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Grid integration of variable renewable sources – Overcoming technical and operational bottlenecks

Francisco Gafaro

The transformation of the power system

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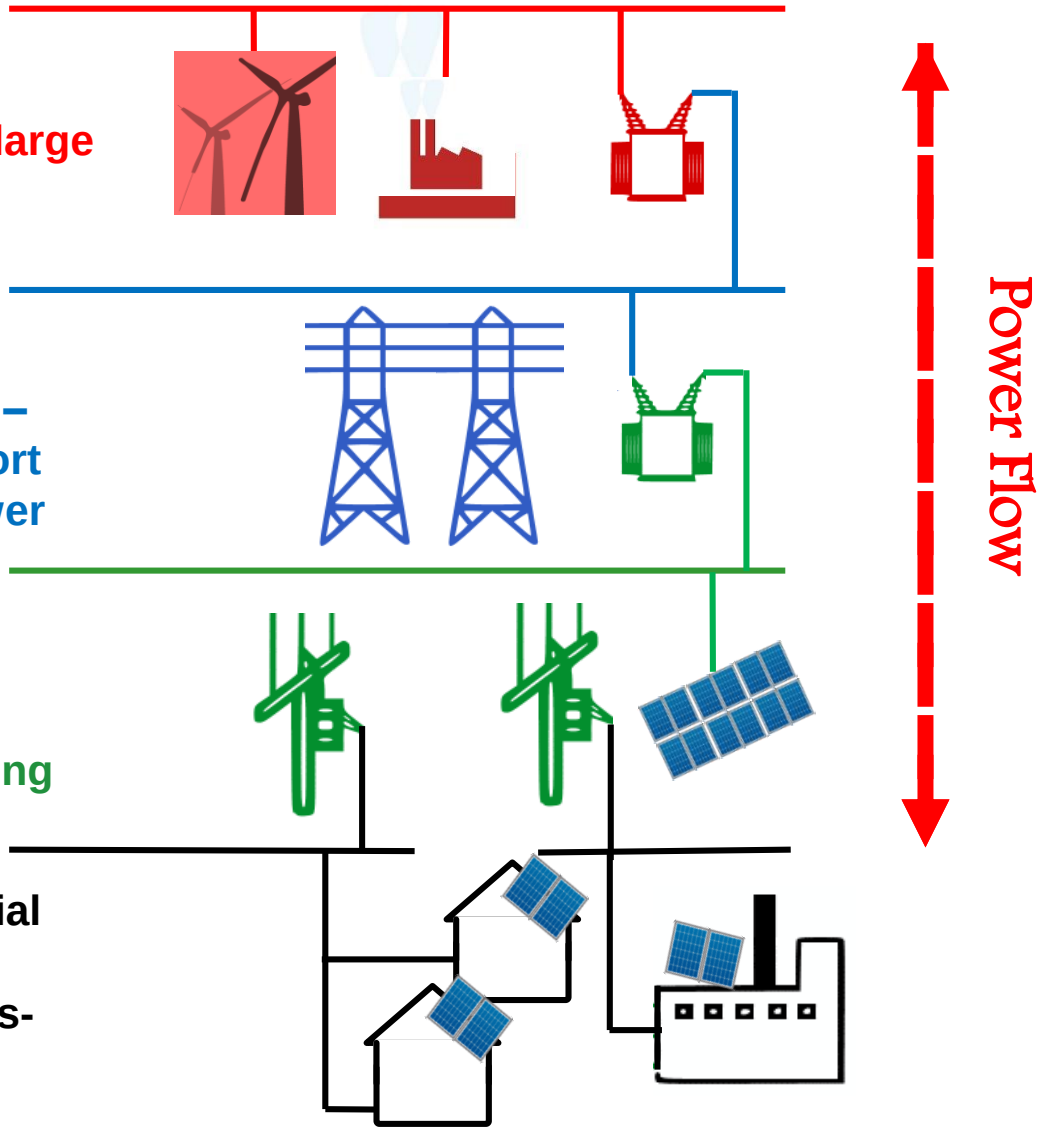
Centralised Power Generation including large scale VRE

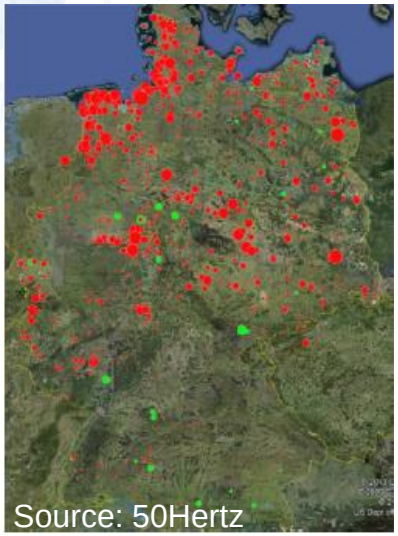
Power Transmission: High Voltage Network – Long distance transport of large blocks of power

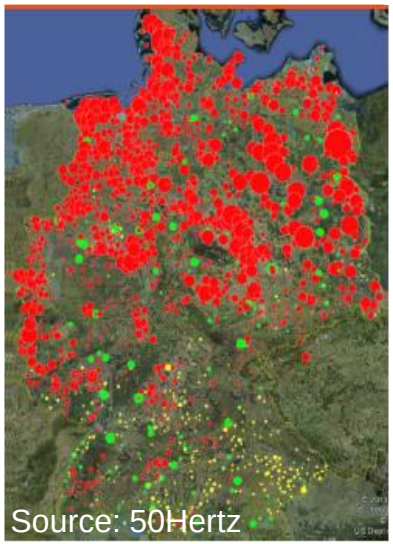
Power Distribution Medium/Low Voltage power delivery including VRE

