The need for flexibility and Energy Storage

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Hydropower and its future role
ITU, Istanbul 21-22 Jan 2016

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Centre for Environmental Design of Renewable Energy

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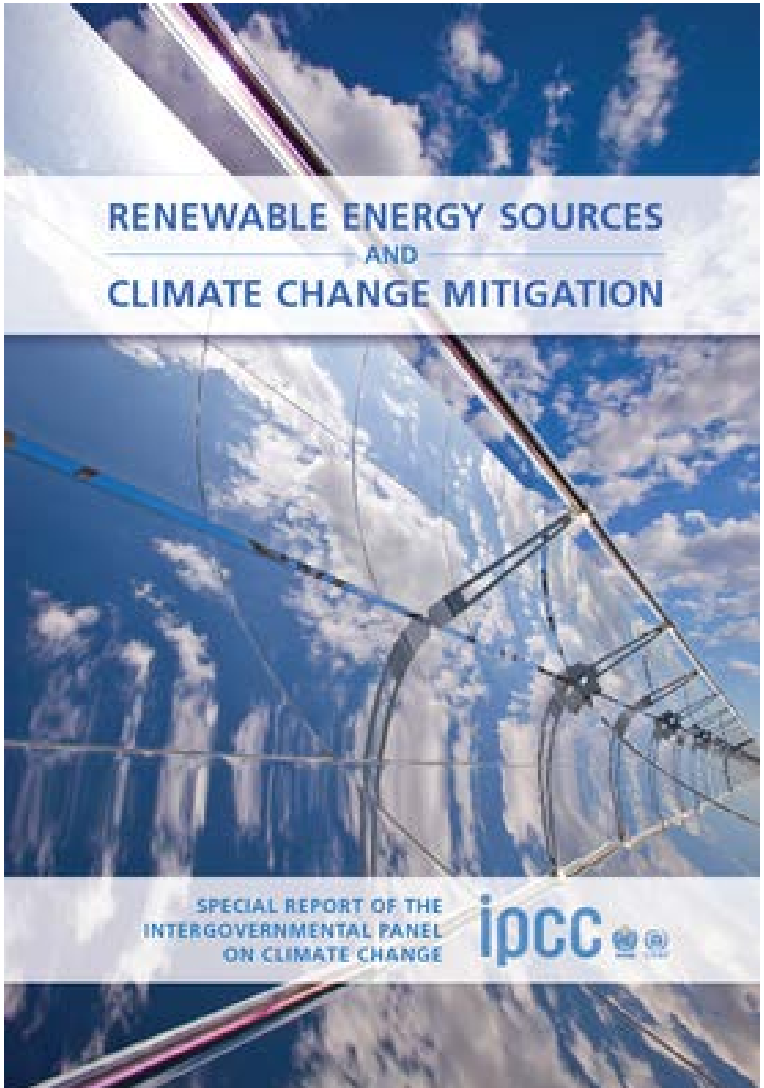
Conclusions Renewable Energy (RE) potential



IPCC SRREN

“The global technical potential of RE sources will not limit continued growth in the use of RE

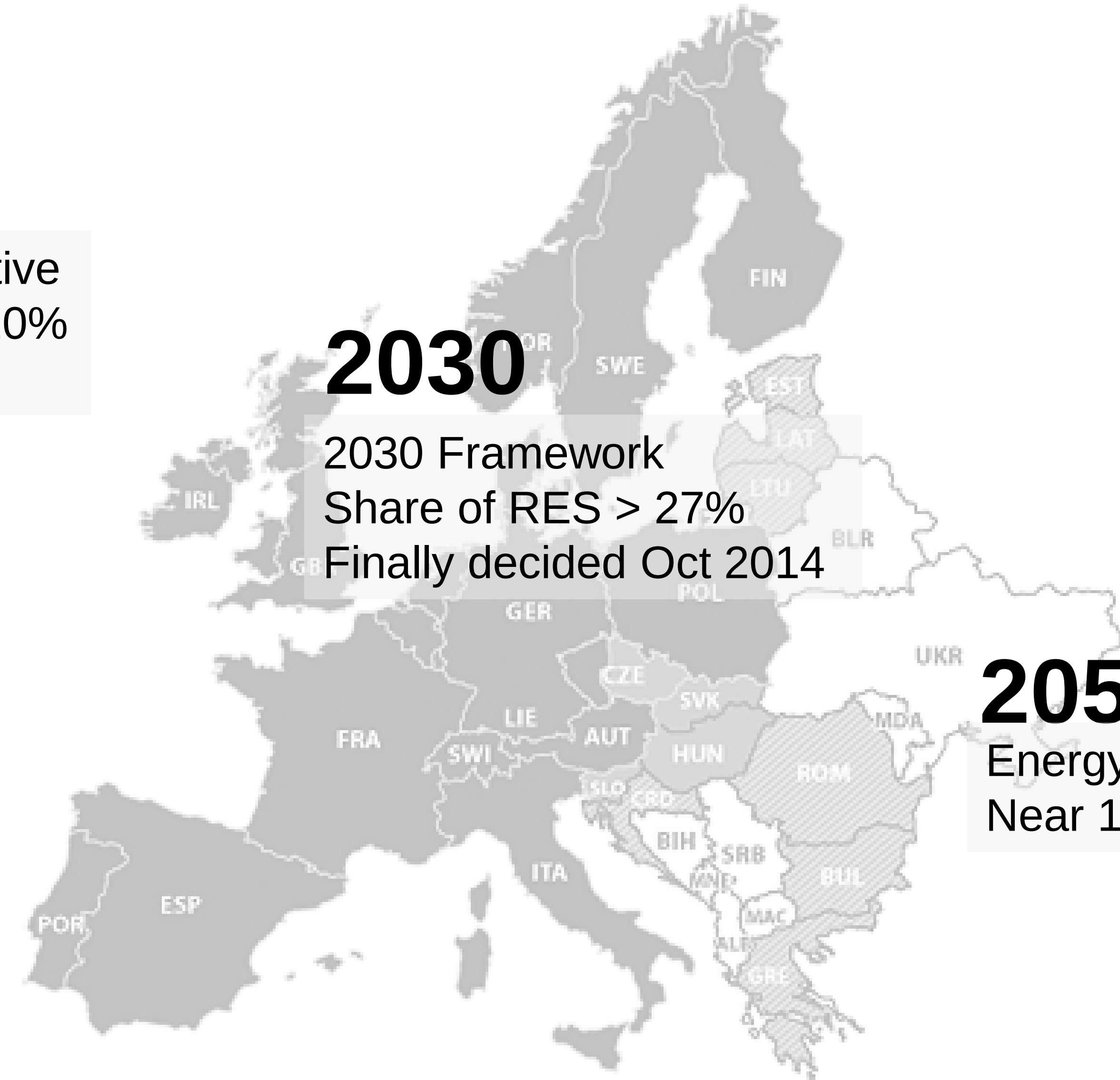
A wide range of estimates are provided in the literature, but studies have consistently found that the total global technical potential for RE is substantially higher than global energy demand

