity could be free. What consequences will that have? For example, why be energy efficient, if electricity is free? How will we refinance projects and raise funds to implement complimentary technologies like grids, storage, and heat pumps?

*Challenges to bringing new grid solutions to the marketplace*
Creating a viable new technologies that enable the grid integration of renewables carries major challenges: One is creating awareness among leaders, many of whom have been dealing with the traditional models for decades. A second is "death by pilot," which can keep proven technologies in the testing phase for too long. A third concerns the fact that utility business models are sometimes not set up to capitalise the expense of new solutions, even if it is cheaper. And fourth, the gap between technologists and the business world is big, and education is needed to bridge this gap.

*Overcoming regulatory barriers*
If we do not get regulations right, the right business models won't fly. We are now in the situation where low cost technology is available, but our regulatory system is still in the last century. Financial experts polled consider regulations the biggest risk to the new energy market. However, government is rarely that nimble and quick. How do we speed up the process?

*Empowering prosumers*
We are living in democracies. That means what we are doing requires the acceptance of citizens. People support the Energiewende in Germany because they are part of the new market. A lesson learned is that we need to give normal prosumers a chance to profit. At the same time, we need to understand how to run a system with many generators instead of a few.

## 3.5. Meeting with the California Public Utility Commission

The delegation met with CPUC Commissioner Michel Florio, one of five Commissioners appointed by the Governor. Participants also included California Energy Commissioner David Hochschild and senior staff from the CPUC and the California ISO.



*Challenges and possible solutions for the Californian electricity system*

As California needs to plan for their utilities to meet 50% renewables, the CPUC has developed four signposts to better understand the reliability impacts that might occur:

- Changing Shape of Net Load and Ramping Needs: currently, the ramping need in California has been posing no significant reliability concerns. However, it is expected to increase significantly in the next years.
- Over-generation: occurs when the grid operator cannot manage over-supply through markets and must manually curtail supply. So far, over-generation events in California are very rare. However, CAISO modelling suggests that within a decade from now, there could be significant generation of solar power in the middle of the day, which poses potential challenges.
- Curtailment: while curtailment is an economic concern, it represents a very small proportion of renewable power generation and does not currently appear to be a reliability concern. Total economic curtailments in California in 2014 were only about 33 GWh, which represents less than 0.1% of RPS generation.
- Increasing the need for ancillary services: Ancillary services are currently most often provided by conventional generators and as the proportion of conventional generation decreases, the question arises whether renewables will be able to supply them. Participants agreed that renewables can indeed provide ancillary services. Studies conducted by the Union of Concerned Scientists 1 and the Western Electricity Coordinating Council (WECC)2 support this conclusion.

Envisioned solutions include adjusting load to better match patterns of renewable generation, using transmission connected wholesale resources to balance out renewables, and improved forecasting for renewable energy source availability and

[1] http://www.ucsusa.org/sites/default/files/attach/2015/03/california-renewables-and-reliability.pdf
[2] http://www.nrel.gov/docs/fy13osti/55588.pdf

for load. Additionally, pilots and studies are underway in California, such as dynamic and time-of-use electricity rates and integrating electric vehicles into the grid.
Demand response has also begun to expand from being used just to modify load to also participating in the CAISO wholesale energy market as a capacity supplier.
California has had a long history of interruptible programmes for large industrial consumers. The state has now introduced "DR 2.0", a programme with a DR auction. However, California may lack the DR potential of some other places in the world because unlike Germany, for example, the state does not have a big industrial load.

*Experiences from Europe – similarities and differences*
One of the biggest differences in coping with these challenges was considered to be the approach towards storage. While German grid operators, for example, curtail high shares of wind energy, the role of storage is currently rather low. Instead, grid development and interconnecting different European countries is currently considered to be the far cheaper solution. In the U.S., however, production tax credits for wind present a challenge for curtailment because under that policy framework, wind generators make their money when they generate electricity and, therefore, do not like being curtailed.

