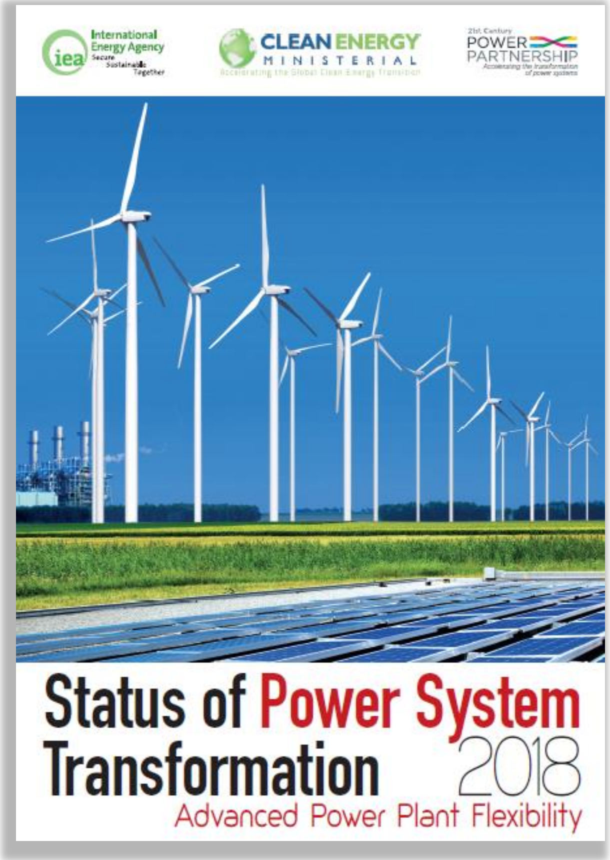
Creating and enabling environment for Power Plant Flexibility

Dr. Peerapat Vithayasrichareon, Energy Analyst – System Integration of Renewables

Grid integration of variable renewable energy
Asia Clean Energy Forum 2018, Manila, 5 June 2018

IEA

Status of Power System Transformation 2018



- ***Advanced Power Plant Flexibility (APPF)***
- The main findings of the APPF campaign can be found in the 2018 PST Report
- This report was a collaboration between the **IEA** and the **US National Renewable Energy Laboratory (NREL)**
- To download the report go to the following link
- https://webstore.iea.org/status-of-power-system-transformation-2018

ADVANCED POWER PLANT FLEXIBILITY

A Clean Energy Ministerial Campaign

Campaign Co-Leads

China | Denmark | Germany

Participating CEM Members

Brazil | Canada | EC | India | Indonesia

Japan | Mexico | Saudi Arabia | South Africa | UAE

COWI | DONG energy | enel | ENERGINET/DK

GE | J-POWER | SIEMENS | KYUSHU ELECTRIC POWER CO.,INC.

MAN Diesel & Turbo

Agora Energiewende | VGB POWERTECH

System integration – boosting power plant flexibility

- Flexible power plants are a major source of flexibility in all power systems
  - Biggest source in several leading countries
  - Key issues: minimum generation levels, start-up times, ramp-rates

- Significant barriers hinder progress:
  - Technical solutions not always known
  - Regulation and/or market design frequently favour running ‘flat-out’
  - Contractual arrangements with manufacturers may penalise flexible operating pattern

Example North-America
From baseload operation to starting daily or twice a day (running from 5h00 to 10h00 and 16h00 to 20h00)
Source: NREL