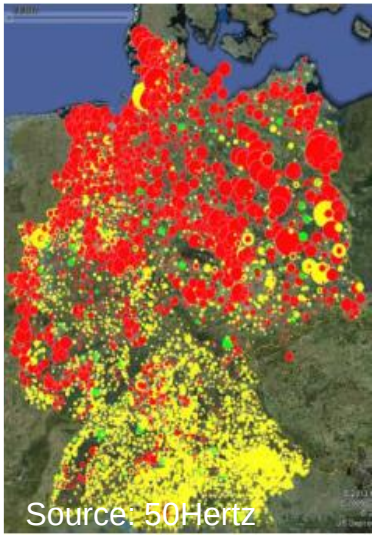
Residential, commercial industrial customers Different voltage levels- Distributed VRE



The transformation of the power system







around 30.000 plants | around 220.000 plants | around 1.500.000 plants

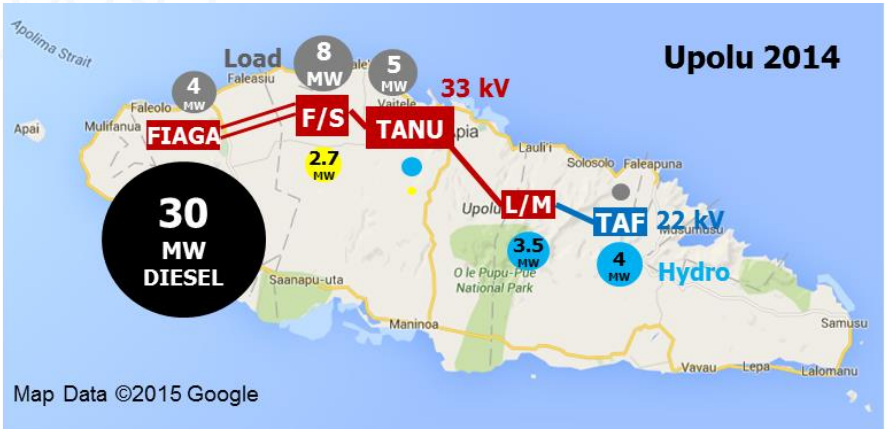
2000 | 2006 | 2014

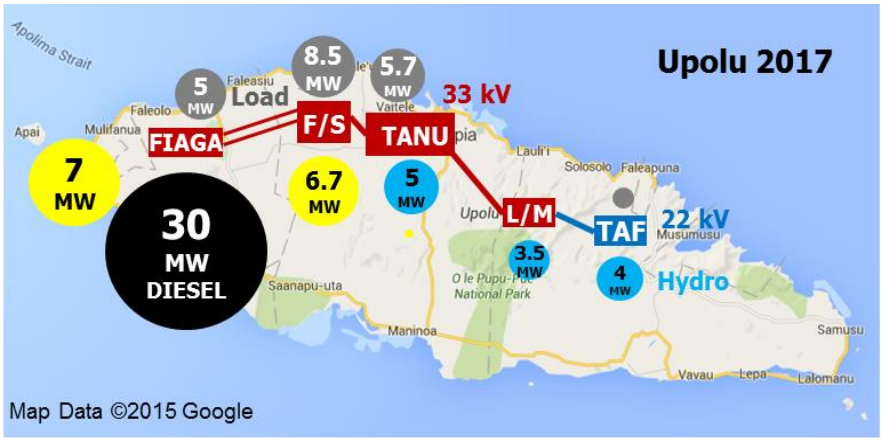
Wind | Photovoltaics | Biomass

Example in Germany

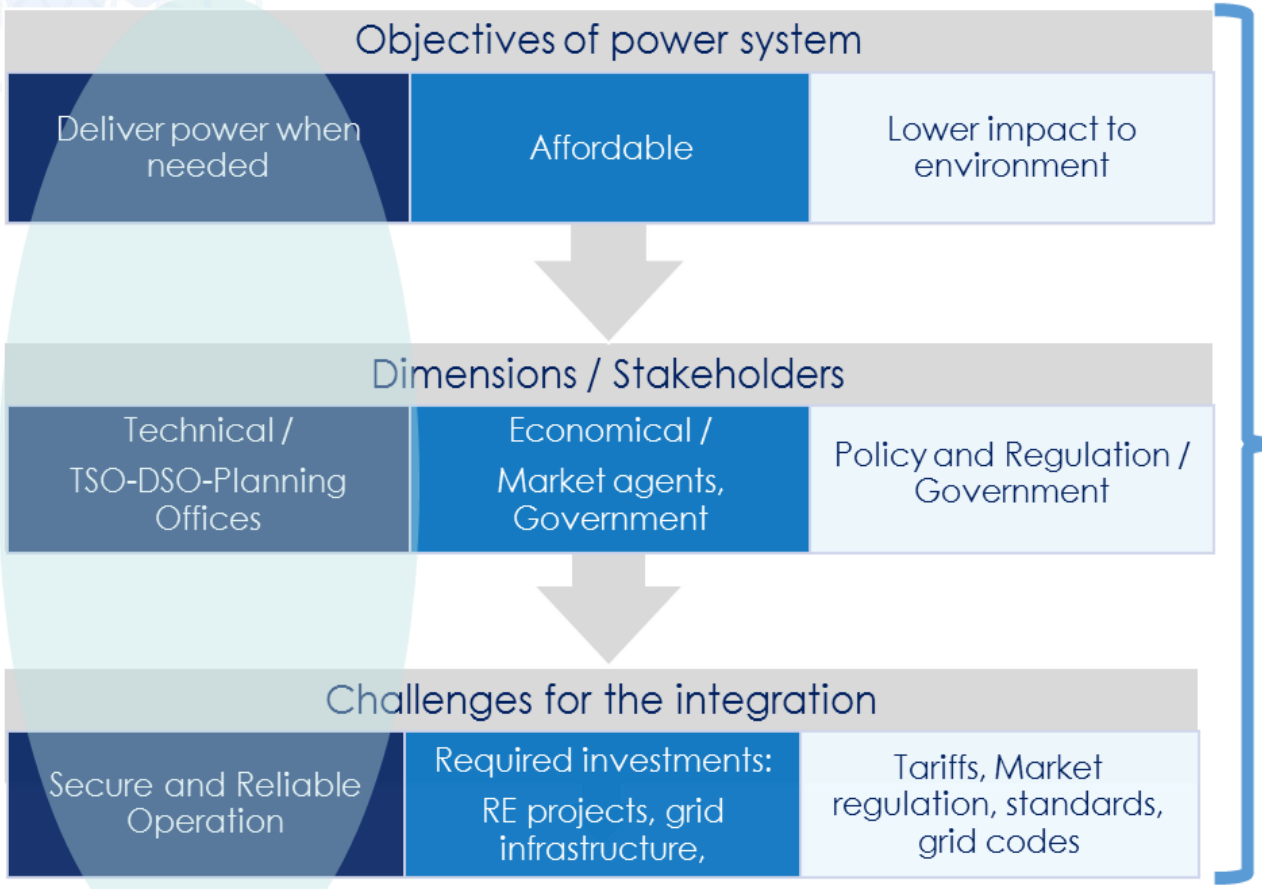
Source: 50Hertz