Another big distinction is the approach towards dispatching. While dispatching is stirred by the market in Europe with different balancing group managers, California has a central dispatching controlled by the CAISO.

One of the European frontrunners in integrating renewables into the market, are the Netherlands. The Dutch power market is transparent with accurate price signals and real time information. Every kilowatt hour, whether from a large industrial power generator or a small renewables producer, is dealt with in the same way - with the same benefits for balancing, as well as penalties for creating a grid imbalance. While individual households have not historically been able to participate, they are now being equipped with smart meters that in the next few years will enable residents to increasingly respond to real time or day ahead pricing.

> "The RGI-trip to California gave me very relevant insight into the Californian energy transition, and provided me with important experiences which are proving to be very relevant for my work at Statnett, for example in areas such as digitalisation and technology transfer. We are also keeping in close contact with our Californian colleagues and have established a solid working relationship that will soon include a visit from CAISO CEO Steve Berberich to Norway."
>
> **Auke Lont, CEO, Statnett**

## 3.6. Bloomberg New Energy Finance

After the visit at CPUC, Michael Liebreich, founder and Advisory Board Chairman of Bloomberg New Energy Finance (BNEF), a firm that delivers analyses on new energy developments to decision makers around the world, hosted a lunch discussion in BNEF's San Francisco offices and presented the delegation with thought-provoking facts and figures surrounding current investment into clean and green stimulus programmes. He talked about the declining flow of money into clean energy in Europe and its relation to macro-economical and political issues, such as the financial

crisis and the policy uncertainty that prevails in Europe when it comes to RES investment schemes (feed- in tariffs, premiums, green certificates and auctions etc.). Prices for renewable electricity capacity are reaching new lows and BNEF expects them to drop further in the year ahead.
Michael also took the opportunity to discuss the inherent danger of capacity markets, which he claims kill innovation by not letting certain technologies into the market and debated the role that transport, aviation and shipping play in the shift to clean energy. In his view, decreasing battery costs, as well as concerns about air quality will help advance the e-vehicle sector and could help push developing regions to leapfrog with regard to technological adoption. "Dieselgate" has also made it exceedingly difficult to argue that emissions goals can be met while depending on diesel-fueled vehicles.
Another topic of discussion were possible future business models for utilities. How will traditional utilities respond to demand being taken away due to the rise of renewables? Many new opportunities lie before them to offer services that can help manage this transition. For example, new customer services will be needed to be able to compete with new startups.

## 3.7. CAISO Stakeholders Symposium

The last two days of the tour were spent at the CAISO Stakeholders Symposium in Sacramento and visiting the CAISO headquarters in Folsom. The Stakeholders Symposium is CAISO's annual major gathering of energy executives, where in 2015, there was record attendance of more than 1000 experts in the field, with another 1000 joining by live stream and many participating via social media. Energy executives, policymakers and the CAISO Board of Governors gathered for the annual event to talk about the major energy issues across the globe that affect the planning and operation of the transmission grid and market in an informal setting that promoted the exchange of knowledge and ideas.

"Welcoming the European delegation as guests at our Annual Symposium was an amazing demonstration of international collaboration and best practice sharing. California and the West were able to hear and see the value of deep regional cooperation across Europe which was extremely valuable to hear. Cooperation across the US Western States will have the same opportunities as those seen in Europe. On going cooperation with the European delegates and RGI is proving very inspiring."

