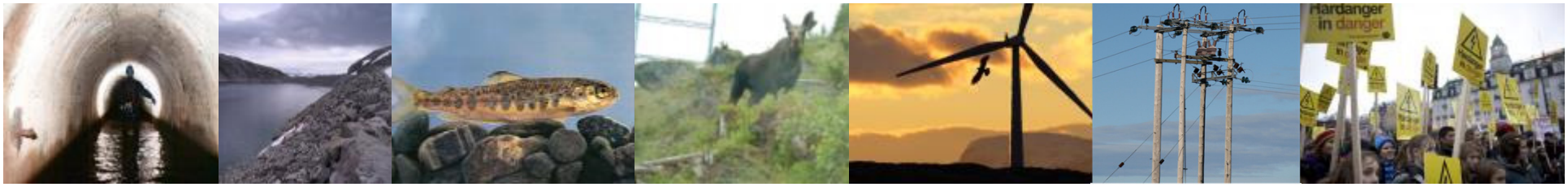
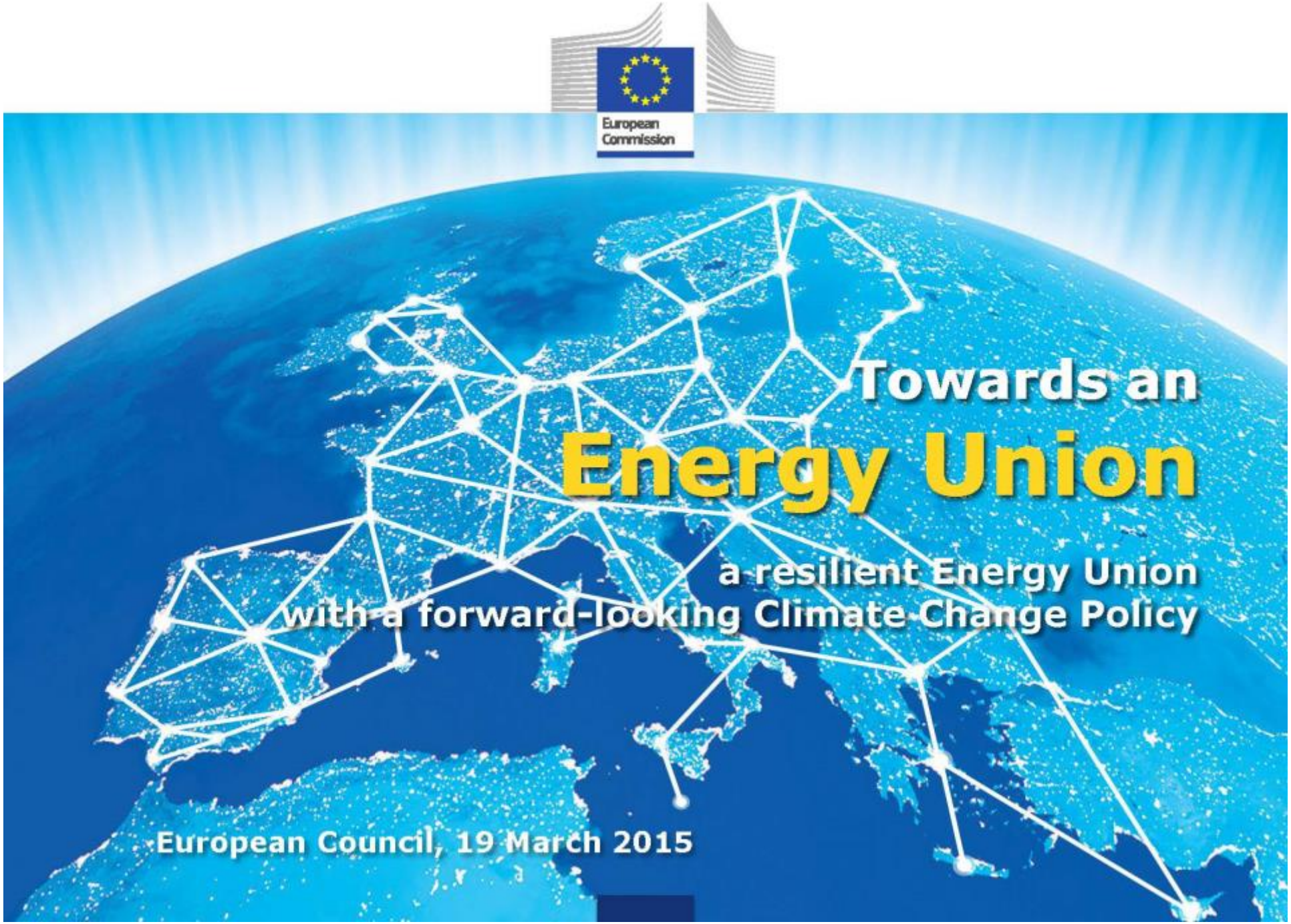


