CEM Advanced Power Plant Flexibility Campaign

Technical Workshop, Paris

18 September 2017

Minsitère de la transition écologique et solidaire
(French Ministry for an Ecological and Solidary Transition)
TOUR SÉQUOÏA, 1 PLACE CARPEAUX, LA DÉFENSE

SUMMARY

Objectives and meeting structure

The Advanced Power Plants Flexibility campaign builds on work taking place in the framework of the Clean Energy Ministerial (CEM) and the System Integration of Renewables (SIR) unit of the IEA is the operating agent. This was the first follow-up meeting following the launch event at the CEM8 in Beijing between 6 and 8 June.

The meeting first highlighted both existing success in improving plant flexibility and the potential for unlocking further flexibility. Speakers from SIEMENS AG, VTT Finland, and the International Atomic Energy Agency (IAEA) provided insights into the flexibility available from coal, gas, bioenergy and nuclear power plants.

The second session of the meeting focused on economic perspectives, with presentations from GE Power, DONG Energy, J-Power and the European Energy Exchange AG. There was general agreement that establishing appropriate mechanisms to incentivise flexibility is the key challenge going forward.

The final meeting session centered on the campaign work plan, starting with an overview from Simon Müller, head of the SIR unit of the IEA. Representatives from China, Denmark and Germany then provided input and a general discussion followed.

Please see below for detailed minutes and the agenda of the meeting.

Main meeting outcomes

First session: power plant flexibility - technology perspective focus

There were three presentations focusing on the technical aspects of unlocking system wide flexibility to accommodate high shares of renewables and a fourth opening the discussion on economic considerations.

Andreas Feldmueller from SIEMENS AG's Power Generation Services Division provided the first presentation, discussing the flexibility of coal and gas-fired power plants. The presentation first covered the main criteria of flexibility, including hot start-up time, ramp rates and minimum load, relevant particularly to coal plants. Cold start-up time was highlighted as an increasingly important issue. In the context of plant modernisation, automation was identified as a key enabler of flexibility improvements.

The second presentation was given by Antti Arasto, from VTT Finland, providing an overview of the potential for flexibility from biomass and combined heat and power (CHP) plants. Mr. Arasto began with a consideration of the benefits of bioenergy as a dispatchable source of low-carbon power. While at present only a small proportion of bioenergy use is for electricity production, bioenergy can help facilitate a smooth transition towards a more distributed, interconnected, smarter and more flexible energy system. The importance of connection of bioenergy to heating systems as a source of flexibility was underlined. The presentation also considered the role of bioenergy for seasonal balancing, including the potential of new biomass technologies to provide storable fuels to provide longer term balancing in low carbon energy systems, and synergies with other technologies such as hydrogen production which can then be used in production of biofuels. The presentation concluded that bioenergy has an increasing role in seasonal balancing as the need for this increases, particularly in connection with heat grids.

Aliki Van Heek from the IAEA gave the third presentation, focused on flexibility available from nuclear power plants (NPPs). The presentation began with a discussion of the meaning of flexibility in the NPP context, putting forward the importance of part-load operation as a source of flexibility in addition to a more common awareness of load following. An example was shown of a nuclear plant frequently operating below 40% during the 10-day period around Christmas. Flexible operations of NPPs can be categorised according to plant driven flexibility (e.g. for planned shutdowns or reactor repair) and grid-driven flexibility, emphasising the importance of grid-driven flexibility, providing changes in output in response to grid needs. The fundamental economic disincentive for load following was explained. Technical flexibility of NPPs was compared with other thermal technologies, showing relatively longer start-up times and slower ramp rates, but demonstrating that nuclear plants can still contribute to operational flexibility with flexible operation already taking place in compliance with safety and quality standards. Flexibility of NPPs is dependent on their fuelling cycle (around yearly), with more flexibility available at the beginning of the cycle and less possibilities towards the end. A key takeaway was that it is possible for NPPs to operate more flexibly while maintaining safety, reliability and quality.

Kevin Spengler from GE Power gave the fourth presentation with a more economic perspective on connecting technical flexibility enablement with economic drivers by comparing the past (old world) and future (new world). In the past, the main performance criteria of a power plant are full load capacity and

full load efficiency. In the new word, however, the main criteria are related to flexibility such as ramp rates, fuel flexibility, turndown. There is also a stark contrast in business cases to improve plant assets. In the old world, the environment is more predictable with long-term PPAs and general regulatory landscape, which presents straightforward business case and investment decisions. Planning on flexibility products, on the other hand, is much more probabilistic (e.g. how many times a particular service such as ramping might be needed across a time horizon). The challenge is to make a business case around investing in flexibility; how to determine the level, which can range from control solutions to complete retrofitting. There is a need for regulatory and market design certainty in order to drive plant adaptations. There are different interests/points of view from different stakeholders associated with the same asset. For example, energy traders would like fast ramping but plant operators do not because of the impact on the plant life.