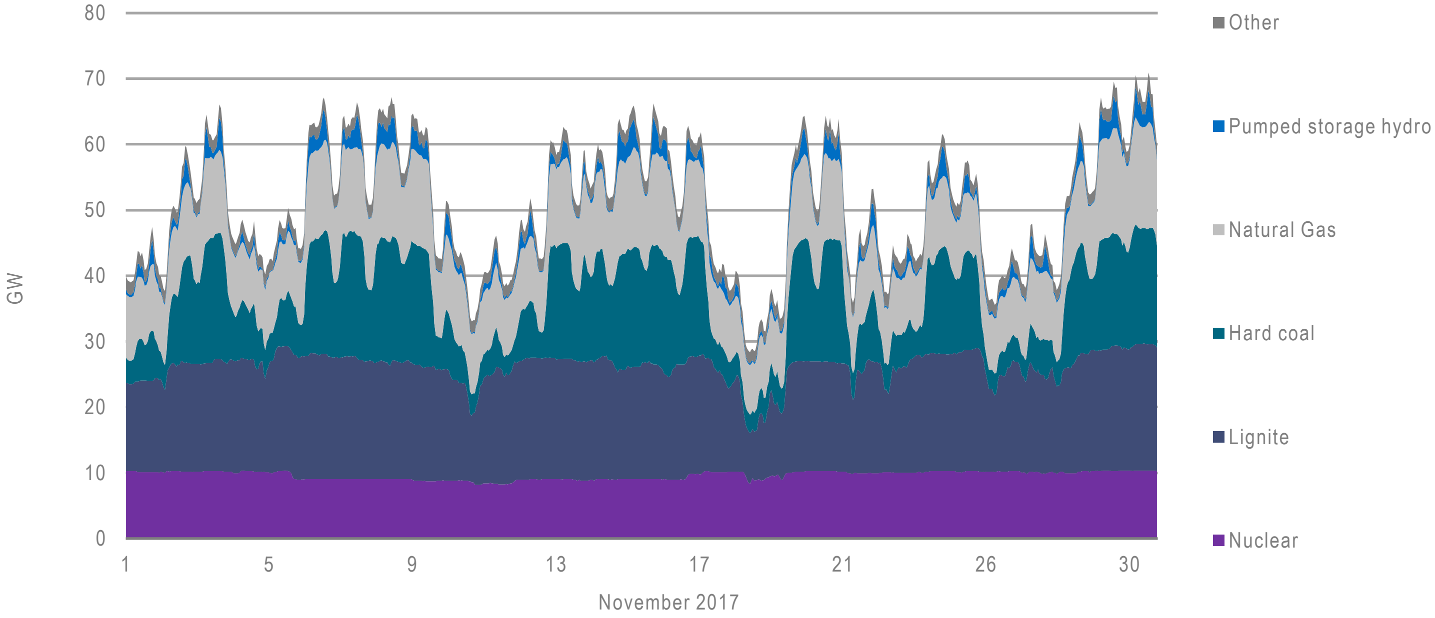
Relevant dimensions for unlocking system flexibility

Roles and responsibilities	*Institutional ("Who")*
Technical rules and economic incentives	*Policy, regulatory and market frameworks ("How")*
Dispatchable generation; State-of-the-art VRE; Demand-side resources; Electricity storage; Grid infrastructure	*Hardware and infrastructure ("What")*

Technical, economic and institutional policy layers mutually influence each other and have to be addressed in consistent way to enhance power system flexibility.

Flexible thermal generation – business as usual already today

Conventional electricity generation in Germany in November 2017



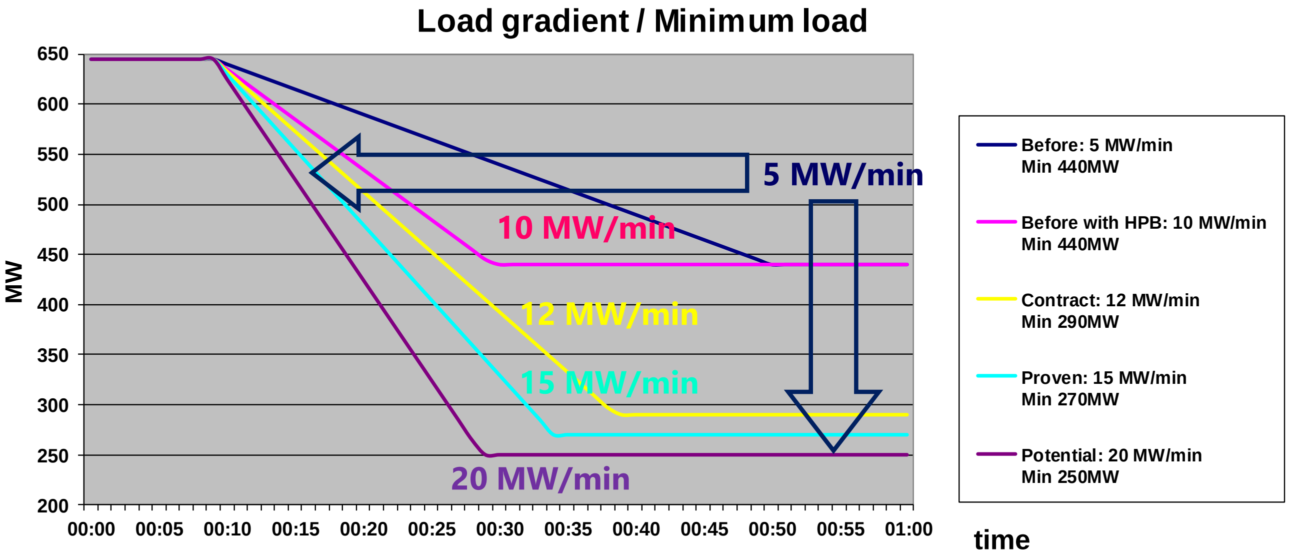
Main technical parameters

- Minimum output – less shut-downs and costs
- Ramp rate and start-up time – faster response
- Minimum up and down times – Flexible scheduling

Power plant flexibility is a priority for the operation of Germany's power system.