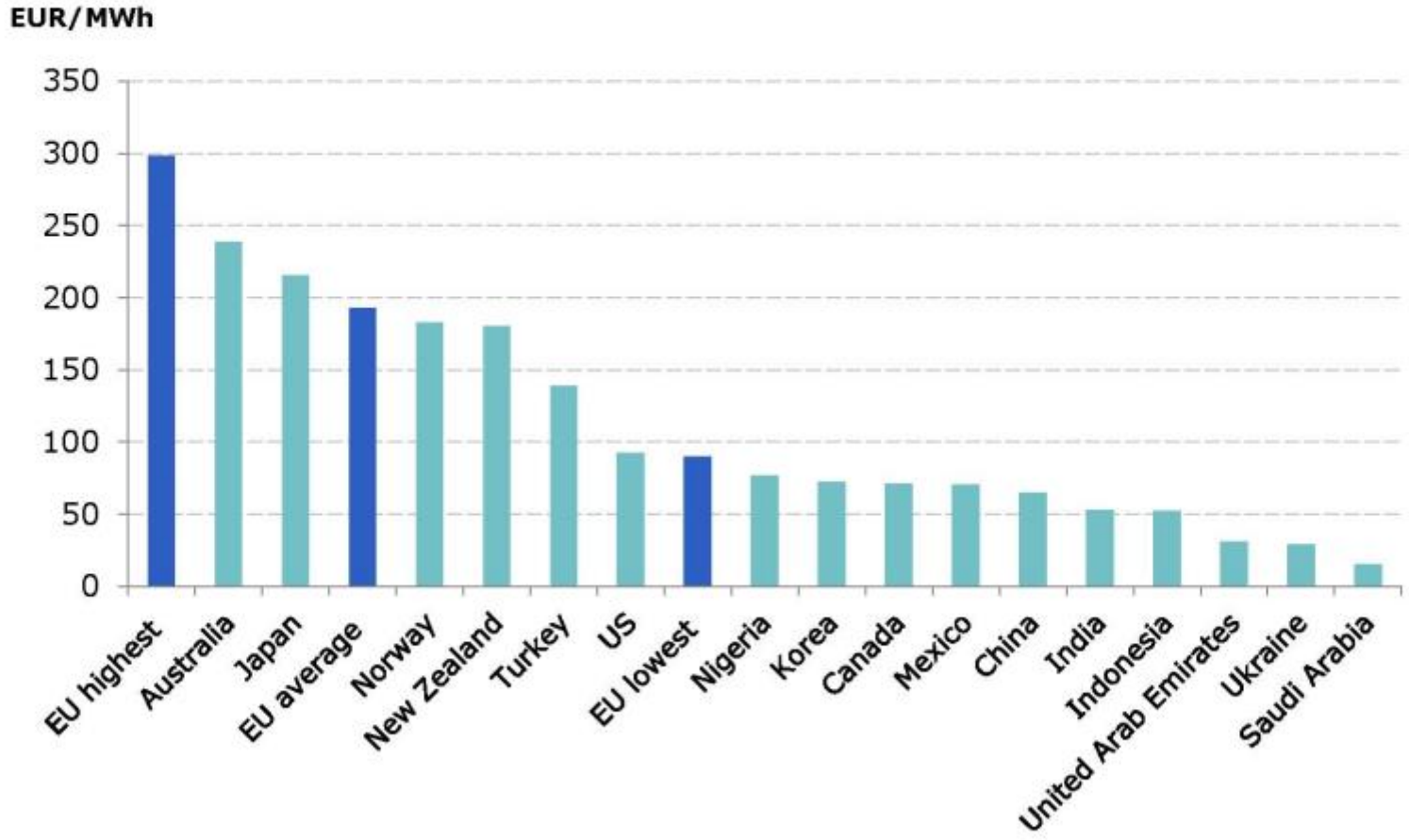
Energy Storage
- perspectives in Europe, China, …