The main discussion of the first session were related to further flexibility opportunities moving forward, the magnitude of investments involved and timeframe to retrofit power plants to increase flexibility as summarised below:

- Power plants can be designed to improve part-load efficiency, but likely at the expense of full-load efficiency.
- Time taken to retrofit thermal generators varies by technology and the type of retrofit. It also highly dependent on whether the procurement process is considered. If the retrofit only involves software, control parameters and optimisation, it can happen virtually overnight.
- Gas turbine technologies could take 1-3 weeks for the mechanical replacement. Steam turbine technologies would take a similar timeframe but lead time in obtaining parts could be much longer.
- For nuclear power plants, some refurbishment is possible but it may be limited by reactor design. Flexibility improvement is still relatively recent area of development
- Planning and procurement processes are much longer than the actual installation of equipment to improve flexibility.
- Timeframe for retrofitting also depends on the business model. With simple business model, it could be within a couple of months including procurement. For flexibility applications, based on more probabilistic business models, timeframe could be at least 6 month minimum and more likely 12-18 months from idea to implementation.
- It has been suggested that flexibility of power plants to cope with relatively extreme events in the power system is suited to capacity markets while daily flexibility is suited to balancing markets, although not for seasonal variability, and that a market between the two extremes is likely also needed

Second session: power plant flexibility - economic perspective

This session featured three presentations giving insights into different economic aspects of flexibility enablement.

Fredrik Andren-Sandberg from Dong Energy provided a utility perspective on power plant flexibility with a focus on bioenergy and thermal generation that also includes a case study from Denmark in transitioning to renewables. Conventional power plant are mostly combined heat and power (CHP) driven by heat demand, which can also be used to balance the power system when required. In 2020, the share of renewables in Denmark's power system is expected to increase to around 80%. It has been shown the wholesale power prices in Denmark are fairly competitive due partly to hydro generation from Sweden and Norway. Denmark also has a very reliable electricity supply (at 99.997%) despite more more than 50% of intermittent renewables. There are four areas of flexibility: supply side, transmission, demand side and organisation (such as Nord pool spot market). The presentation pointed out that flexibility of power plants can be improved in a cost effective manner through minor investments. For CHP plants that are producing heat and power simultaneously, there is a potential to increase flexibility from the heat side. This can be achieved by investing heat accumulators to storage heat from periods with high CHP production and also bypass of the power turbine.

Sumie Nakayama from J-Power gave a presentation that provide insights into power plant flexibility from the perspective of an independent power producer (IPP) based on modelling results with a focus on Japan. The Japanese Government has set RE targets in 2030 at 22-24%, of which around 10% is from wind and solar PV. The growth of solar PV capacity (with a 29% average annual growth rate) was driven by FiT that began in 2012. The main section of the presentation covered modelling outcomes to assess the value of flexibility in Japan. The modelling was conducted to assess the flexibility in 2030 using a production cost modelling. Two scenarios were considered: the government's target in 2030 scenario (64 GW of solar PV); larger PV deployment scenario (103 GW of solar PV). Different flexibility options were considered including interconnections, pumped storage hydro and load frequency control service of coal-fired power plants. The modelling results showed that VRE curtailment increases when flexibility options were not available. Pumped storage hydro has been shown to reduce VRE curtailment and fuel costs.

The final presentation in the session was given by Maximilian Rinck from the European Energy Exchange (EEX), who detailed the design of a new flexibility product available on the EEX. The idea of two fundamentally different flexibility notions were outlined: dispatch and load flexibility day ahead vs. rapid ramping in real time; the latter is what is needed for VRE. The rapid ramping is represented in the short-term intraday domain of EEX; the need for flexibility is shown in the price spread in short-term markets, and once flexibility commits to the market the spread is reduced (i.e. this spread is not static). Conventional price signal, which show values of future price for future years, is not an effective price signal for a low capacity factor plant. There needs to be products that capture the tails of price distribution rather than the average. There have been initiatives by EEX to provide markets and products for flexibility. In terms of price signals, EEX has designed the ID_3-Price for the German Intraday market. The index captures the temporal requirement or availability of flexibility by reflecting scarcity or surplus situations. Intraday Cap/Floor Futures have been introduced by EEX where the derivatives capture the tails of the intraday price distribution. New product breaks up conventional trading paradigm where there is a more complex price signal for the new energy world (additional to old market, not a replacement). A new product is a work in progress since it cannot be expected to trade strongly straight

away. Derivative basically captures a particular part of the price distribution (cap and floor futures). Flexibility also has a regional component which is currently not reflected in the price signal.

Third session: Campaign work plan

Simon Mueller, Head of the System Integration of Renewables (SIR) Unit, began the session with an overview of the system integration context of the campaign as well as reflections on the broad stakeholder involvement and campaign events achieved so far. He emphasised that the campaign would be limited to the time frame of CEM9 and aimed at high level policy engagements, and technical workshops such as this one. SIR's publication on Power System Transformation for 2018 would have a key focus on power plant flexibility, including development of an interactive tool.