The transformation is happening everywhere regardless of its size





Challenges at different levels



Successful transformation requires:

- ✓ **Political commitment - stable regulatory framework**
- ✓ **Planning for coherent energy systems**
- ✓ **Innovative solutions**

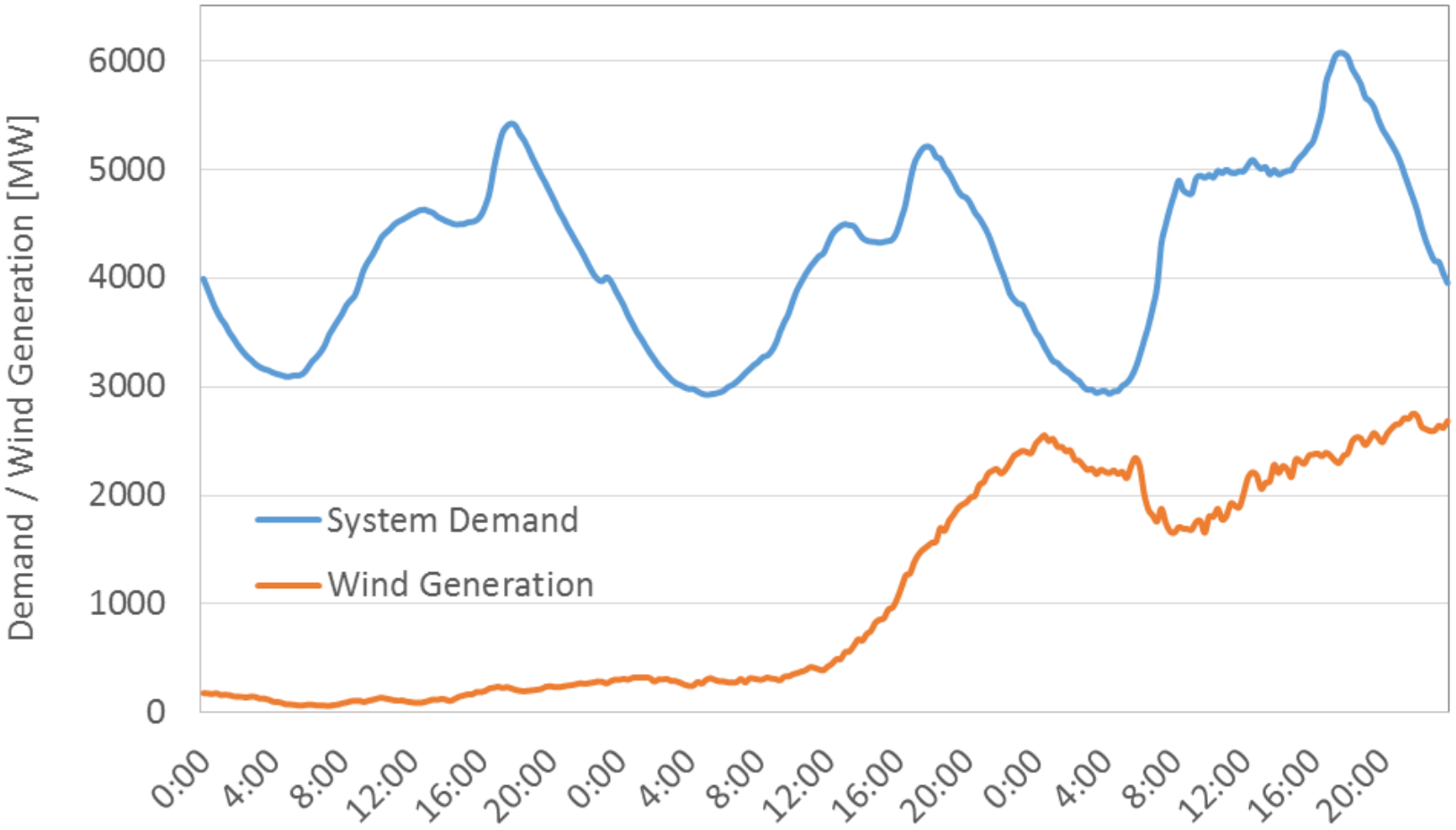
The technical Challenge

How to develop the system to maximize the value of VRE generation as it comes - and still ensure the security of supply?