Source: Agora (2018b), Die Energiewende im Stromsektor: Stand der Dinge 2017

Neurath power plant - Germany



- 630 MW lignite, built 1975
- Boiler design for base load
- Siemens

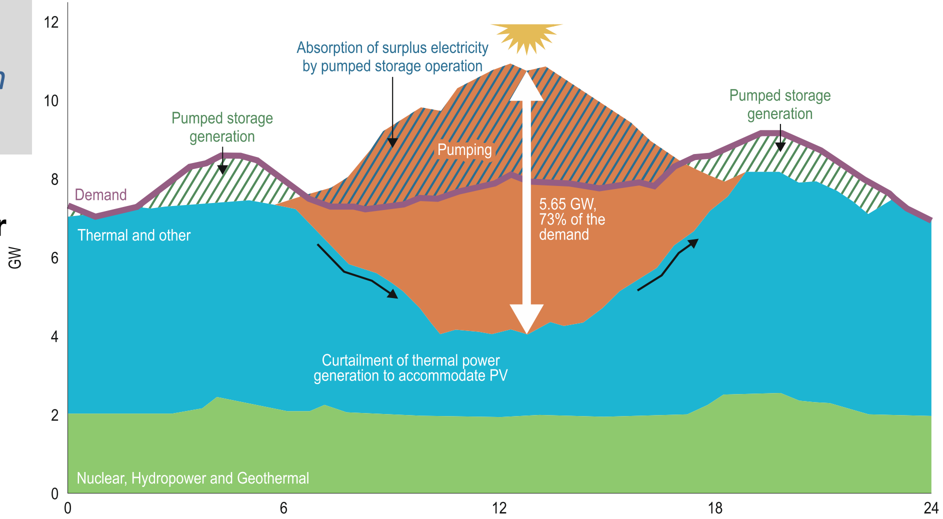
- Ramp rate tripled (5 -> 15 MW/min),
- Minimum load reduced by 40% (440 -> 270 MW)
- Startup time reduced from 4 hr 15 min -> 3 hr 15 min
- Optimisation of all subordinated controllers, e.g. air, feedwater, fuel

Kyushu - Fleet coordination for increased flexibility

With 6 GW installed PV capacity, 16 GW peak load and 8 GW minimum daytime load, Japan's southern-most main island, Kyushu, has the highest VRE penetration in Japan.

6 dispatch rules developed by the Japanese Organization for Cross-regional Coordination of Transmission Operators:

- Avoid generation from reservoirs and PSH during daytime.
- Prioritise electricity surplus absorption by PSH.
- Reduce thermal plant output to min gen
- Export surplus electricity through cross-regional interconnectors.
- Reduce biomass power plant output.
- Curtail solar PV and wind as a last resort.



- Avoiding thermal generation shutdown is crucial as their start-up times range between 2 and 8 hours
- At sun-down solar PV output decreases at 1.3GW/hour
- High solar PV penetration high-lights the importance of improving forecasting

Introducing protocols for coordinating power plant response to manage VRE variability can be useful in maintaining system stability at high VRE shares.

Source: Kyushu EPCO, Case-study on portfolio coordination based on system conditions from 30 April 2016