SRREN: RE integration into the future energy system

Few, if any, fundamental technical limits exist to the integration of a majority share of RE, but advancements in several areas are needed:

- Transmission and distribution infrastructure
- Energy storage technologies
- Demand side management
- Improved forecasting of resource availability

Three Important deadlines in EU Energy/Climate policy



2020

The RES Directive
Share of RES 20%
Policy in effect

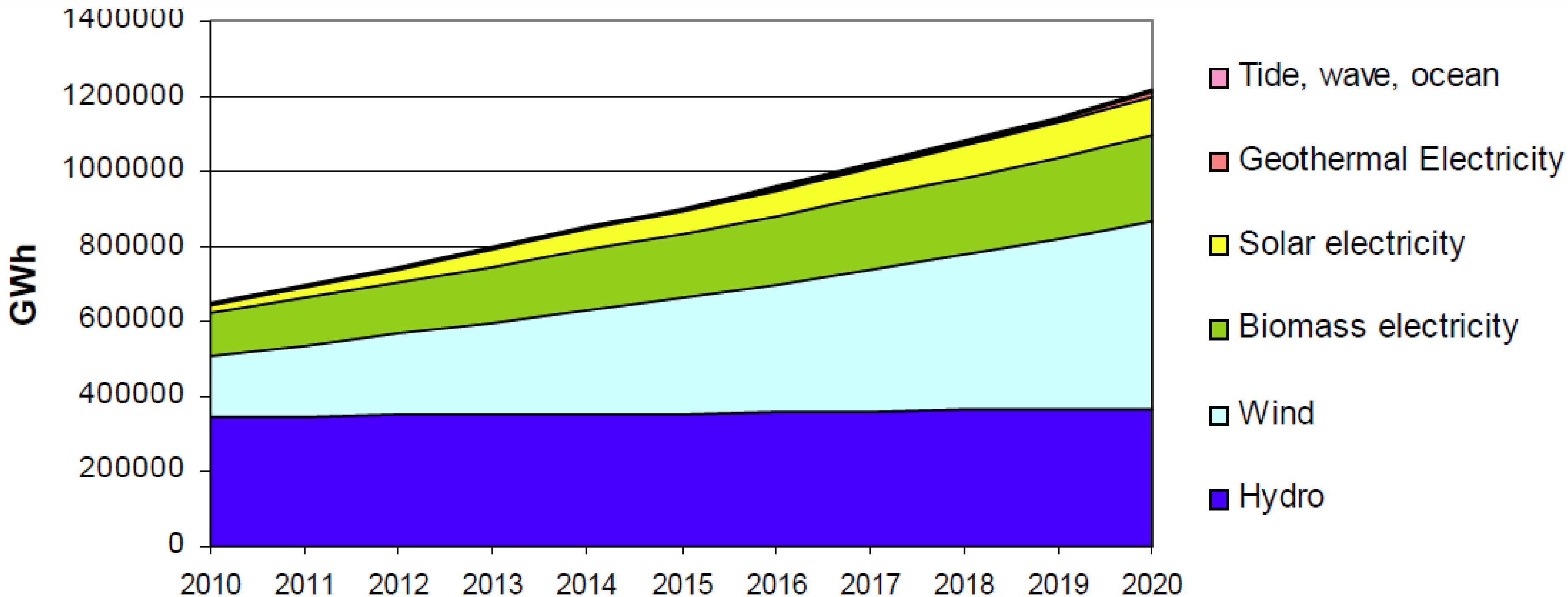
2030

2030 Framework
Share of RES > 27%
Finally decided Oct 2014

2050

Energy roadmap 2014
Near 100% Renewable?

Example from Europe – The EU 20/20/20 strategy



REN will increase from **632** TWh (2010) to **1152** TWh (2020)
Largest absolute increase in Wind (ca 120 GW and 305 TWh)
Strong relative increase for solar PV (ca 65 GW and 82 TWh)

➔ Largest increase for non-dispatchable sources (wind, solar, small hydro, ..)

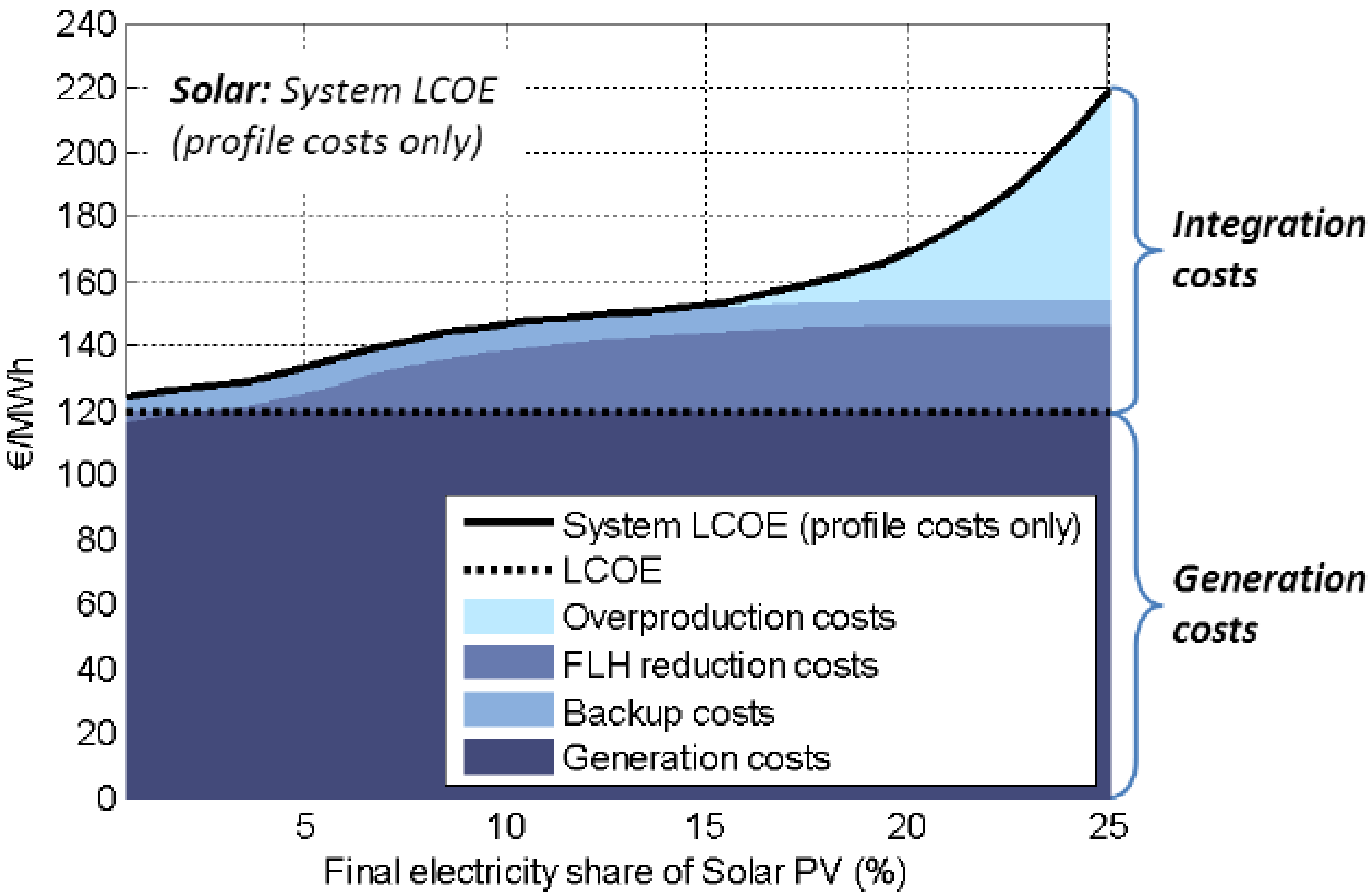
RE integration into the future energy system