This was followed by input from leading countries:

- Laust Rieman from the Danish Energy Agency (DEA) emphasised two key messages. First, that there is a large change in capacity with renewable energy (primarily wind) taking over the backbone of production. As a result thermal thus takes a new role, providing flexibility rather than being the main source of production. Second, that different types of flexibility of power plants play different roles in intraday and day ahead markets. Key measures to add flexibility to the system include heat storage tanks on all large CHP plants and increased deployment of electric boilers to give the system flexibility.
- Wang Shunchao from the National Energy Administration in China commented on overshooting targets of PV and wind, curtailment challenges as high as 30% in some provinces and a need to consider both the demand and supply side. There is a target to reduce curtailment below 5%. Over the next five years, coal plants continue to be the most cost effective. Mr. Wang also commented that there is currently a lot of CHP which is not very flexible, and there are plans to retrofit 130 GW of CHP. Since 2016 (organisation name) has been working with the DEA on power plant transition in China, to achieve both fuel and operational flexibility. Two years ago the solution was less obvious, but there is now much more momentum for investment in flexibility from large power producers in China.
- A representative from Energinet in Denmark commented that the situation is more about retrofitting old coal plants rather than new plants. It was also observed that there are many improvements that can be achieved for almost no cost, based on operational mode, incentives to operate differently and small changes to control systems. He put forward some concrete proposals. First was to gain insight from Energinet's model in a day ahead time frame to see the effect on operational mode of being more flexible. This would also involve looking at what happens at the system level considering imports and exports and the impact of less flexibility, and impact on power prices for flexible power plants. Second was to dig into the discussion on derivatives and the interplay between different short term markets (intraday, day ahead, balancing) for flexibility. A key question is where is the value of power plant flexibility in different markets. An output from this could be a report or paper. Third, he mentioned a joint contribution

leveraging an existing power model in China (CNREC) for comprehensive power market modelling, which could include analysis of impact on different stakeholders.

Following this, comments were taken during a tour de table, including Takuma Inamura affirming Japan's commitment and desire to contribute. A 6-fold increase in PV in Japan with feed in tariffs was noted and that the high PV output requires operation of the existing pumped hydro resources. While curtailment is not yet an issue it is expected to be in future.

GIZ (Hannah Sternberg) also commented that power plant flexibility is an important topic for the organisation and mentioned the workshop on the 1st of November in Berlin to be hosted by the Ministry. This event will welcome policy makers in addition to diverse stakeholders and include four sessions covering topics including, a global outlook on power system flexibility requirements, technical and regulatory aspects of power plant flexibility, the role of markets to unlock flexibility investment and site visits to a retrofitted CHP plant as well as a transmission control centre.

The meeting closed with a general discussion. One additional comment suggested that an important topic for the next session would be considering flexibility enablement within a regulated rather than restructured context and how to get flexibility into long term PPAs. The possibility of improving the analysis around the impacts of more flexible, variable operation on plant lifespan was also raised by VGB commenting that they have a long term (40 year) database and there has been a recent increase in forced outage. VGB would be interested in digging deeper into this database, bearing in mind that there are different potential reasons for correlations (ageing fleet, flexible operations, reduced maintenance budgets).

Agenda

9h15	**Doors open**
9h30	**Welcome, overview of the meeting** *Christian Zinglersen, Head, Clean Energy Ministerial, Secretariat* *Rui Luo, Deputy Head, Clean Energy Ministerial, Secretariat* *Welcome from campaign lead countries: China, Denmark and Germany* *Simon Müller, Head, System Integration of Renewables, IEA*
	Session 1: Power plant flexibility – technology perspective
10h00	**Flexibility of coal and gas fired power plants** *Andreas Feldmueller, Power Generation Services Division, SIEMENS AG*
10h30	**Bioenergy flexibility** *Antti Arasto, Research Manager, VTT Finland*
11h00	**Refreshments**
11h15	**Nuclear flexibility** *Aliki van Heek, Head, 3E Analysis Unit, International Atomic Energy Agency*
11h45	**Connecting the physics and the financials (economics)** Kevin Spengler, *GE Power, Steam Power Systems*
12h30	**Lunch break**
	Session 2: Power plant flexibility – economic perspective
14h00	**A utilities' perspective on power plant flexibility** *Fredrik Andren-Sandberg, Senior Regulatory Advisor - Regulatory Affairs, Wind Power at DONG Energy*
14h30	**An IPP's perspective on power plant flexibility – Focus on Japan** *Sumie Nakayama, Senior Adviser on Climate Change, J-Power*
15h00	**Market design to incentivise flexibility** *Maximilian Rinck, Business Development, European Energy Exchange AG*
15h30	*Discussion*
16h00	**Refreshments**
	Session 3: Campaign work plan
16h20	***Overview of campaign work plan*** *Simon Müller, Head, System Integration of Renewables, IEA*
16h35	**Input from lead countries** *Representatives from China, Denmark, and Germany*
17h00	**Tour de table with presentation of commitments**
17h30	***General discussion and next steps***
18h00	**End of meeting**