Policy guidelines for power plant flexibility

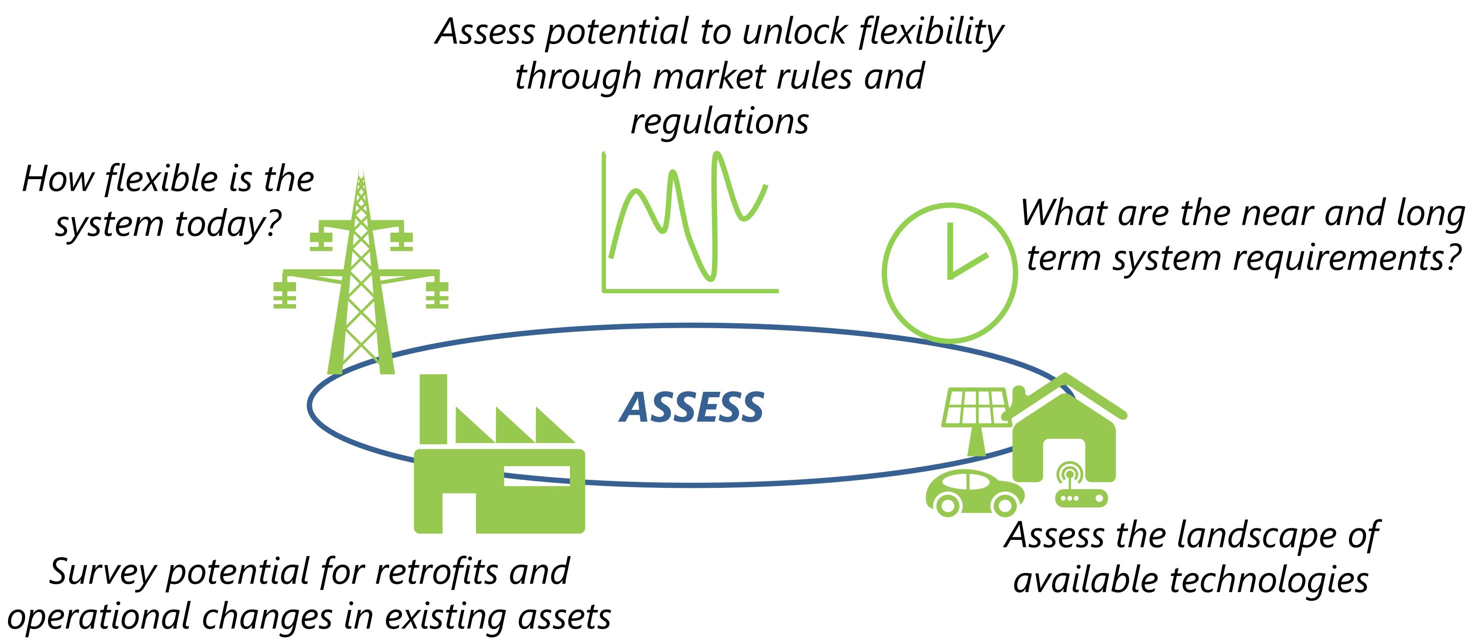
1. Assess	2. Engage	3. Enhance	4. Unlock	5. Incentivise	6. Roadmap
Prioritise action steps	Engage stakeholder community	Enhance system-wide flexibility	Mobilise existing power plants	Facilitate flexibility investments	Enhance planning
Conduct assessments of system-wide flexibility requirements, opportunities and barriers to understand urgency and prioritise actions.	Strengthen technical, policy, and institutional capabilities to enhance power system and power plant flexibility. Engage with international communities to share best practices.	Enhance the use of available power system flexibility through adapting a range of market, regulatory and operational best practices at the system level.	Update regulations, policies and practices that govern power plant operation to unlock latent flexibility.	Facilitate opportunity to seek fair remuneration for all assets that can provide flexibility to the power system through changes to policy, regulatory and market frameworks.	Enhance planning procedures to incorporate future expectations of system flexibility requirements.

Near-term actions (1–4) | Long-term planning (5–6)

Following a set of best practice policy guidelines allows successful roll-out of power plant flexibility.

Source: Status of Power System Transformation 2018

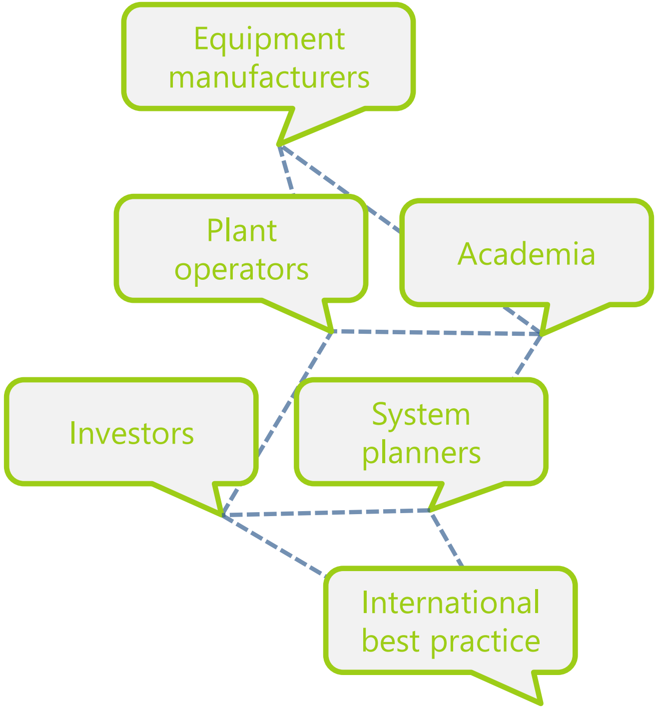
Consideration 1 - Assess



Building up a flexibility inventory can allow policy makers to see what options are available today and how to plan for future flexibility requirements.