RE integration need to consider:

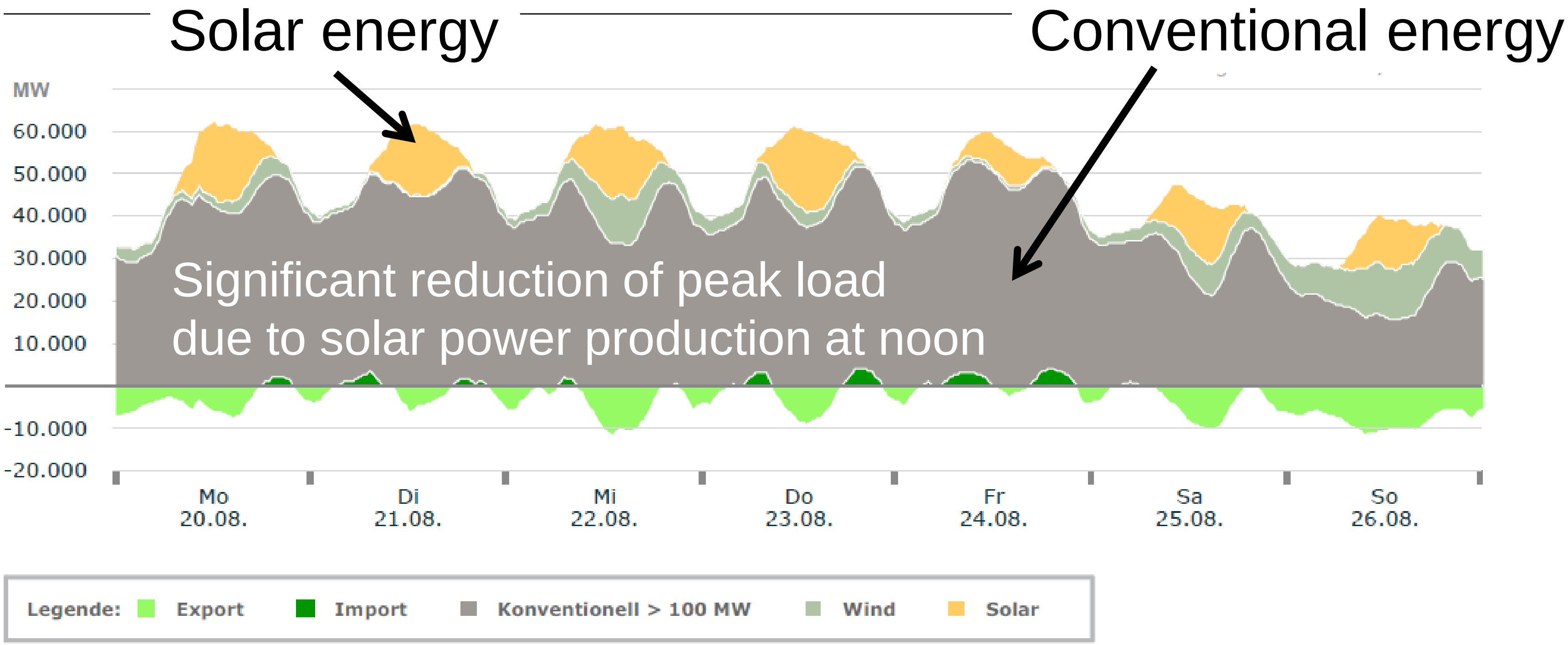
- Variability in demand and supply, in time and space
- Dispatchability Predictability
- Capacity Factor
- Capacity Credit
- Active power, frequency control
- Voltage, reactive power control

Variable renewables (VREN) like Wind and Solar PV are more difficult (and expensive) to integrate