Preconditions for secure system operation:

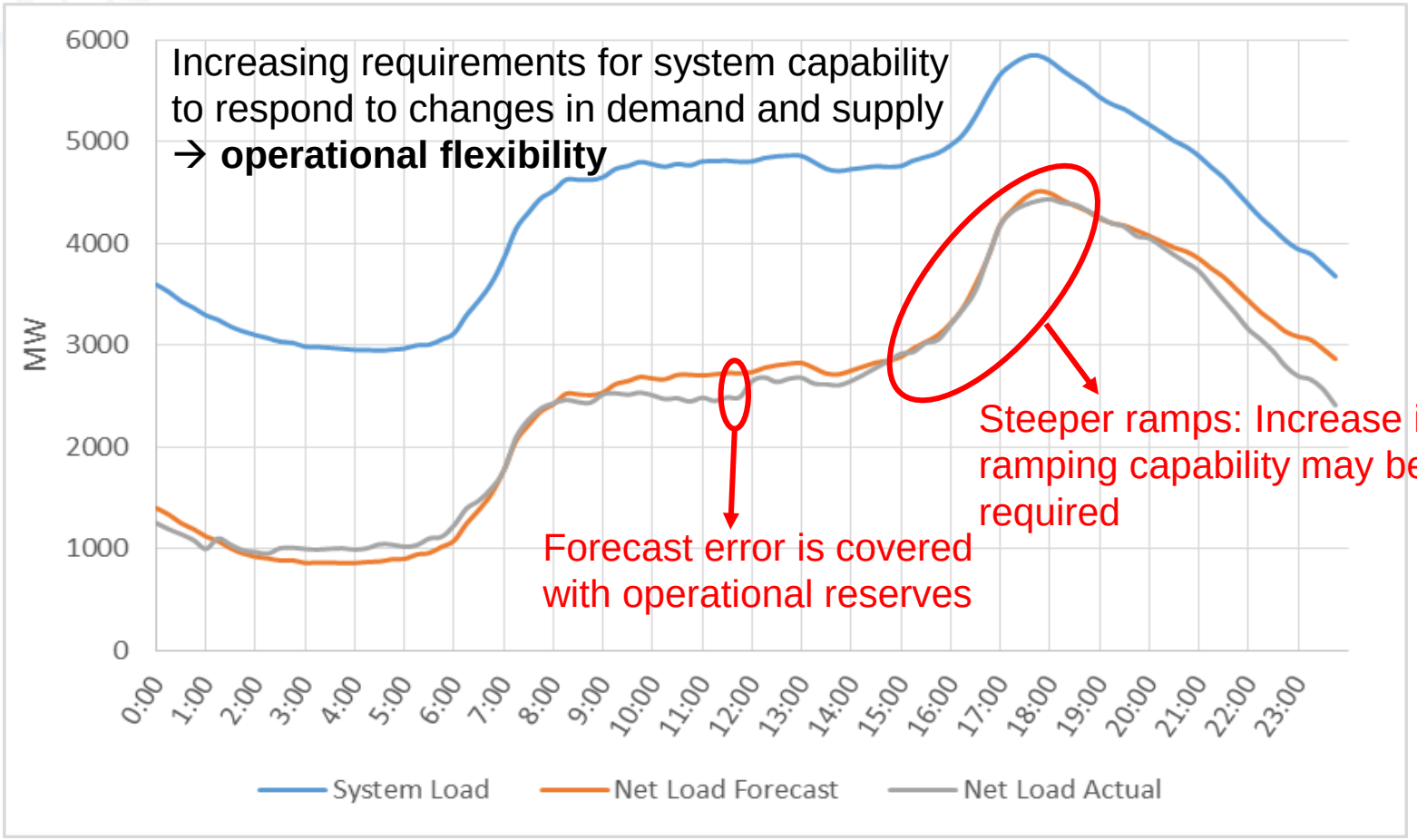
- ✓ Availability of power to cover demand (adequate generation fleet)
- ✓ Adequate network and associated infrastructure
- ✓ Availability of ressources to cover system imbalances in the operational hour
- ✓ System stability