Consideration 2 - Engage

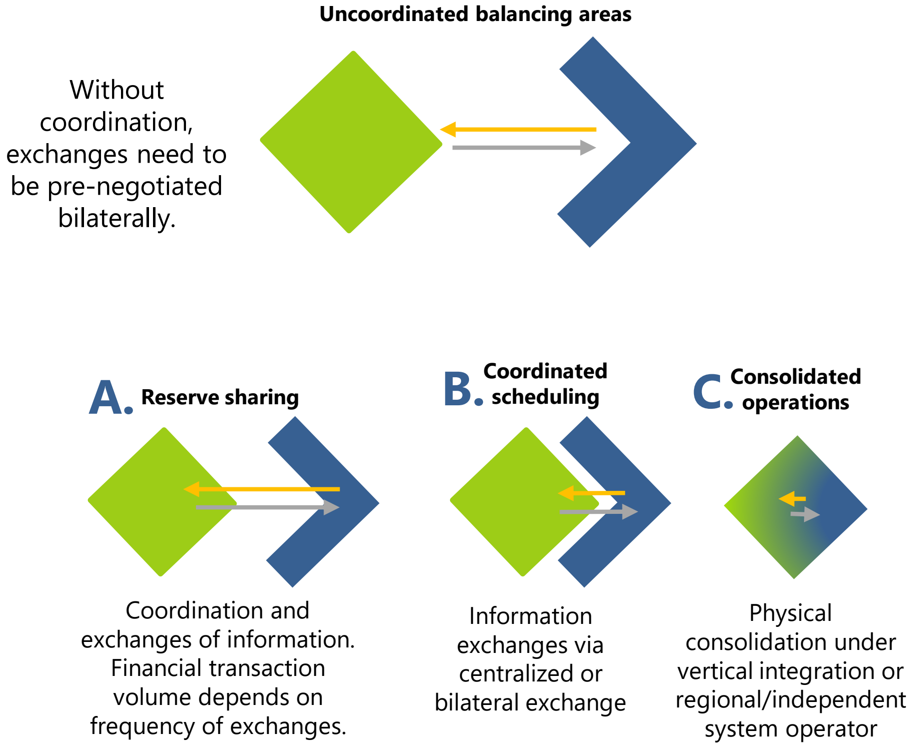
- Disseminate high-quality data across various stakeholder groups, including beyond direct system operation
- Facilitate capacity building through international exchange
- Promote domestic research through data sharing and issuing public research grants
- Share experiences on system flexibility in national and international forums
- Engage with plant operators and original equipment manufacturers



Domestic and international stakeholder engagement can help build momentum for embedding flexibility in modern power systems.

Consideration 3 - Enhance

- Encourage system operators to engage in "faster" power system operation
- Transition towards centralized VRE forecasting systems
- Increase communication and coordination between balancing areas
- Incentivise technologies that "flexibilise" demand
- Adopt advanced strategies to increase available grid capacity

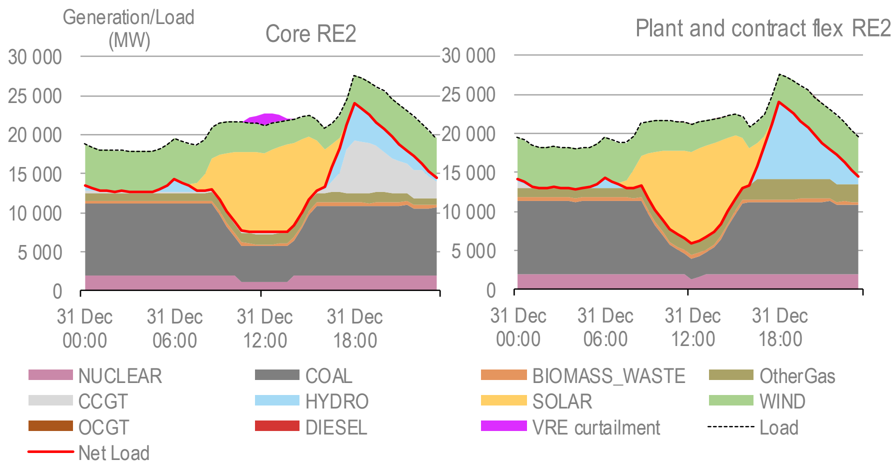


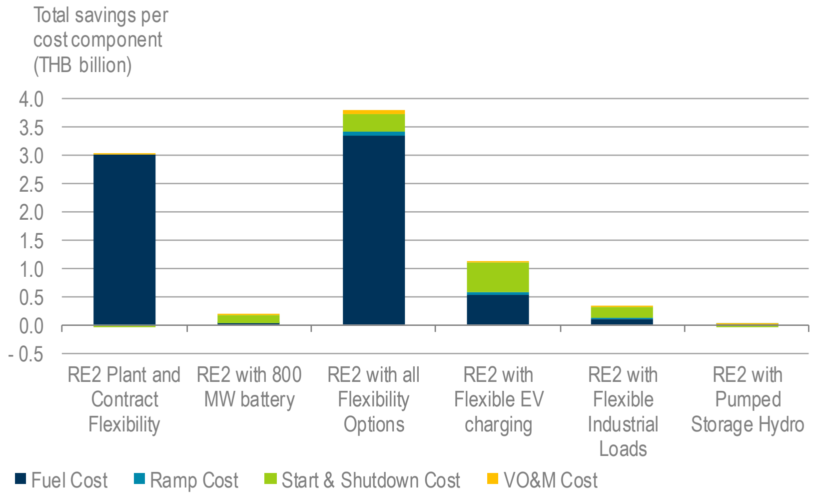
Enhancing system-wide flexibility requires coordinating technical options from operational changes to demand-side measures