Integration costs increases with increasing share of VREN

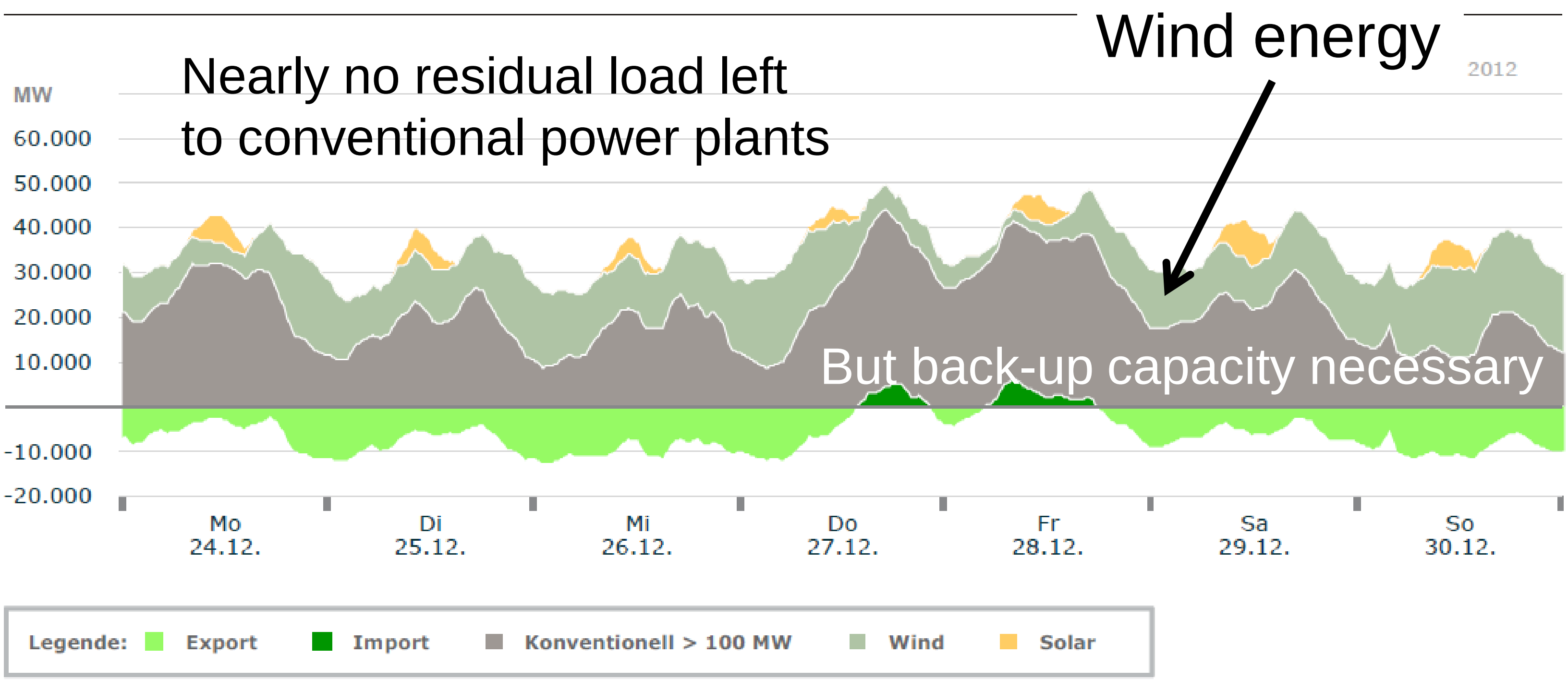


RES challenges - Germany
High Photovoltaic production
Summer



Source: Burger, B. "Electricity production from solar and wind energy in 2012", Fraunhofer ISE, presentation, February, 2013
URL: http://www.ise.fraunhofer.de/en/renewable-energy-data

RES challenges
High Wind power production
Winter



Source: Burger, B. "Electricity production from solar and wind energy in 2012", Fraunhofer ISE, presentation, February, 2013
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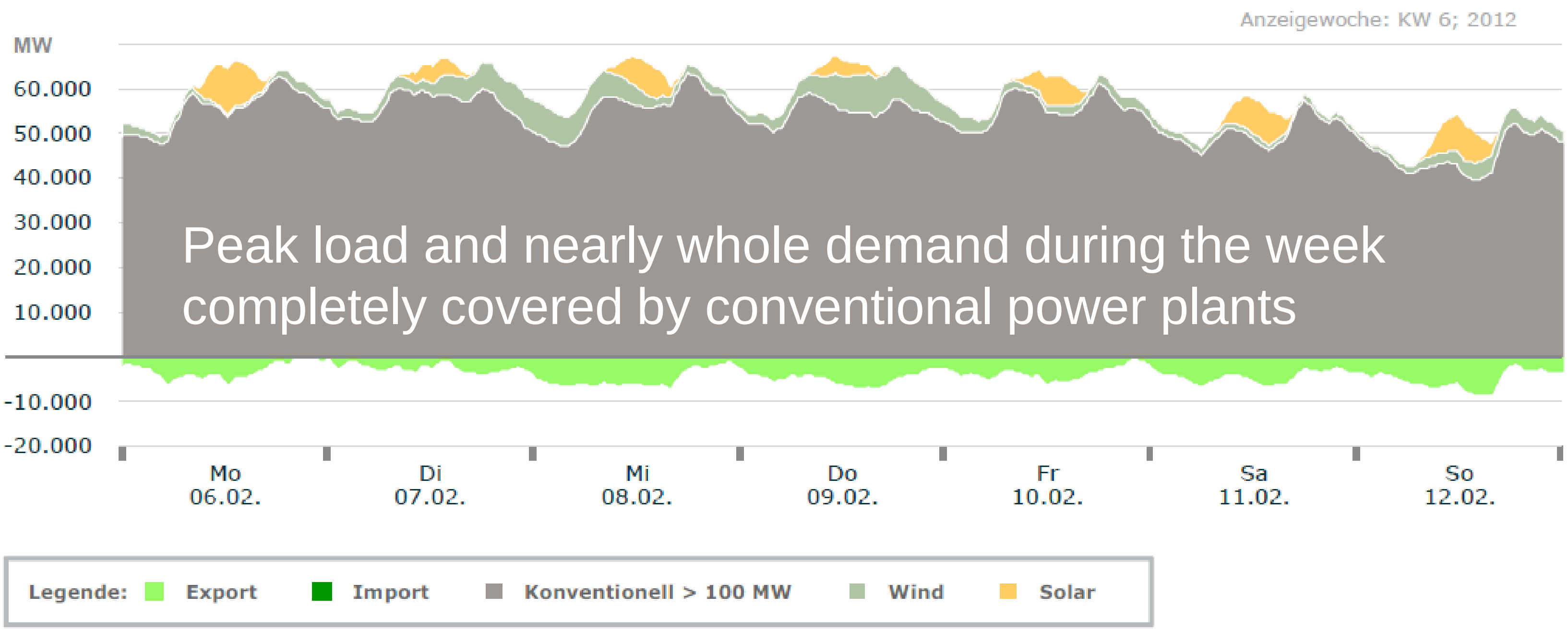
RES challenges
No production from RES
Winter



