

## FLEXIBILITY OF NUCLEAR POWER IN A CLEAN ENERGY SYSTEM

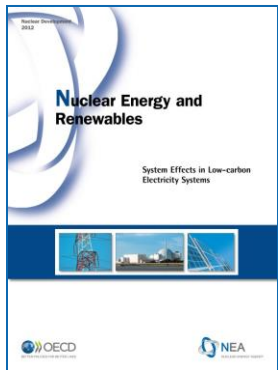
**William D. Magwood, IV**  
*Director-General*  
*Nuclear Energy Agency*

*2019 IEA WS on Nuclear Power*  
*25 February 2019*

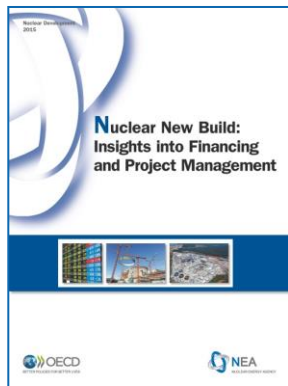
Reliable Long Term Electricity Supply and the Role of Nuclear Energy  
Budapest, Hungary - 25 January 2019

## Ongoing NEA Work on Electricity Supply

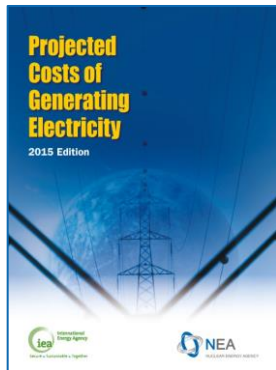