Figure adapted from NREL (2015) Balancing Area Coordination: Efficiently integrating Renewable Energy into the Grid, Greening the Grid

Consideration 4 - Unlock

- Review “must-run” requirements for power plants
- Oversee the review of electricity and fuel contracts to enhance flexibility through contract flexibility
- Allow VRE participation in reserve provision





Unlocking flexibility from existing assets can be a cost-effective approach but should be informed by cost-benefit analyses

Consideration 5 - Incentivise

In liberalised markets

- Improve wholesale market design
- Implement market instruments for all relevant system services
- Implement additional mechanisms that appropriately value capacity, flexibility and other relevant resource attributes

In regulated markets

- Allow cost recovery for retrofit investments
- Provide incentives that allow for resilient, high-flexibility components in new power plants

Introduce fair remuneration that accounts for the system value of flexibility

Consideration 6 - Roadmap

- Encourage the inclusion of flexibility assessments in planned system adequacy assessments
- Request state-of-the-art decision support tools for long-term planning purposes
- Encourage the integration of generation and transmission investment planning
- Assess costs and benefits of demand-side resources and electricity storage options

Long-term system transformation is an iterative process.
It requires regular evaluation and update of system planning.

Picture credit: Shutterstock

Key messages

- Power plants are one option to provide system flexibility, but many other options are available in modern power systems.

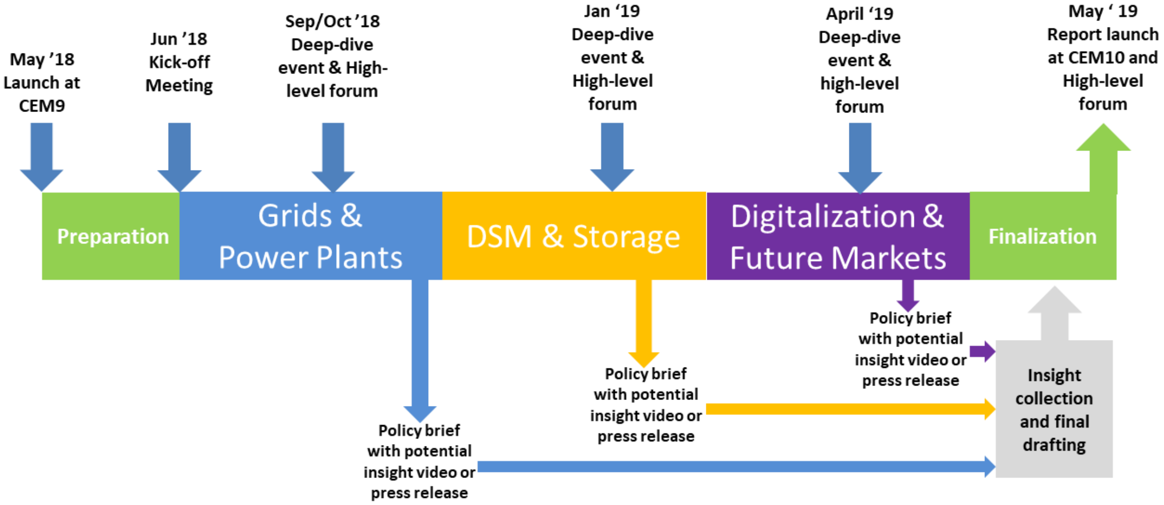
- The role of existing thermal power plants is transitioning in many modern power systems toward more flexible modes of operation and, at times, reduced operating hours.
  - Significant system flexibility lies latent in many power plants; global experience suggests a range of known strategies are available to unlock that flexibility, many non-technical.
  - Generators initially designed and operated as “inflexible” have been successfully engineered into highly flexible assets

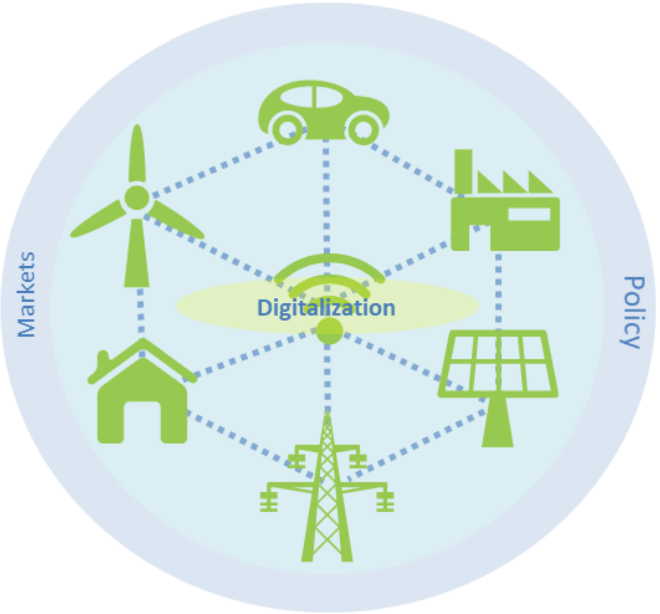
- Well-designed policy, market and regulatory frameworks critical to unlock power plant flexibility
  - Improved market design and proper valuation of flexibility services