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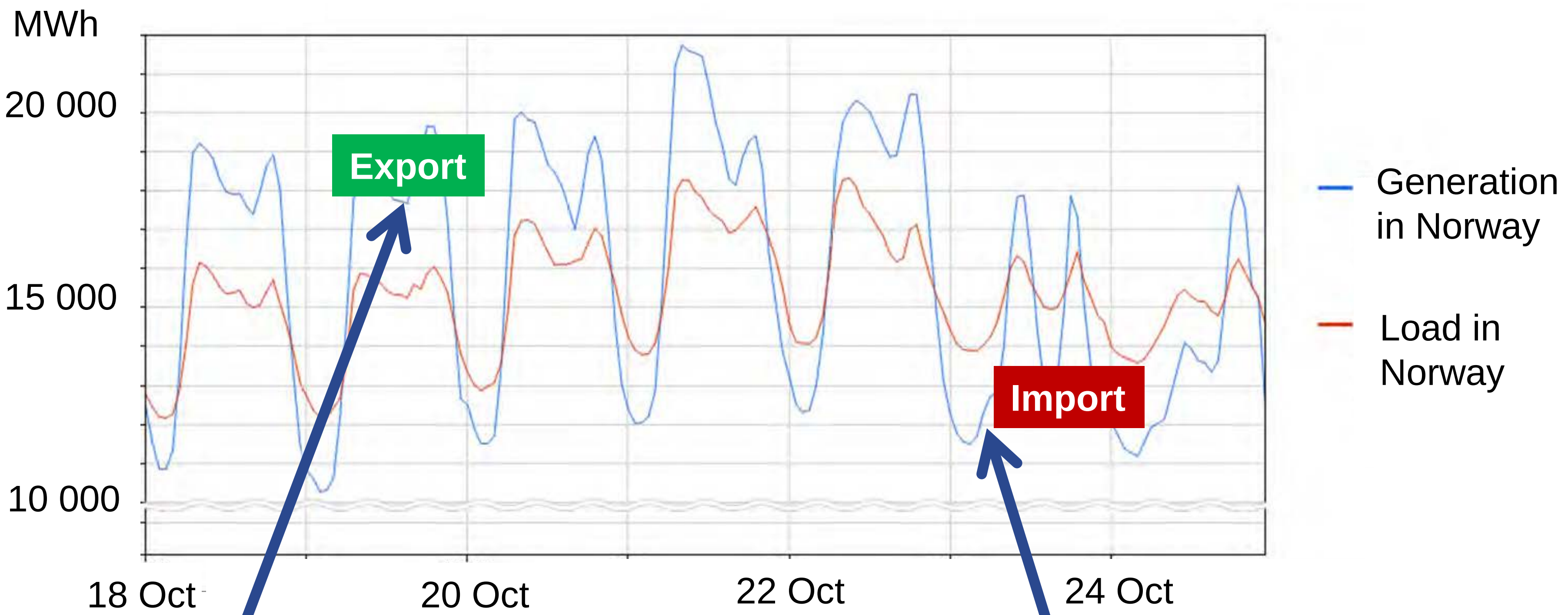
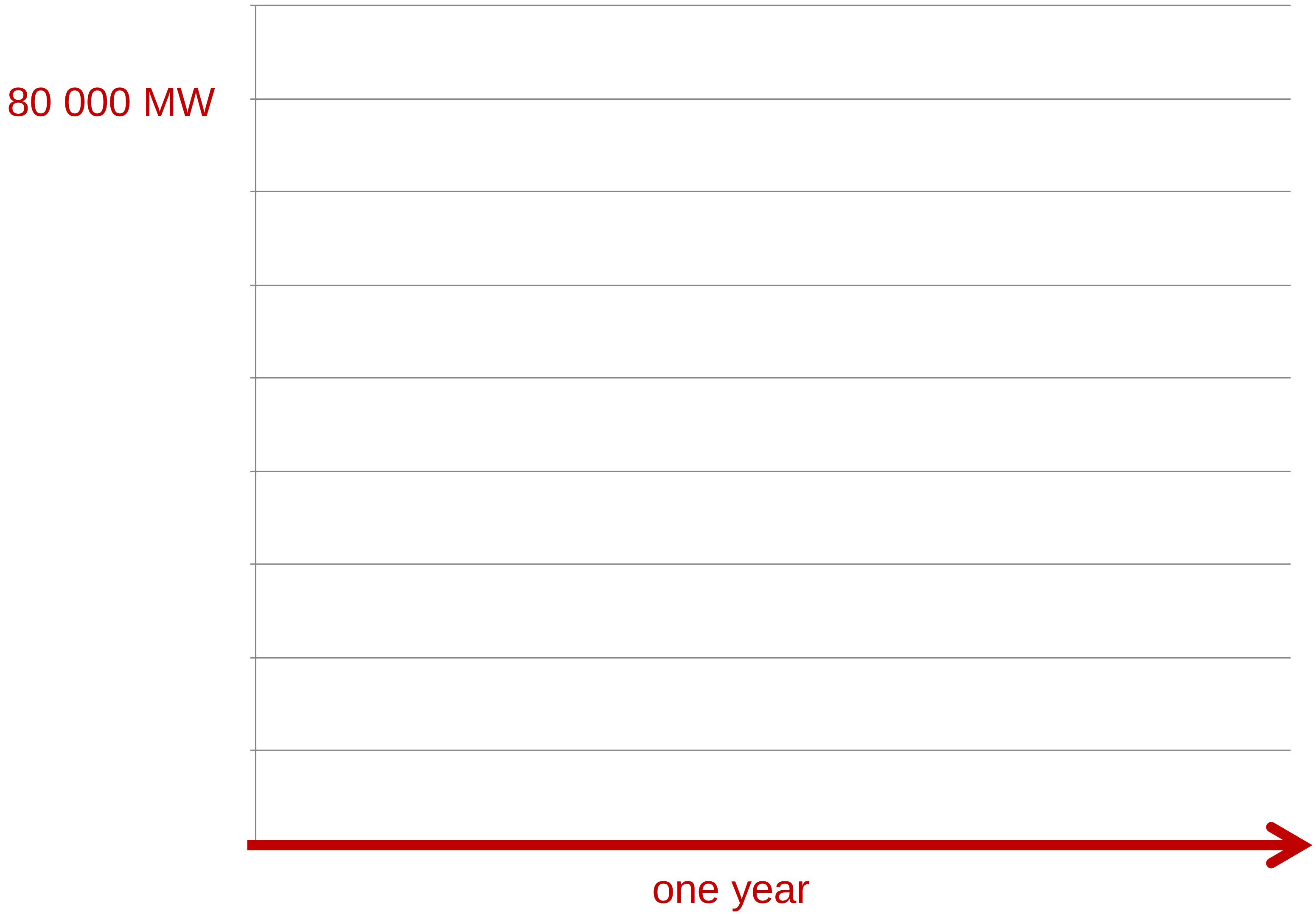
Norwegian hydro and Danish wind