Generation does not coincide with consumption



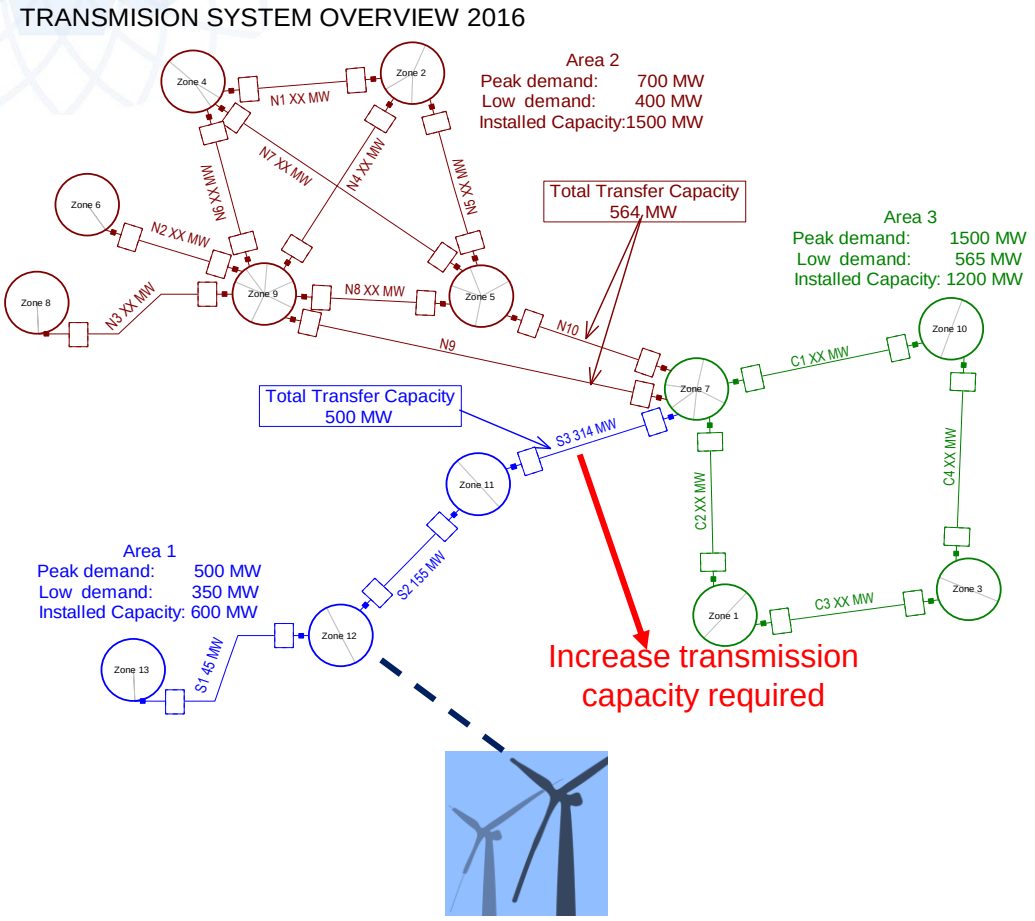
Data from: http://www.eirgridgroup.com

Variability and limited predictability

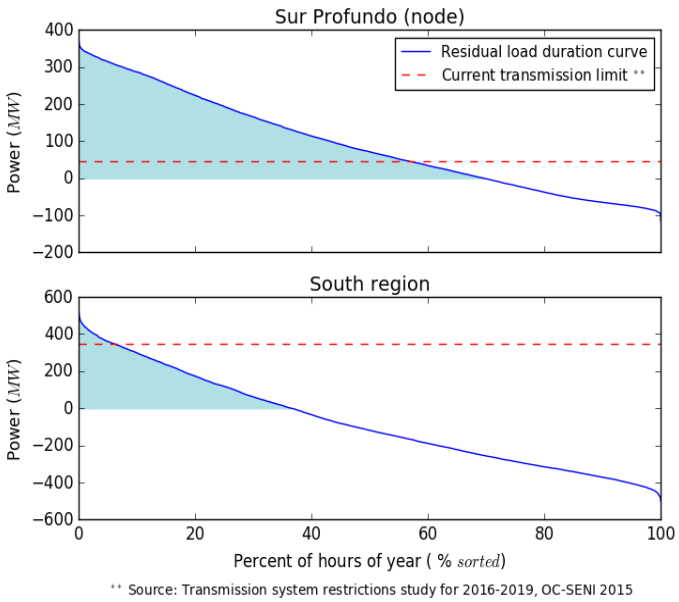


Data from: http://www.eirgridgroup.com

Transmission system adequacy



High Wind Resources Zone identified for future development



** Source: Transmission system restrictions study for 2016-2019, OC-SENI 2015

Different interaction with the grid

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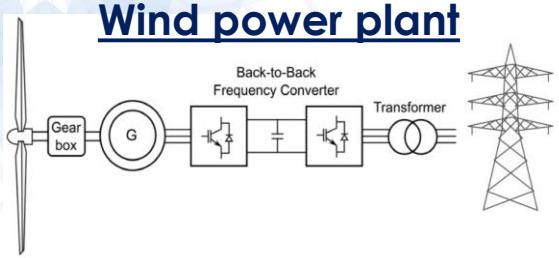
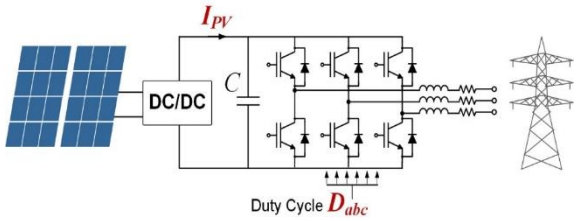
Wind power plant