- Incorporating regular flexibility assessments into planning and strategy dialogues is key.
  - Established decision support tools can be used to assess flexibility requirements, understand the value of proposed changes, and plan for the future

Campaign continuation Power System Flexibility

- Continuation of the APPF campaign with a wider scope on power system flexibility
- 3 main themes and associated events





Further information available via campaign coordinator:
Enrique Gutierrez (Enrique.Gutierrez@IEA.org)

www.iea.org

IEA

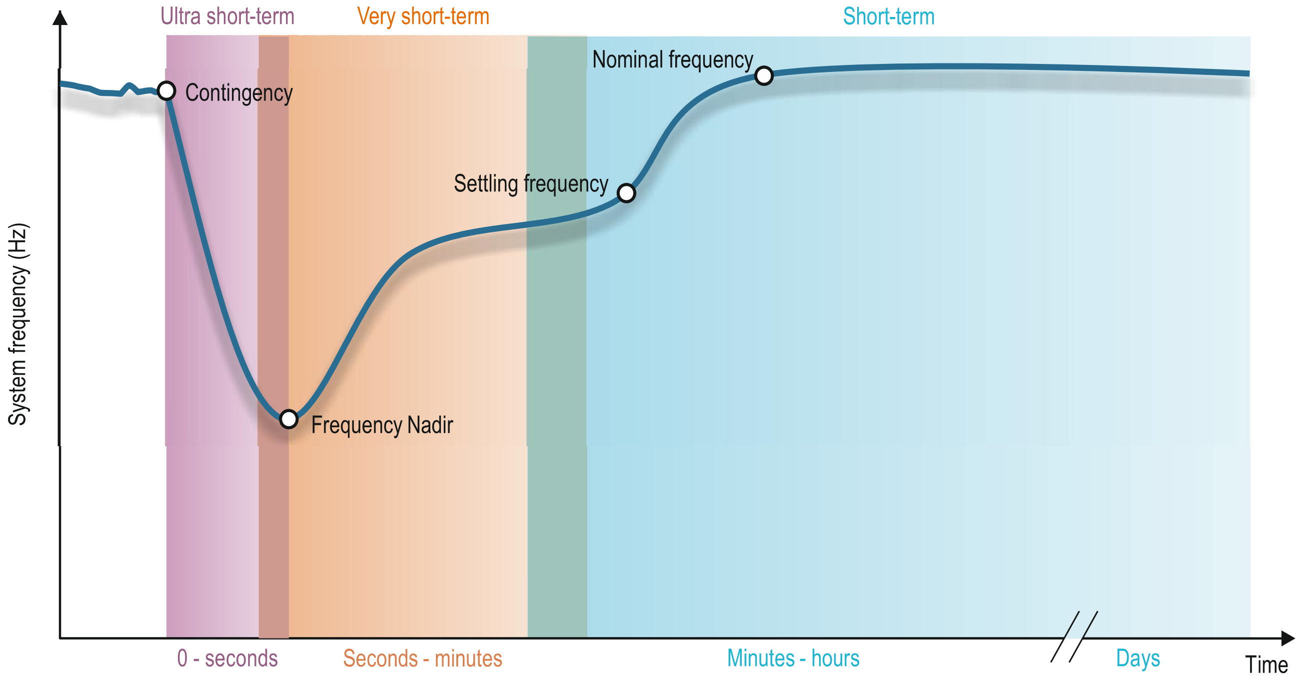
peerapat.vithaya@iea.org

Flexibility - Needed across a wide range of time scales

Flexibility type	Short-term flexibility			Medium term flexibility	Long-term flexibility	
Time-scale	**Sub-seconds to seconds**	**Seconds to minutes**	**Minutes to hours**	**Hours to days**	**Days to months**	**Months to years**
Issue	Ensure system stability *Cope with large disturbances such as loosing a large power plant*	Short term frequency control *Balance of demand and supply*	Meeting more frequent, rapid and less predictable changes in the supply / demand balance,	Operation schedule in hour- and day-ahead. *Decide how many thermal plants should remain connected to and running*	Managing scheduled maintenance of power plants and larger periods of surplus or deficit e.g., hydropower *availability*	Balancing seasonal and inter-annual availability of VRE generation *Often influenced by weather and electricity demand*
Relevance for system operation and planning	Dynamic stability (inertia response, protection schemes)	Primary and secondary frequency response (includes AGC)	AGC, economic dispatch (ED), balancing real time market, regulation	ED for hour- ahead, unit commitment (UC) for day-ahead,	UC, scheduling, adequacy	Hydro-thermal coordination, adequacy, power system planning

System flexibility addresses a set of issues and across different time scales from sub-seconds to years

Contributions of flexibility services in different time scales



Ultra-short-, very short- and short-term flexibility services are important for maintaining system frequency

MoorFlex - Flexible coal and co-generation

Co-generation plant located in Hamburg with 827MWe capacity.
Plant was unable to obtain sufficient revenue from base-load operation under changing market conditions.