### NEA publications



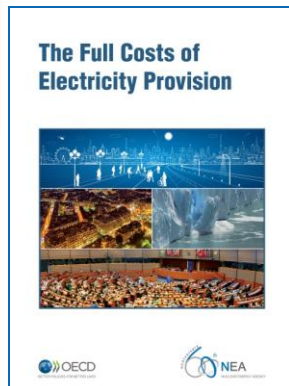
2012



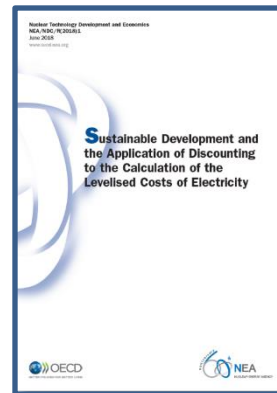
2015



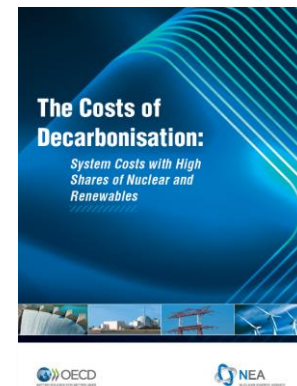
2015



2018

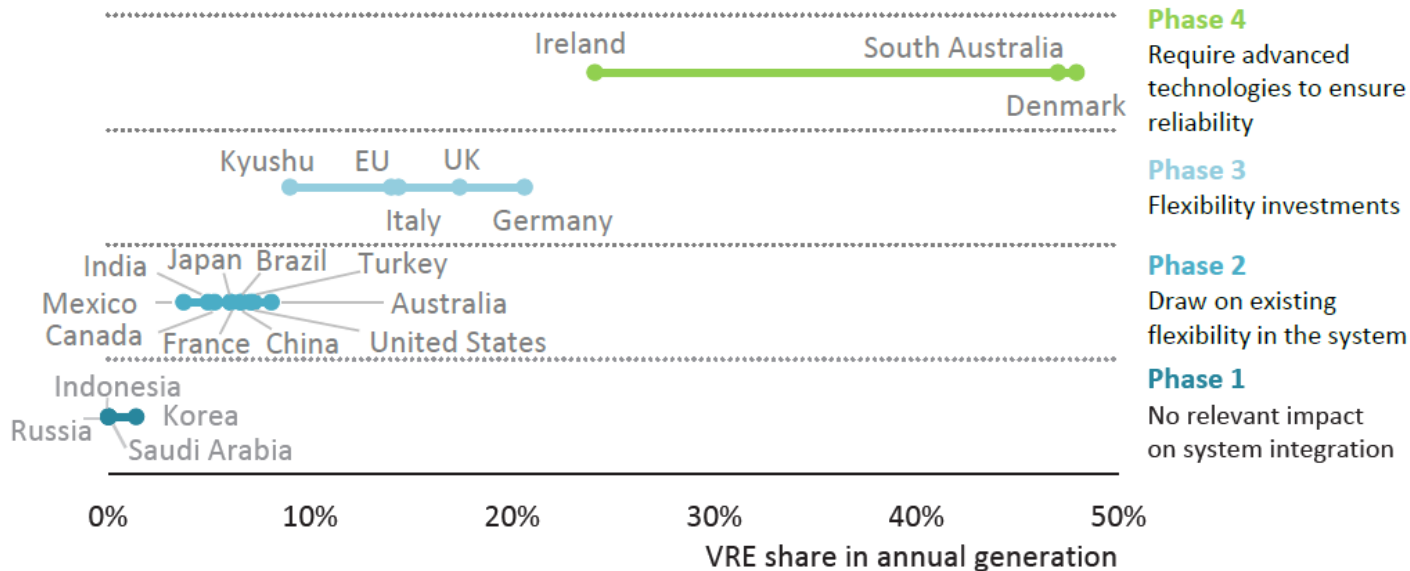


2018



2019

## Increased Flexibility Needs Due to VREs Penetration



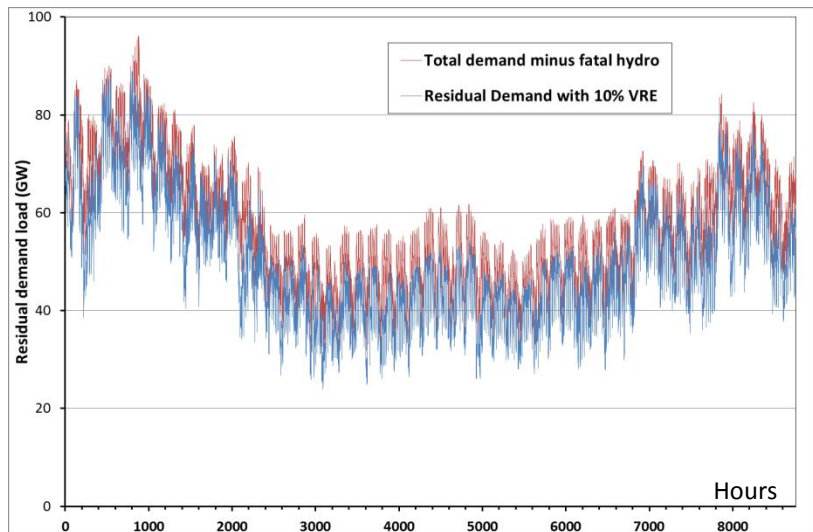
*Many regions are in Phase 1 and 2, with a handful in Phase 4*

Notes: EU = European Union, UK = United Kingdom. Kyushu is a subsystem in Japan.