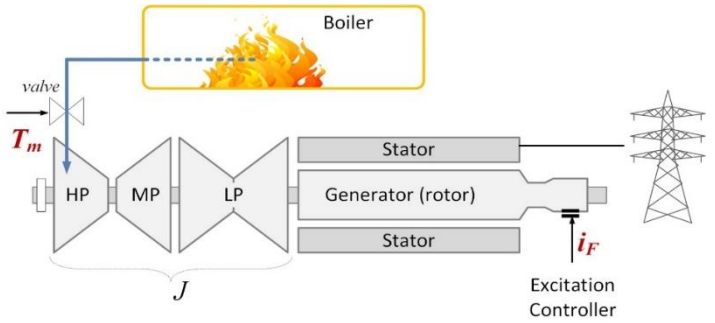


Solar power plant



VS

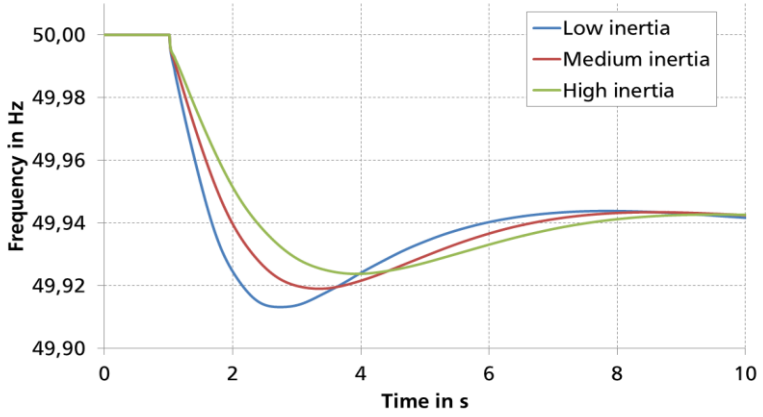
Conventional power pant



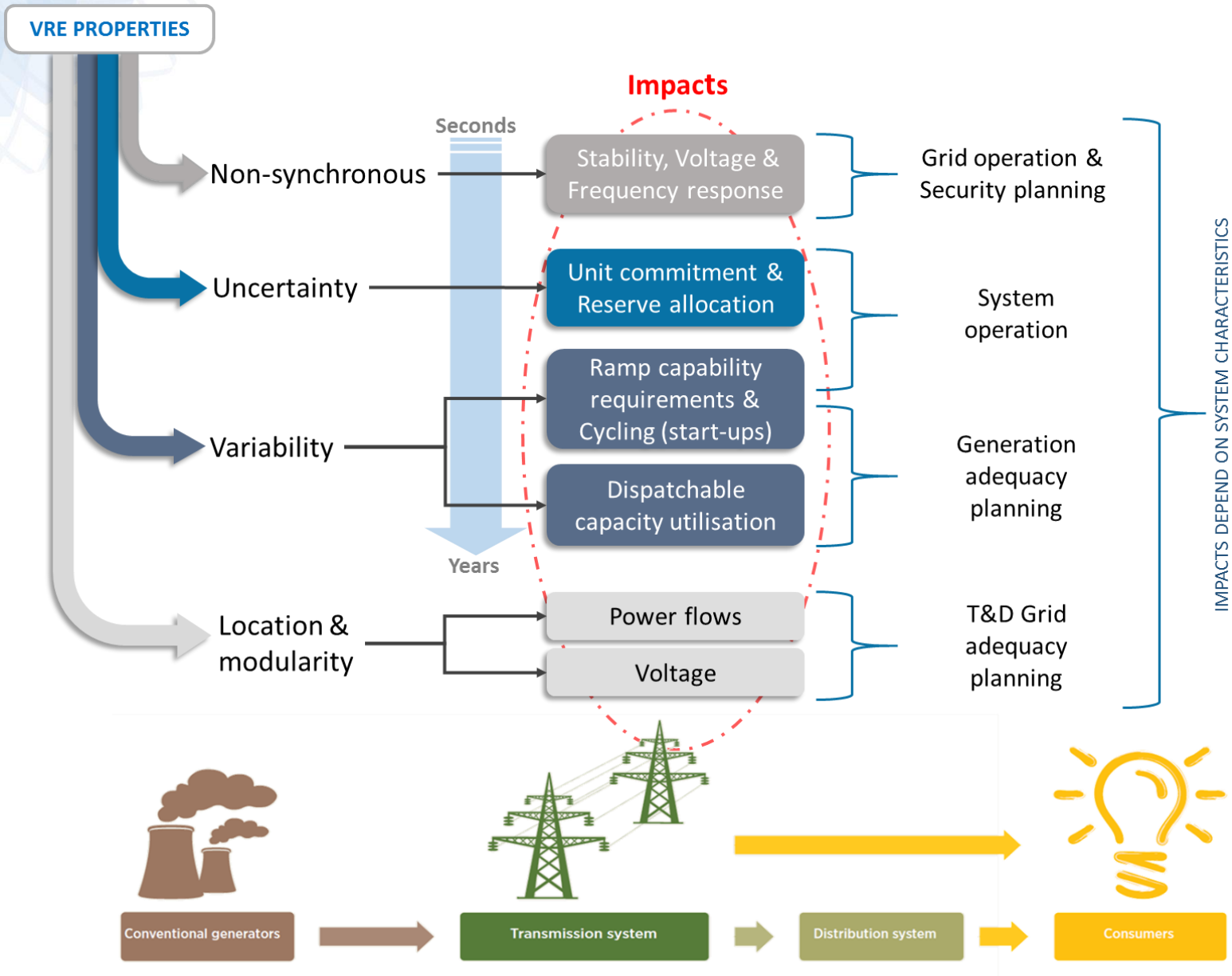
Source: CPES Virginia Tech

- Physical principle, and included interface between the grid and the source of energy is different.
  - Robustness of the system and capability to control frequency and voltage may be affected (stability).
- **Minimum grid performance requirements and technical assessment to identify security threads are required.**

Inertia



The technical challenges - Summary



Solutions for the recognised issues are already in place

- Provision of grid services from VRE
- Strong transmission grids.
- Interconnection with neighbour systems.
- Flexible conventional generation.
- Storage/ demand side management.
- Specialised forecasting and operational planning tools
- SmartGrids to SmartEnergy to optimize RES utilization across energy sectors and support price flexibility
- …