**Steve Berberich, CEO, CAISO**

The first Symposium day saw panel discussions on "Exploring measures to unlock the value of plentiful, clean energy" and "Western States Regulators – Unlocking the full potential of regional collaboration" and was crowned by a keynote speech given by our delegation member 50Hertz CEO Boris Schucht. He heralded the section of the event that would look beyond the United States and focus on the European perspective. Schucht explained to the Symposium participants how 50Hertz has so far succeeded in integrating a share of 42% variable renewables without reliability problems. He described 50Hertz as a living laboratory at the centre of the German Energiewende. Renewable energy, especially wind power, he shared, has quickly developed in the TSO's region in northeastern Germany and already dominates the system with over 25 gigawatts of installed capacity so far. He tried to convey to the

audience that there is no reason to fear these volatile renewables. Those responsible for reliability will learn step by step how to cope. For the 50Hertz team to succeed at this stage, several factors came into play. For one, regulations had to change. For example, curtailment had to be permitted, and technicians needed to learn how to curtail. Forecasting models, especially weather forecasting, also needed to become far more accurate. The team furthermore needed to learn how to steer renewables, whether via the market by encouraging renewable generators to sell their power on the wholesale market, or technically via the TSO's control centres. A major lesson learned was that the existing system offered "far more flexibility than expected." In fact, there was enough "every second of every day."

With shares of renewables steadily climbing, we need new market products closer to real time, Schucht argues, and market designs need to be better tailored to renewables. Renewables additionally have to take over stabilising the system by providing ancillary services.

Furthermore, interconnection between regions and European nations will play an important role. We need "a collaborative approach to master this transition," said Schucht. "Many stakeholders are needed to make it a success." This, he explained, includes greater cooperation between transmission, distribution, demand and generation, as well as between regions, and with the public to ensure their acceptance.

On Friday morning the spotlight was on the European delegation, who took the stage for three hours, talking about "Regional Collaboration across the European Grid." The first panel, moderated by Antonella Battaglini (RGI), featured TSO representatives Auke Lont (Statnett), Ben Voorhorst (TenneT), Hervé Laffaye (RTE), Jörg Spicker (Swissgrid) and Boris Schucht. The second panel moderated by Michael Liebreich (BNEF) focused on the "Transition to a Low-Carbon Grid" and it was made up of regulators Alparslan Bayraktar (ICER) and Andrew Burgess (Ofgem), TSO representative Luigi Michi (Terna), researcher Eicke Weber (Fraunhofer Institut) and think tank representative Patrick Graichen (Agora Energiewende). The following is a snapshot of some of the issues they discussed:

*Regional collaboration: Europe's North*

Regional collaboration among the grid operators of Europe's North (Norway, Sweden, Finland, Denmark) started in the 1960s with the build up of interconnecting grids. With very different electricity portfolios (ranging from almost 100% hydro in Norway to almost 100% fossil in Denmark) the countries were seeking to improve security of energy supply and drive down costs. In the past years, combating climate change has become a third driver of this regional cooperation.

Today, the Nordic electricity exchange, that started with an internal Norwegian power market in the early 1990s, is a well functioning market that supports a secure electricity supply, enables the sharing of oversupply with neighbours and climate friendly electricity production. For example, regional integration has enabled Denmark to get off coal and build up a massive wind capacity, which was only possible because of Denmark's connection to Norwegian hydro supplies. The Nordic

countries are now focusing on systems integration and building a common IT infrastructure.

*Switzerland – balancer in Central Europe*
Concession contracts established 130 years ago are still in place in Switzerland today. The first run-of-river hydro plants were built 120 years ago and paved the way for the first international energy cooperation between European countries, with the Rhine and the Rhône, rivers bordering with Germany and France, respectively. In the 1930s, transmission lines were built that enabled Germany to use Swiss hydropower for its peak supply, and in the 1950s, a decision was taken to connect the grids between Switzerland, Germany, and France. In the past, transmission operators had their own bidding zones and were settling imbalances themselves, whereas today, there are cross-border balancing services that are acquired on a market platform used by several countries' TSOs and which deliver considerable cost savings.