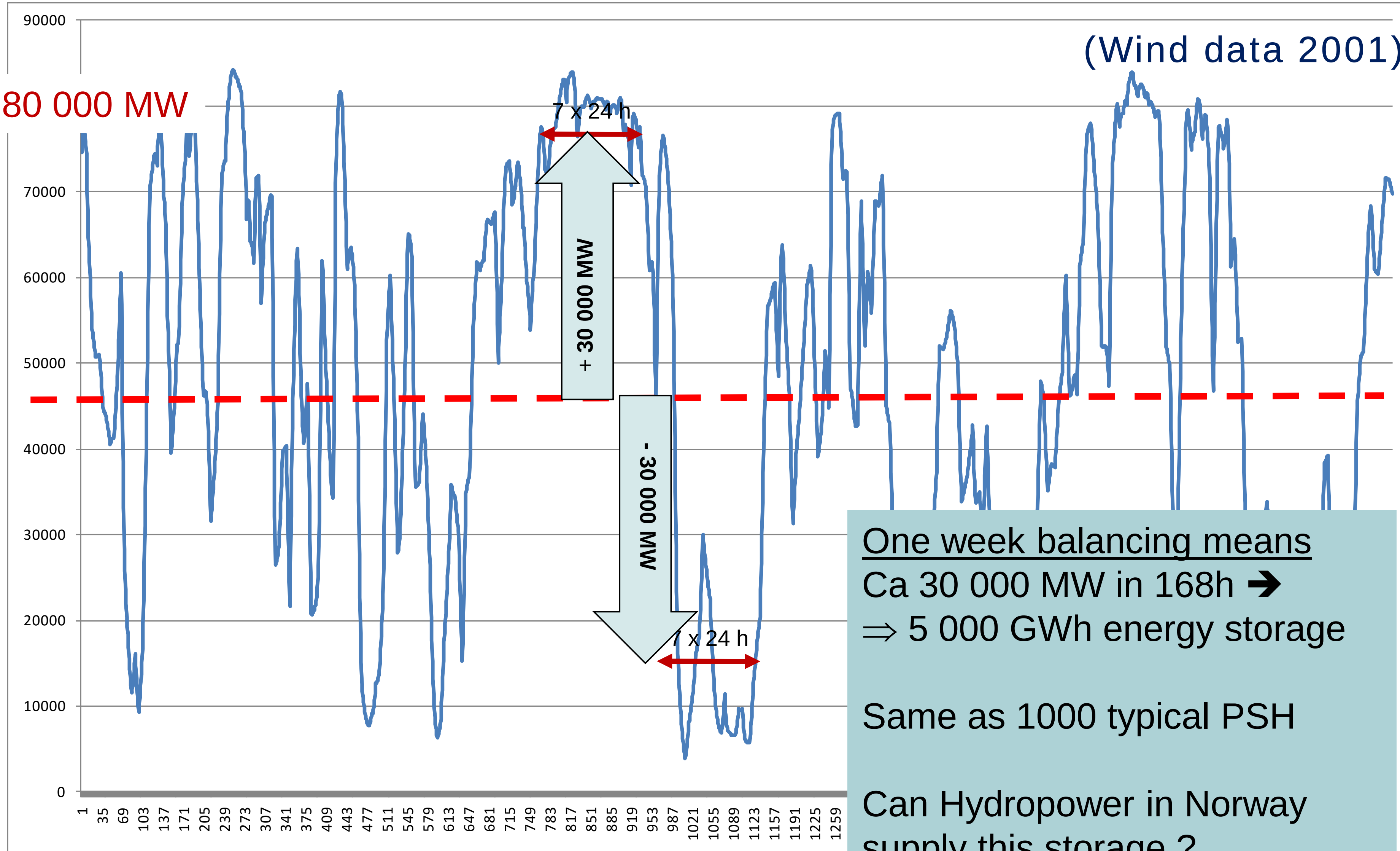

Norwegian hydro exporting


Danish wind cover underproduction

Simulated wind production in the North Sea area in 2030 – 95 000 MW installed capacity



Wind Power North-Sea Region - Jan – March



<u>One week balancing means</u>
Ca 30 000 MW in 168h ➔
⇒ 5 000 GWh energy storage

Same as 1000 typical PSH

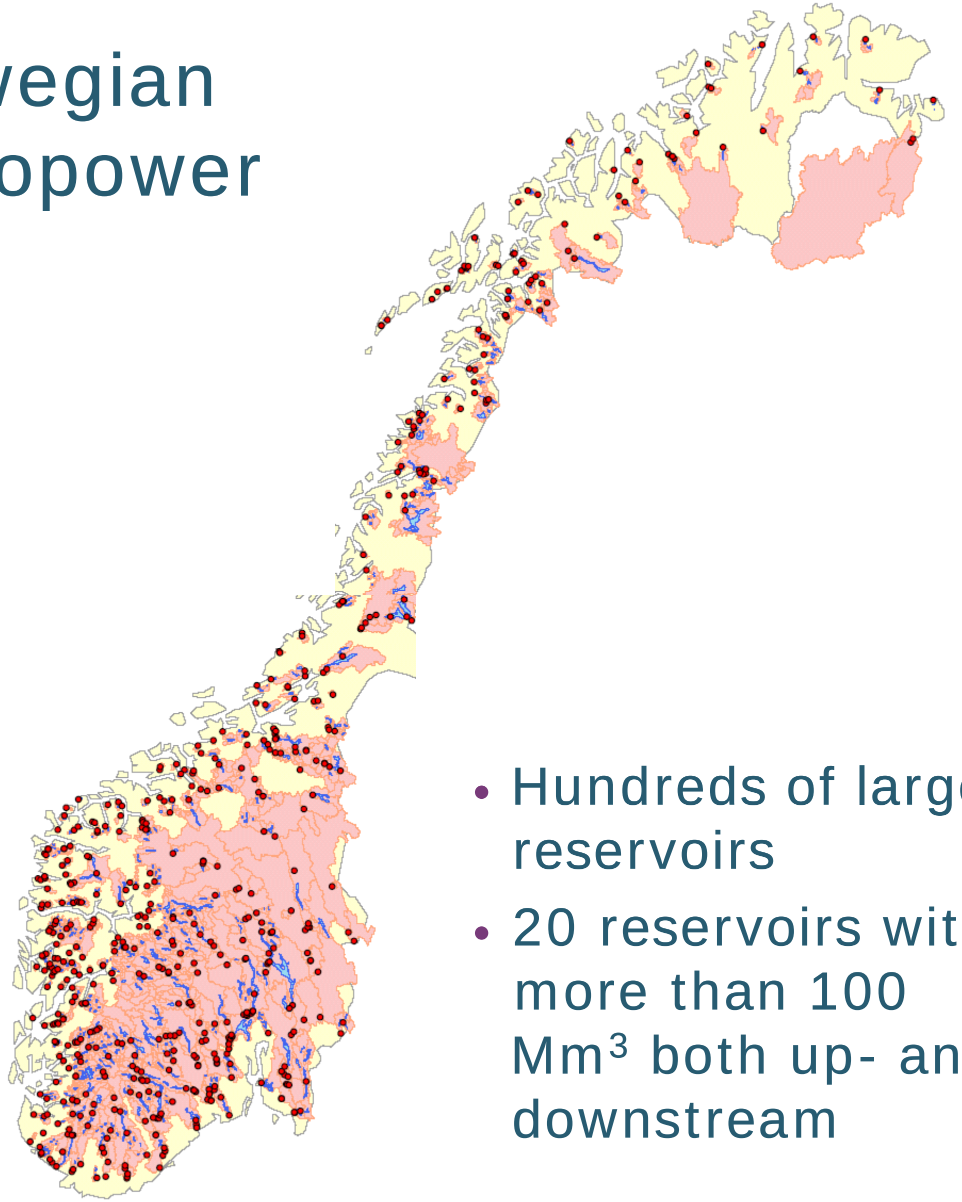
Can Hydropower in Norway supply this storage ?