Atle Harby,
SINTEF Energy Research

HydroBalance User Meeting
September 2015


European Commission
Towards an
Energy Union
a resilient Energy Union
with a forward-looking Climate Change Policy
European Council, 19 March 2015

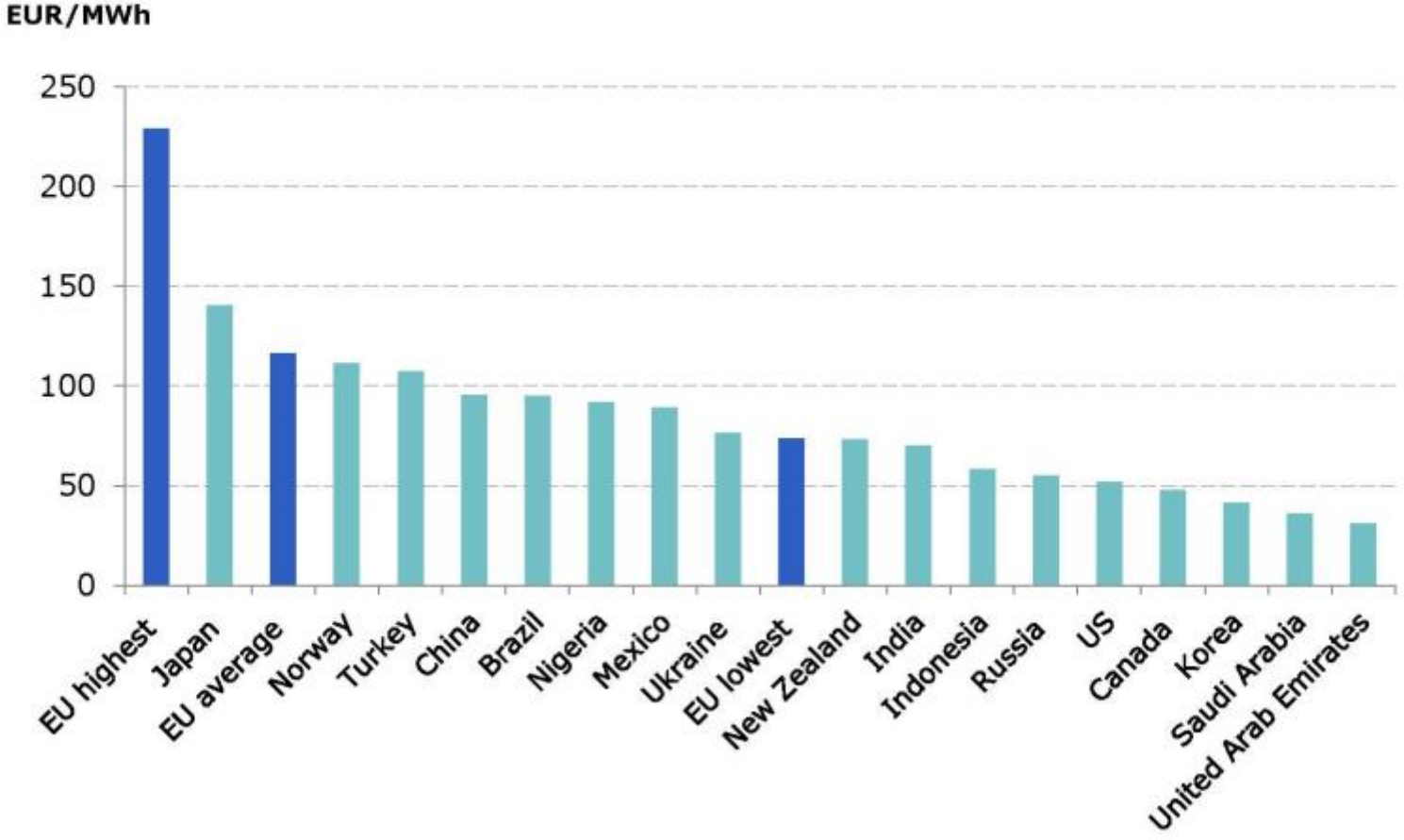
Current Prices for Electricity – Household Consumers