*The Netherlands – market reliance*
In the late 1980s, Europe decided that an internal, European market would be more cost-effective for consumers. In response, the Netherlands established a TSO that is completely unbundled from generation. This TSO (TenneT) has a monopoly over the transmission grid, while nine regional grid companies maintain the grid, and commercial companies make up the rest of the system.
Interest in integrating the market led the TSO to build the longest undersea cable to Norway because there was inexpensive energy there, and Norway was able to benefit by diversifying power supplies. The Netherlands has since coupled their markets with Belgium, France and Germany, with other countries following. This type of cooperation among TSOs is motivated by a common desire to make Europe competitive, to keep costs down, and to integrate renewables. Results have been price equalisation throughout Europe and increased competition.
In addition, with the right market mechanisms in place, demand response has some of the greatest potential to stabilise the grid in rare weather conditions that could otherwise critically strain the grid, as Europe transitions to high shares of renewable

electricity sources. Establishing the necessary, well functioning market requires a long period of time for various players, from households to small businesses and industry, to learn how to respond to market signals. Supporting this process should be a priority of regulators and policymakers, as it can enable the system to handle a very large amount of renewables.

*Cooperation Between TSOs and DSOs*

With more and more decentralised renewable electricity generators emerging and connecting to the distribution grid – 1.7 million in Germany alone, for example – cooperation between transmission and distribution system operators becomes more vital to guarantee the successful integration of renewables. Steering this electricity requires entirely new ways of managing the system and redefining who does what, starting an increasingly necessary process of closer collaboration between transmission and distribution system operators.

> "In Italy, for example, we are trying to understand how to increase renewables through self-production and energy efficiency with new policies, and Californian innovations in local grids and household tariffs, and the new targets approved for renewables, are now furthering our discussions."
> **Edoardo Zanchini, Vice President, Legambiente**

British regulator Ofgem also recently published a paper looking at, among other things, how the roles of the distribution and transmission networks and system operators ought to evolve to meet all the new challenges.[3]

*The regional power market and the human factor*

In Europe, transmission grid operators don't operate the power market, as is the case in California. A network of power exchanges does. These exchanges have developed price calculation algorithms and simultaneously allocate capacity and calculate prices for the day ahead and partly for the intraday market.

[3] See: https://www.ofgem.gov.uk/publications-and-updates/position-paper-making-electricity-system-more-flexible-and-delivering-benefits-consumers

While at times this set-up leads to market integration across all or nearly all of Europe, this comes with a hidden "price" because the power traders' commercial flows sometimes deviate from the technical flows, which presents a challenge to grid operators. For example, Switzerland may technically get an unscheduled flow of wind energy from the northern countries when the wind blows there, but not commercially because that wind power gets sold somewhere else. Likewise, Italy's sun-generated electricity regularly technically flows into the Swiss grid but may get sold on the market to another bidder.

To manage this discrepancy, European TSOs have been developing "security cooperation" in which they all have a common grid model that they operate, each conduct day-ahead grid calculations in their own control centre, and then they carry out a teleconference to work out issues. This requires not only technical knowledge, but also the understanding of different cultures, languages, and generations. In other words, the human factor remains of paramount importance to finding and implementing solutions.

*The role of storage in Europe*

The need for batteries was heavily debated, with one panellist offering the view that Central Europe is unlikely to need large-scale storage solutions in significant quantities until there is 70% renewable electricity in the transmission grid, which is not expected for another 10-15 years. Until then, interconnectivity between regions and using existing pumped storage will be more cost effective. That said, batteries coupled with solar PV for private home use may continue to gain traction sooner. Another speaker shared that while Europe does indeed have pumped storage in place, a study looking ten years into the future showed that if solar power generation reaches 40%, about a billion dollars could be saved on grid expansion by installing large amounts of battery storage at only three strategic locations where the grid tends to experience congestion. A third panellist added his opinion that well functioning markets with accurate price signals to all market participants, with the addition of IT to help integrate the demand side, can go a long way before investment in battery storage is necessary.