Hydropower in Norway – Resource base

Water, high head

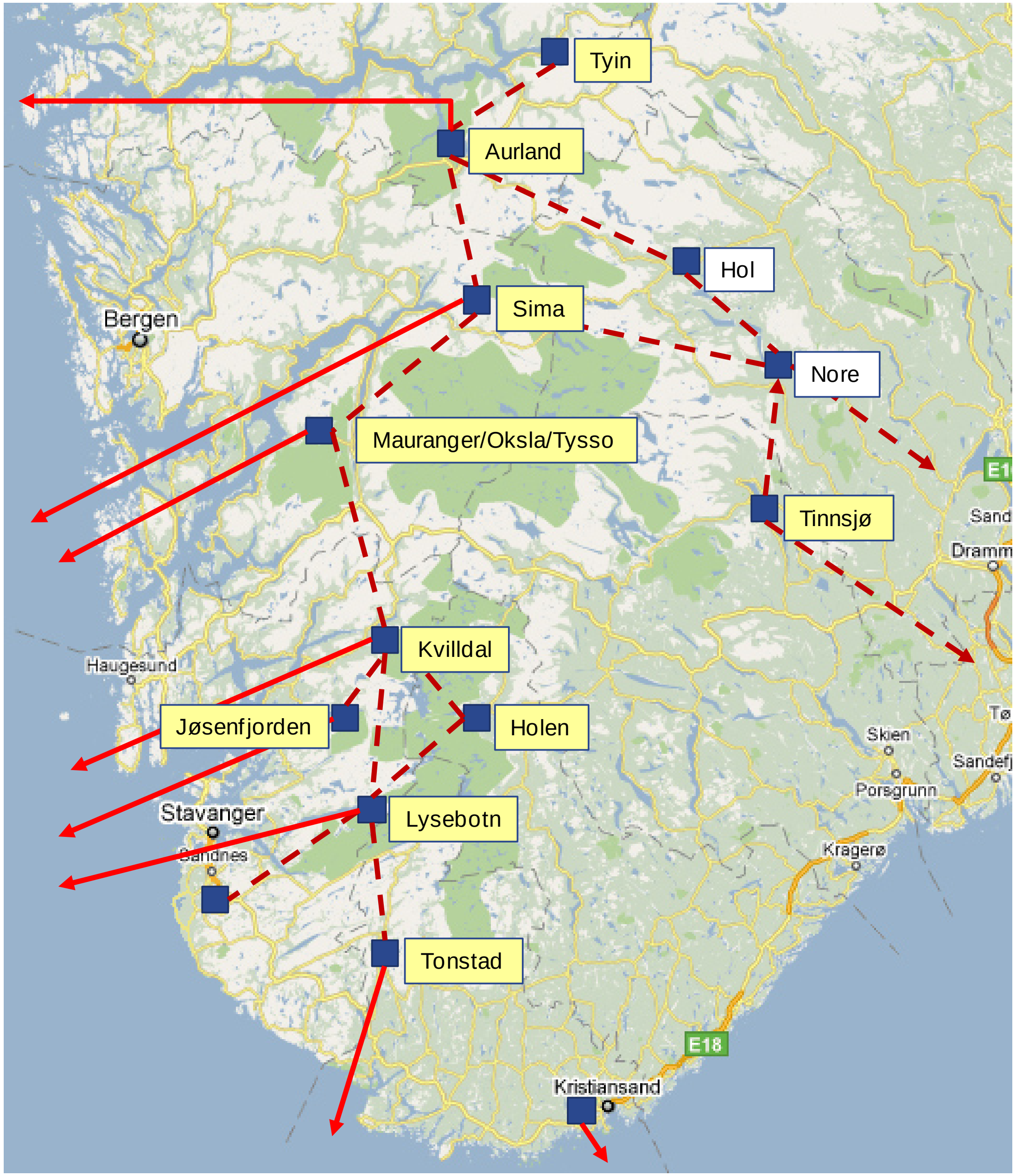
Large natural reservoirs

Norwegian hydropower



- Hundreds of large reservoirs
- 20 reservoirs with more than 100 Mm^3 both up- and downstream

CEDREN Case study 2030



Goldistal, Germany 8 GWh

Indirect storage

Blåsjø
7.8TWh reservoir
(1000 times Goldistal)

Hydropower – Supporting other Renewables

Environmental impacts

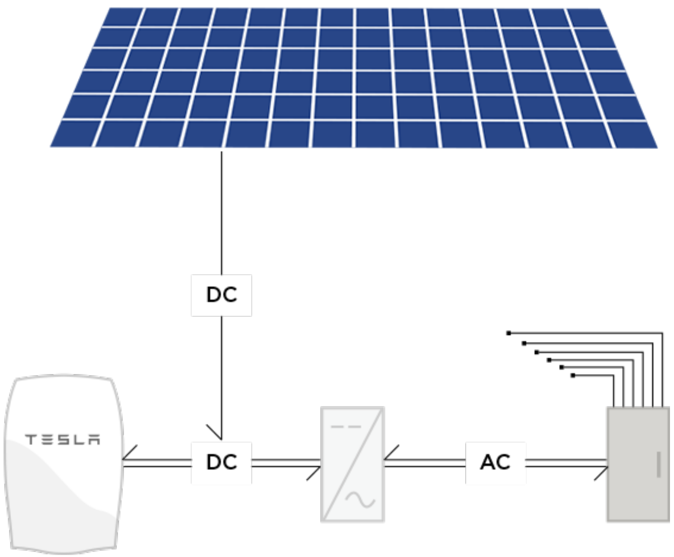



Hydropower supporting grid operation

- Flexibility (with storage)
- Very fast response (seconds)
- Large Storage is possible
- Frequency control
- Grid stability
- «Black start» capability
- Balancing variable generation & load
- …