Measures

- Reduction of minimum stable output levels from 35% to 26%
- Optimization of control loops and operation modes
- Retrofitting with flue gas dampers to regulate cooling

Results

- Reduction of minimum stable output level lead to reduced number of start-ups and shut-downs associated with increased costs
- Faster ramping rates: able to ramp at 48MW/min and up to 90MW/min under special conditions
- Improved start-up:
  - Cold 20% faster
  - Warm 42%-50% faster
  - Hot 40 – 46% faster

Power plant flexibility can enable existing assets to remain profitable in changing market conditions.

Source: Case-study provided by MHPS,March 2018. Vattenfall (2016)

La Casella - CCGT refurbishment for increased flexibility

Built in the 1970s as an oil-fired plant for baseload operation. Converted to a CCGT with four 370MW units between 2000 and 2003. First intervention in 2008, second in 2014 to adapt to new market requirements: competition and reserve provision.

1st set of measures

- Exploration of plant's real limits and constraints
- Equipment modernization and partial automation
- Update to operational procedures

2nd set of measures

- Optimisation of combustion behaviour at low loads
- Study of component limits under increased stress conditions, particularly HRSG unit.
- Measurement and redesign of turbine to reduce rotor stress

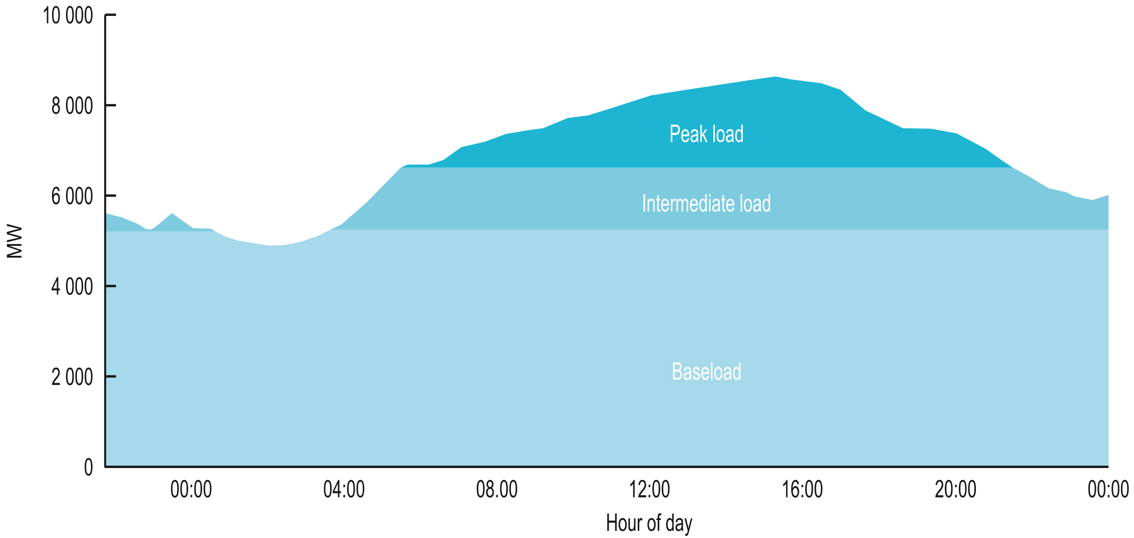
Results

- **Start-up time improvement:**
  Warm 50% faster
  Cold 20% faster
- **Reduced minimum stable level** from 230 MW to 170 MW and faster ramping
- Ability to provide reserve and meet emissions requirements
- Reduced damage to equipment in the face of faster ramps
- Data availability and experiences have been deployed across ENEL's fleet

Improving plant performance is an iterative process that extend the plant's lifetime, while ensuring that changing market requirements and regulations are upheld.

Source: ENEL

Traditional categorisation of electricity demand



- Traditional basis that power plant roles have been categorised
  - Baseload, Intermediate and Peak

- With growing shares of wind and solar, demand side management and DER, the classical categorisation of power plants is changing
  - the roles of existing power plants are changing. This is driven by the need for more flexible operation.
  - Modern resources such as VRE plants are not captured by the above categorisation. They are very capital intensive (similar to baseload plants) but their capacity factor is closer to that of mid-merit or peaking generation.