Looking forward for new innovative solutions

Planning the secure operation of the power system

Source: Amprion GmbH
http://www.amprion.net/en/picture-archives

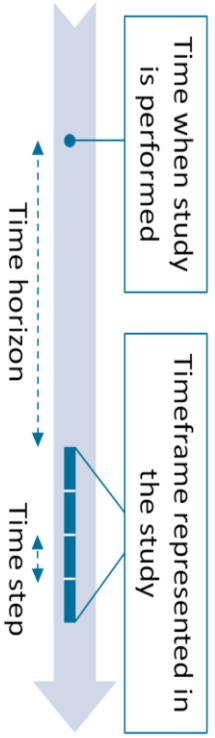
Long term generation adequacy planning

Long term grid adequacy planning

Update of operational constraints / reserve requirements

Outage planning and programming

Day ahead generation scheduling & Security Checks



Real time operation

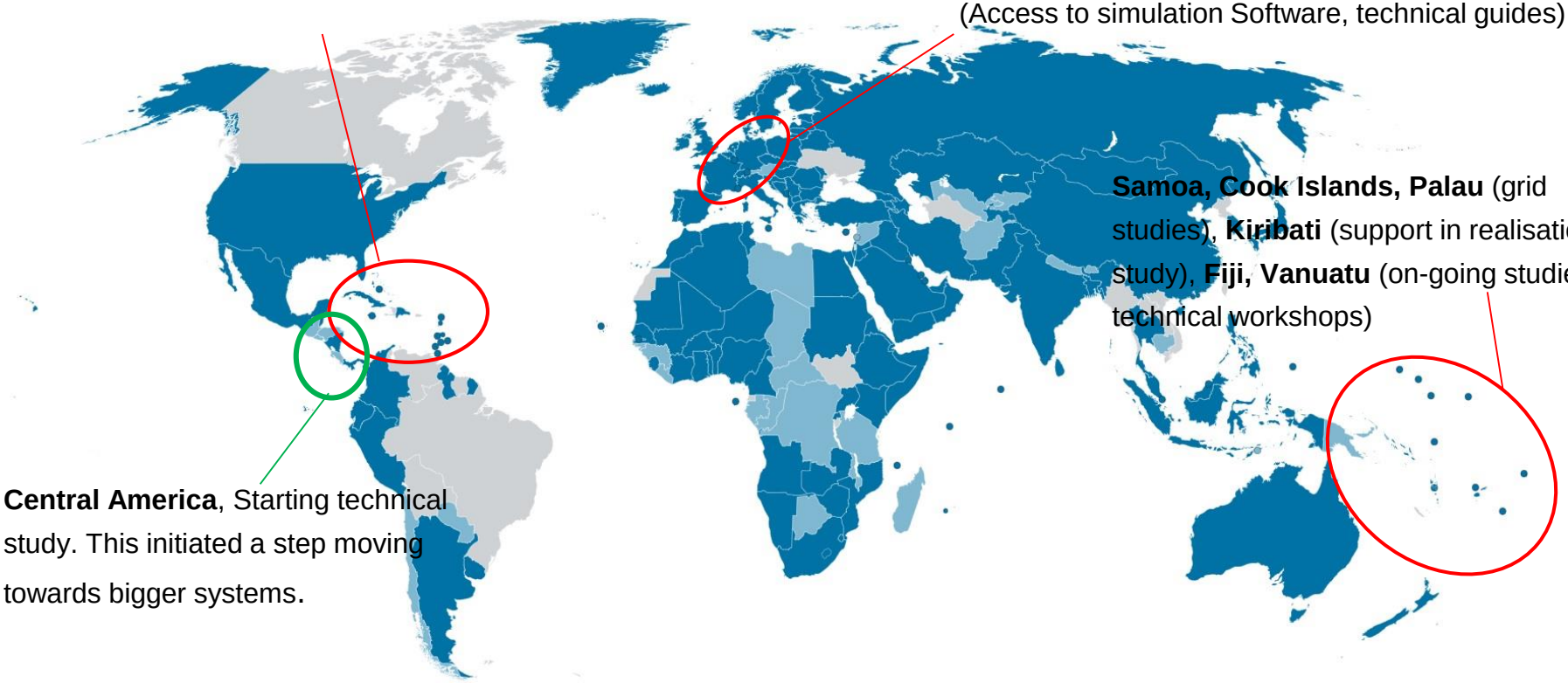
- Power system operation and planning aims to provide a **reliable** and **efficient** supply of electricity at any time.
- Operation of the power system is a very **complicated and critical task** that must be supported by a **strong planning process.**

Engagement with Member Countries

Cooperation with decision makers, network operators and technical experts at a global level supporting exchange of experiences on grid operation & expansion – Until now focus on small islands but moving towards larger interconnected systems

Dominican Republic (grid study**), Antigua & Barbuda** (grid study), **Barbados** (revision of studies), **CARILEC** (technical workshops), **CUBA** Workshop Planning and Operating the Electricity System

DIgSILENT, TU Darmstadt, TRACTEBEL-ENGIE (Access to simulation Software, technical guides)



Samoa, Cook Islands, Palau (grid studies), **Kiribati** (support in realisation of study), **Fiji, Vanuatu** (on-going studies, technical workshops)

Central America, Starting technical study. This initiated a step moving towards bigger systems.

VRE Grid integration studies

RE Roadmaps

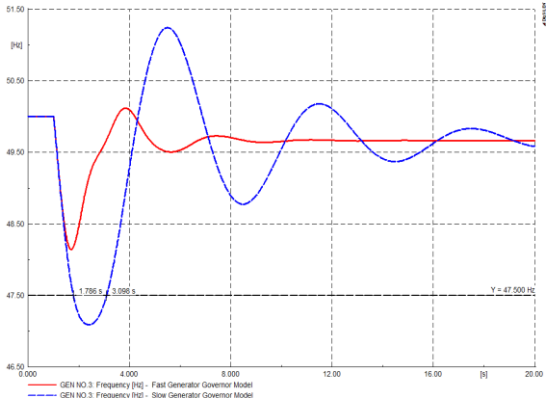
Grid Integration studies

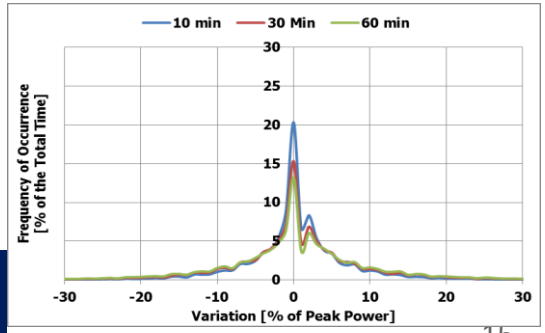
- Identification of technical constraints
- Recommendations on grid infrastructure investments
- Recommendations on Grid support functions to be provided by VRE / Planning & Operational procedures

Aim: Facilitate coordination between long-term, policy-driven RE targets and their actual deployment in the grid

General Approach: Assessment of reliability and security of the system with planned penetration levels of VRE through statistical analysis and electricity grid modelling & simulation

- Mid term time horizon (2 – 5 years)
- Cooperation with relevant stakeholders, **Flexible and adapted to the country needs**





Facilitation of exchange of experiences with network of top technical experts.