Tesla PowerWall© - 10kWh units for homes

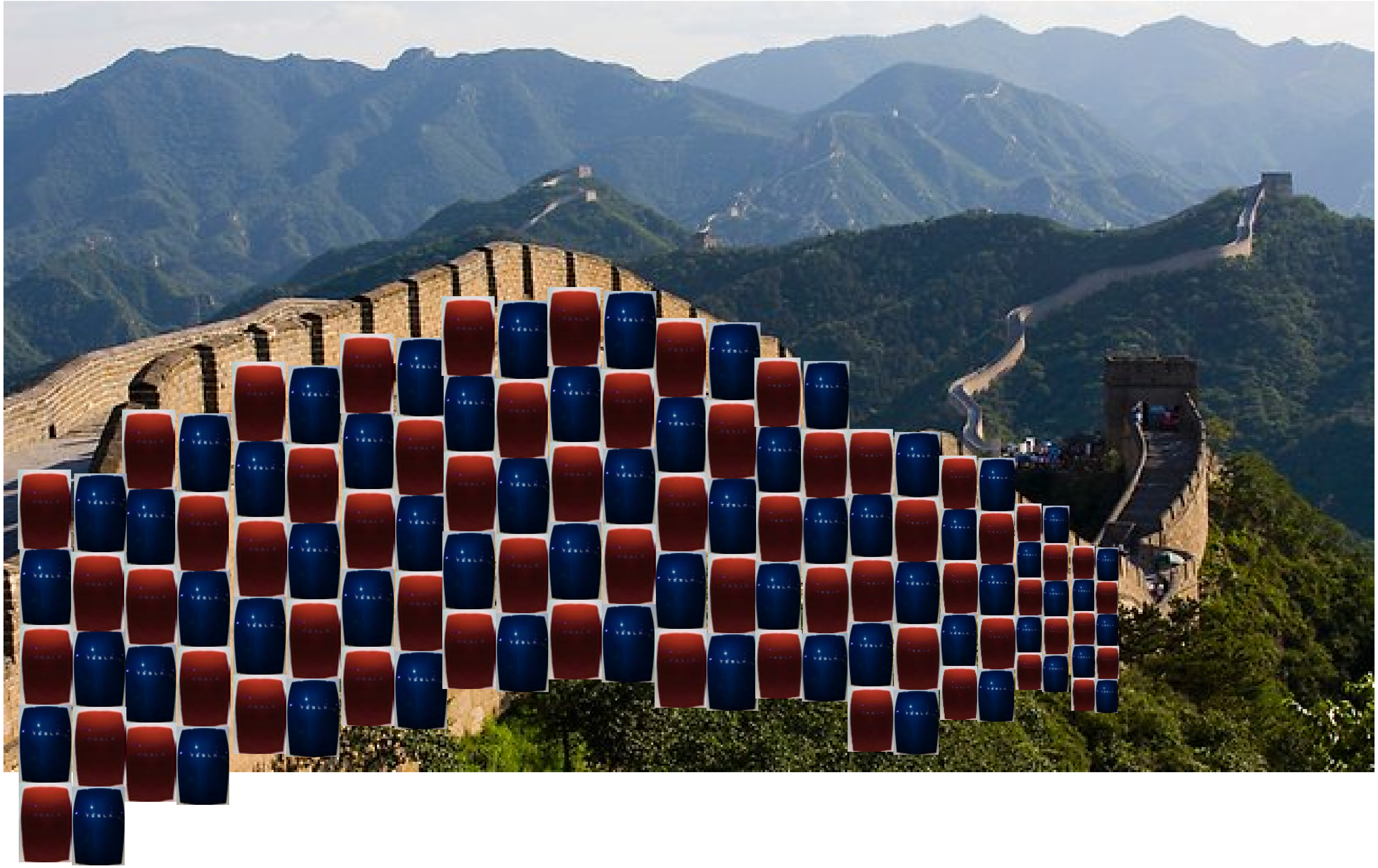
Roof-top solar panel or similar



PowerWall©

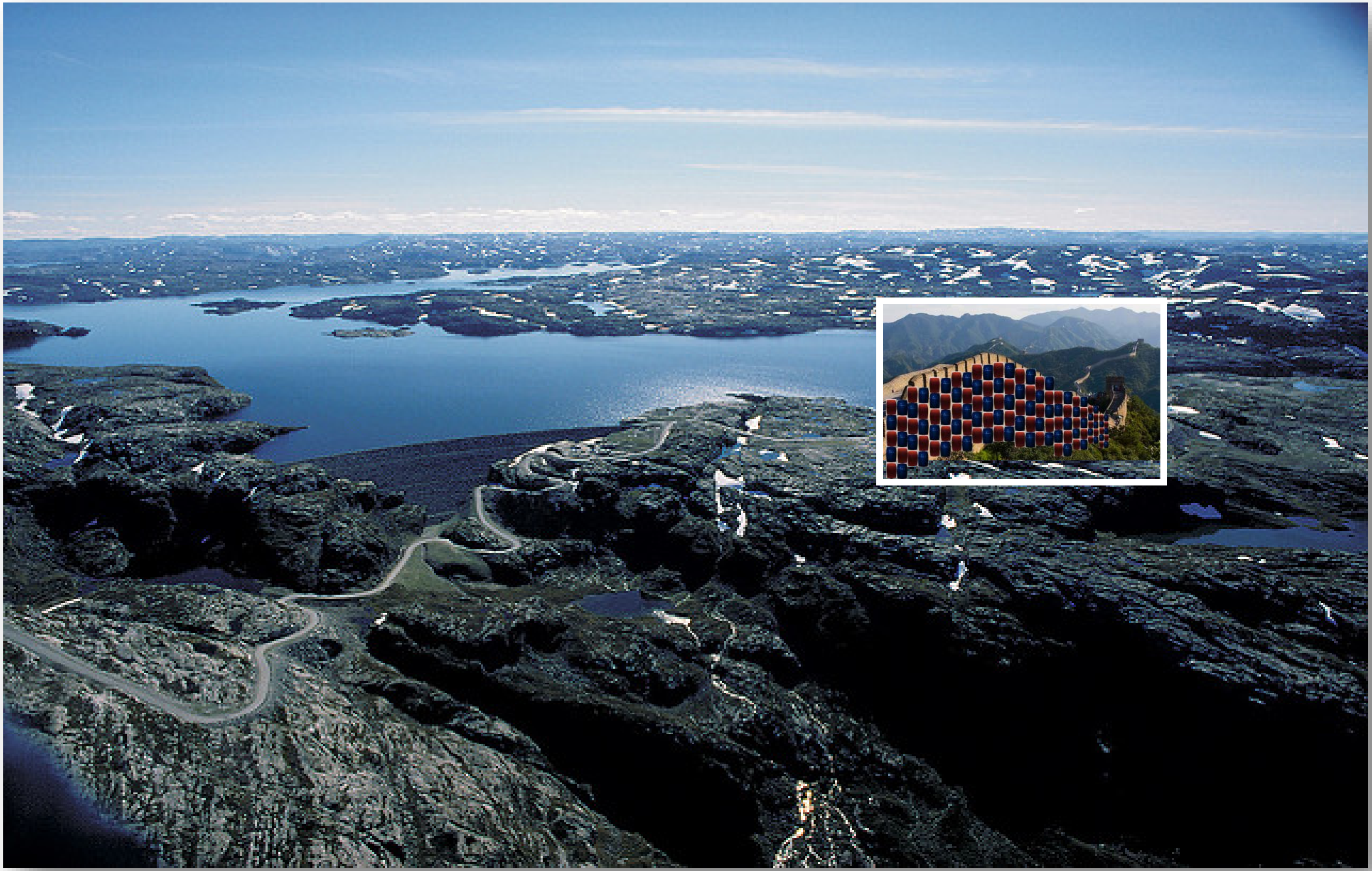
- Balancing solar energy
- Energy security
- Off-grid solutions

The Great Wall



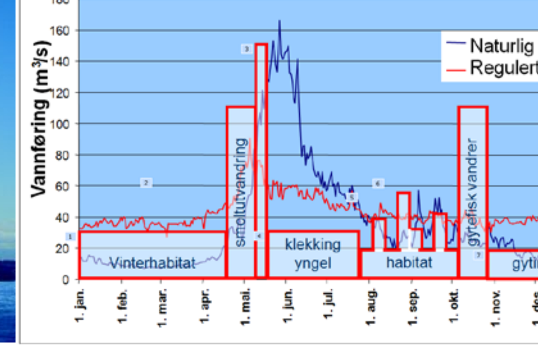
Cover with Tesla PowerWall©

1,23 TWh = 15 % of Blåsjø









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NTNU
100 skapende år

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