*Regulators can prevent over-generation from becoming a problem*

Over-generation does not need to be a problem if markets are set up to encourage flexibility, meaning many entities must participate in the power market, both on the demand and supply sides, and they must "feel their marginal cost." If regulatory systems support this dynamic, they will enable flexibility. Specific measures that Germany has taken to encourage the right price signals have so far included allowing for a wide range of pricing from - 500 to 3000 Euros/MWh, as well as ensuring ample liquidity by including renewable generators in the day ahead market.

*Regulators must adjust to the changing energy world*

Generally, regulators are trying to make imperfect markets work in the consumer's interest, to improve competition, to deal with monopoly elements, and to make sure that the market rules are fit for purpose. Regulators must be careful to match the course of action to the need.

With new dynamics and technologies entering the world of energy, regulators have to adjust. British regulator Ofgem is currently trying to do so. They recently reviewed the regulation of network monopolies, that is, the transmission operator, the system operator, and the distribution companies, and came up with a new framework, under which companies receive revenue for an eight-year period. By the end of this period, they must deliver outputs, but are free to decide on how and when they deliver those outputs. Mechanisms are also in place to stimulate innovation, such as competitions for network companies to engage with third parties and non-energy sector players to test innovative solutions. Regulatory barriers are often cited as a major concern when it comes to energy investment and new market entries.

> "I arrived well aware of the issues that I have to cope with in Italy, with […] more concerns than solutions; but I left with a positive sentiment, […] our goal from now on will not just be 'to fix something' but, more interestingly, 'to seize new opportunities'."
>
> **Luigi Michi, Head of Strategy and Development, Terna**

However, regulators must focus on not only technical innovation, which is certainly important, but also on social engagement and improving regulator competency. Educating and engaging the full range of stakeholders while providing transparent information and encouraging dialogue is critical to overcoming resistance and identifying pathways forward. Also important is the cooperation among regulators from different sectors – e.g. not just energy, but land use, finance, and environmental protection.

## 4. Lessons learned

1. **California and European countries are facing many common challenges in their efforts to decarbonise the electricity sector and increase shares of renewable energy. Grid operators on both sides of the Atlantic recognised their fundamental role as enablers of the energy transition.**
   Despite the differences across EU Member States and US States, the electricity system is changing and bringing operational challenges that are very similar across the Atlantic. Three main areas of interventions have been identified: system operation with increasing shares of renewables, markets and underlying regulatory schemes and public acceptance.

   a) **System operation: expanded regionalism is strongly needed to successfully implement the energy transition.**
   European delegates have explained how collaboration across borders, regional grid integration and market coupling are fundamental to enable large shares of renewables to be integrated in the existing grids. Collaboration across the different voltage levels also becomes essential with increasing decentralisation of generation and storage. European system operators have supported California's ambition to create closer operational practices with neighbouring states as the most economical and efficient way to integrate increasing shares of variable renewable energy sources.

   b) **Markets are more developed in Europe than in California, but still need redefinement to better integrate renewable energy sources.**
   The European delegation was surprised to see that markets in California are underdeveloped when compared to the EU. Despite inefficiency and manipulation there is a strong reliance on electricity markets in Europe. The on-going market reform should allow all market players to participate on an equal basis. A well functioning market should reward flexibility and dispatchability. Clarity of regulations and predictability of energy policies should enable sufficient investments in generation and transmission.

   c) **Public acceptance is fundamental. Strong alliances across sectors are needed to gain necessary public support for the energy transition.**
   Opposition to grid infrastructure is common across the Atlantic and across states. 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.

2. **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. As these new sources impact daily utility/distribution company operations, new business models will be needed to enable fluid information and data exchange across the board.

3. **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. Striking the right balance is made all the more difficult by the typical slow pace of regulatory and government processes compared to technology development and consumer readiness. To overcome this critical challenge, regulators and policymakers must strengthen their capacity to respond to rapidly developing clean electricity technologies and consumer demand.