Guide : Planning of electricity grids in Small Island Developing States with VRE – A methodological guide

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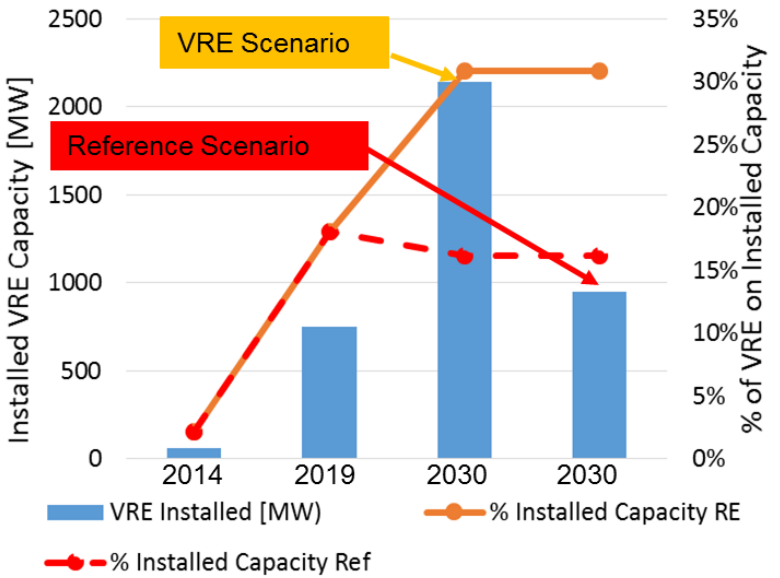
		Time horizons at which assessment is generally performed			Parts of the power system to be represented		
		Mid- and long-term planning (month to years ahead)	Operational planning (day to week ahead)	Real time dispatch (second to minutes ahead)	Load & generation	Transmission	Distribution
	Generation adequacy	■			■		
	Sizing of operating reserves	■			■		
	Generation scheduling	■	■		■	■	
Static	Load flow & static security assessment	■	■	■	■	■	■
Static	Voltage & reactive power control	■	■	■	■	■	■
Static	Short-circuit currents	■	■		■	■	■
Dynamic	System stability	■	■	■	■	■	
Special	Protection coordination	■			■	■	■
Special	Power quality	■			■	■	■
Special	Defence plans	■			■	■	(UFLS & UVLS)

Exchange of knowledge

- ✓ Webinars and technical workshops in partnerships with local stakeholders and regional organizations
- ✓ Global access and support in use of stability analysis software DigSilent PowerFactory
- ✓ Guides on grid stability and technical assessments for grid integration planning

Support in planning the operability in the Central America Clean Energy Corridor-Panama

- High shares of VRE expected in the mid term.
- Associated technical challenges must be addressed.
- TSO has a very well stablished planning process already including impact of VRE.
- **Project plan is currently under development with national stakeholders. Based on exchange of knowledge considered options include:**
  - Improvement of simulation models
  - Assessment of current operational practices and system flexibility
  - Identification of additional constraints in the mid term
  - Facilitate exchange of knowledge



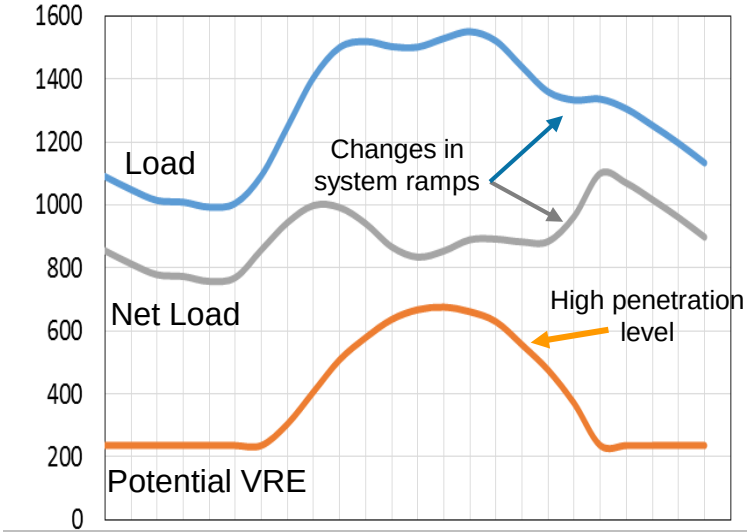


Illustration of potential VRE and impact on daily operation (wind assumed constant, using data from CND)

CONCLUSIONS

- The transformation of the power system is rapidly happening in developing and emerging countries quick action is required to support operability of systems in the mid term
- Challenges for the integration are at different levels, usually are addressed separately but can not be isolated. Holistic approach is required to support planning
- There is an enormous variety. Each power system is a unique case. Particularities define approach required for support / technical assessments
- The transformation of the power system is a journey with stop and review stages
- RE integration is a new field nothing is possible without people with the proper skills. There is knowledge and awareness in emerging countries but still a a lot of work to do

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