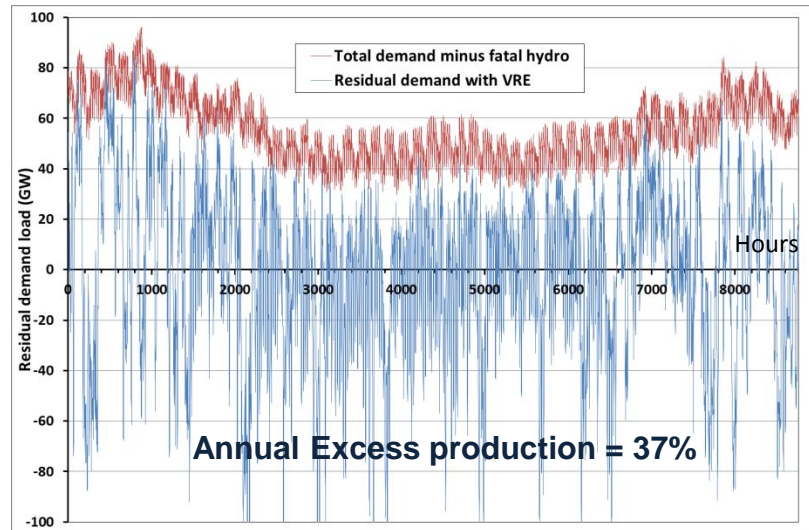
Source: OECD/IEA WEO 2018

## High VRE Result in Large Inefficiencies

### 10% Variable Renewables



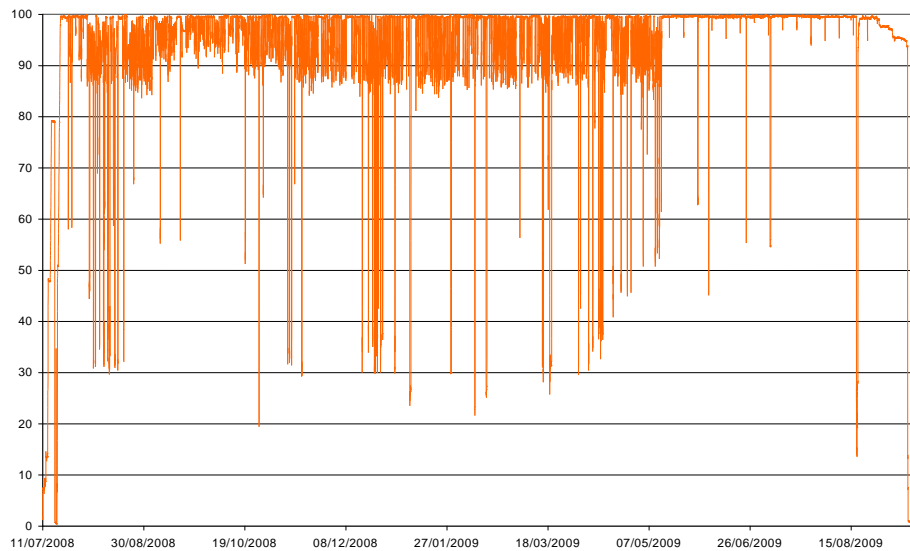
### 75% Variable Renewables



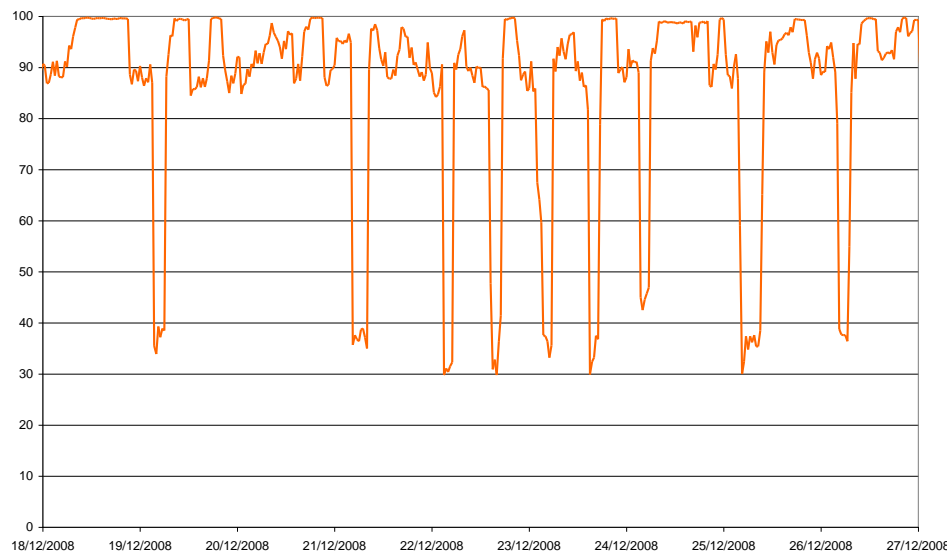
- High VRE penetration result in challenges for system management.
- Residual demand (**BLUE** line) – the available market for dispatchable generation becomes volatile and unpredictable.

## Nuclear power plants are flexible

### Power history of a French PWR reactor



**Whole cycle**



**10-day period around Christmas**

Source: EDF and OECD/NEA



## Expanded Concept of Flexibility for Nuclear Generation

Attribute	Sub-Attribute	Benefits
Operational Flexibility	Maneuverability	Load following
	Compatibility with Hybrid Energy Systems and Polygeneration	Economic operation with increasing penetration of intermittent generation, alternative missions
	Diversified Fuel Use	Economics and security of fuel supply
	Island Operation	System resiliency, remote power, micro-grid, emergency power applications
Deployment Flexibility	Scalability	Ability to deploy at scale needed
	Siting	Ability to deploy where needed
	Constructability	Ability to deploy on schedule and on budget
Product Flexibility	<b>Electricity</b>	<b>Reliable, dispatchable power supply</b>
	<b>Industrial Heat</b>	<b>Reliable, dispatchable process heat supply</b>
	<b>District Heating</b>	<b>Reliable, dispatchable district heating supply</b>
	<b>Desalination</b>	<b>Reliable, dispatchable fresh water supply</b>
	<b>Hydrogen</b>	<b>Reliable, dispatchable hydrogen supply</b>
	<b>Radioisotopes</b>	<b>Unique or high demand isotopes supply</b>

Source: Adapted from EPRI

## Considerations

- **VREs and nuclear energy are the only expandable sources of low-carbon electricity**
- **VRE shares beyond 30-40% lead to significant system costs and require grid technologies that do not exist today**
- **Larger shares of VREs also will require flexible nuclear generation**
  - Which is happening today in several countries
  - Which can be expanded through deployment of advanced technologies such as SMRs
  - But does it make economic sense in most markets?

*Thank you for your attention*



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