4. **The energy transition specifically requires two sets of policy and regulatory mechanisms: one to transform the energy system, and the other to ensure the efficient and reliable operation of the energy system.**

   The energy transition around the world requires two basic sets of policy and regulatory solutions: One to encourage transformation of the energy markets and investment in the required new technologies, and another to enable the actual running of the system. While an all-renewables based system could possibly someday be purely market driven, most regions are not yet ready. In the meantime, incentives and fee structures, that ensure on-going investment in transforming the system, must continue to be in place. At the same time, operating and continuing to develop an efficient, flexible power market that can deliver reliable, cost effective energy to consumers must remain a primary mandate for all grid operators.

5. **Stakeholders must be engaged in transparent transmission grid planning from the start.**

   Engaging stakeholders early on is an important aspect of a successful initiative, including making the transmission grid ready for a decarbonised energy future. The Renewables Grid Initiative (RGI) has an excellent track record of engaging NGOs, the public and civil society on transmission issues in the European Union.

On the United States side of the Atlantic, the CAISO has a programme, in which stakeholders are engaged to help ensure that everyone is well informed and that all considerations are taken into account in the decision-making process. Fine-tuning such practices and learning from each other's experience will help to improve transparency and make educated decisions.

7. **The energy transition is cross-sectoral, and further collaboration and exchange among frontrunners is needed to better understand, navigate, and indeed create this new energy playbook.**

   While pathways to reaching 30-40% renewable electricity goals are becoming more common and better understood, the playbook on how to go beyond this to fully decarbonise not just the electricity sector, but the entire energy system is in the midst of being written, with no one having all the answers yet. But it is clear that along the way, the electricity market is increasingly integrating with other energy sectors, such as transportation, heating and cooling. Moreover, the energy sector is increasingly integrating with other industrial sectors, such as buildings, water and telecommunications. Anticipating these developments and positioning market and regulatory rules to support their integration is needed to help accelerate the transition. Collaboration and knowledge exchange between regions and countries, as well as across sectors, is essential to ensure a faster and more successful effort.

8. **The international multi-stakeholder dialogue on the tour needs to be institutionalised into a long-term, regular exchange.**

   There was broad consensus among participants that the tour was an unusual and highly useful gathering of minds from many sectors and that this multi-stakeholder, international exchange ought to be more of a beginning than an end. Nearly every participant shared that institutionalising this exchange into an established, high-level process for sharing experience, knowledge and technology solutions on a regular basis would be highly valuable and ensure that this important dialogue and collaboration continues. Many participants additionally expressed interest in eventually including other regions that are working on their own energy transition efforts, such as China, India, Brazil, South Africa, and other U.S. states.

## 5. Way forward

The organisational team is currently developing the experience into a long-term activity. As the name suggests "Energy Regions in Transition" will not exclusively look at Europe and California but reach out to different world regions where needs and opportunities are high. The work is relevant and necessary both for the tour participants and for new large entrants into the energy marketplace, such as Brazil, Indonesia, Russia, China, India, Eastern Europe, and other US states, as they transition to a lower carbon energy system. We are convinced that this event can be a further step towards a wider-reaching and systematic regular exchange of best practices between different regions of the world.

The Paris COP 21 Agreement has underscored the fact that a comprehensive initiative to prevent global temperatures from exceeding 1.5 degrees Celsius above pre-industrialised levels must include a strong focus on both existing and planned grid infrastructure. Optimising existing grid infrastructure and assets, as well as taking a long term perspective on the future development and regional integration, with a particular focus on governance, will enable a faster, more efficient and lower cost transition to a carbon free energy infrastructure by mid-century, if not sooner in some locations.

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**List of abbreviations**
TSO – transmission system operator
ISO – independent system operator
PV – photovoltaic
CAISO – California independent system operator
DR – demand response

**Annex:**
List of participants

Renewables Grid Initiative

## Energy Regions in Transition – EU California Tour 2015

Transatlantic collaboration on best practices to improve reliability, increase economic benefits, and limit environmental impacts during the energy transition

**October 19-24, 2015**

**Participant list:**

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