Reference year 2012

Source: European Commission

Current Prices for Electricity – Industrial Consumers



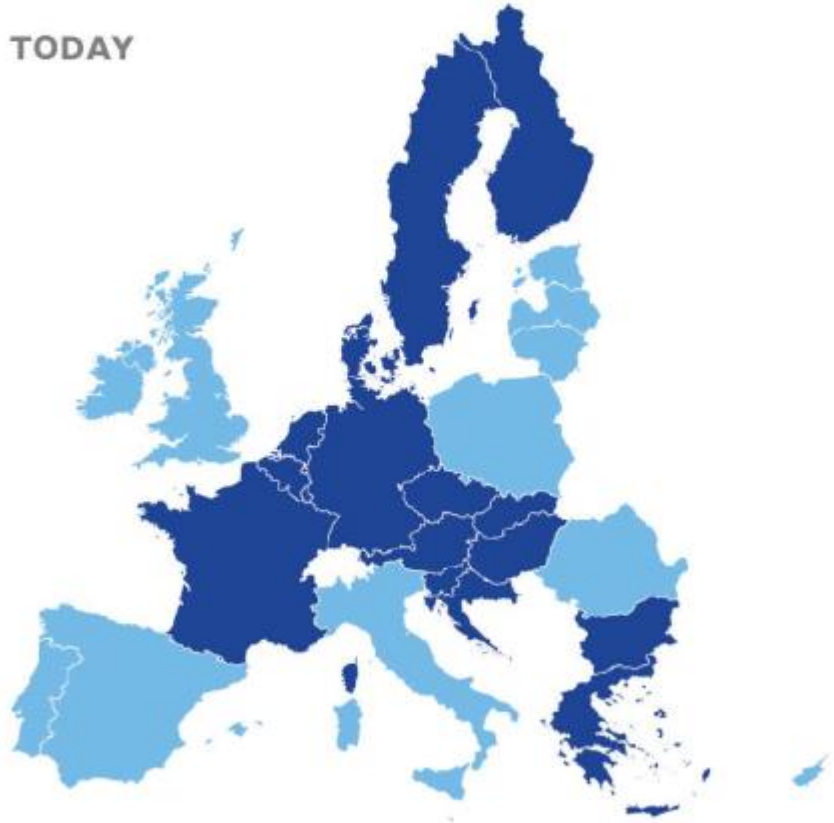
Reference year 2012

Source: European Commission

European Commission

Connecting Electricity Markets

TODAY



Countries meeting the 10% **interconnection** target

Countries not meeting the 10% **interconnection** target

POTENTIAL BY 2020

Efforts need to be stepped up for those below the 10% target by 2020, mainly Spain and Cyprus, and in view of achieving the 15% target by 2030.

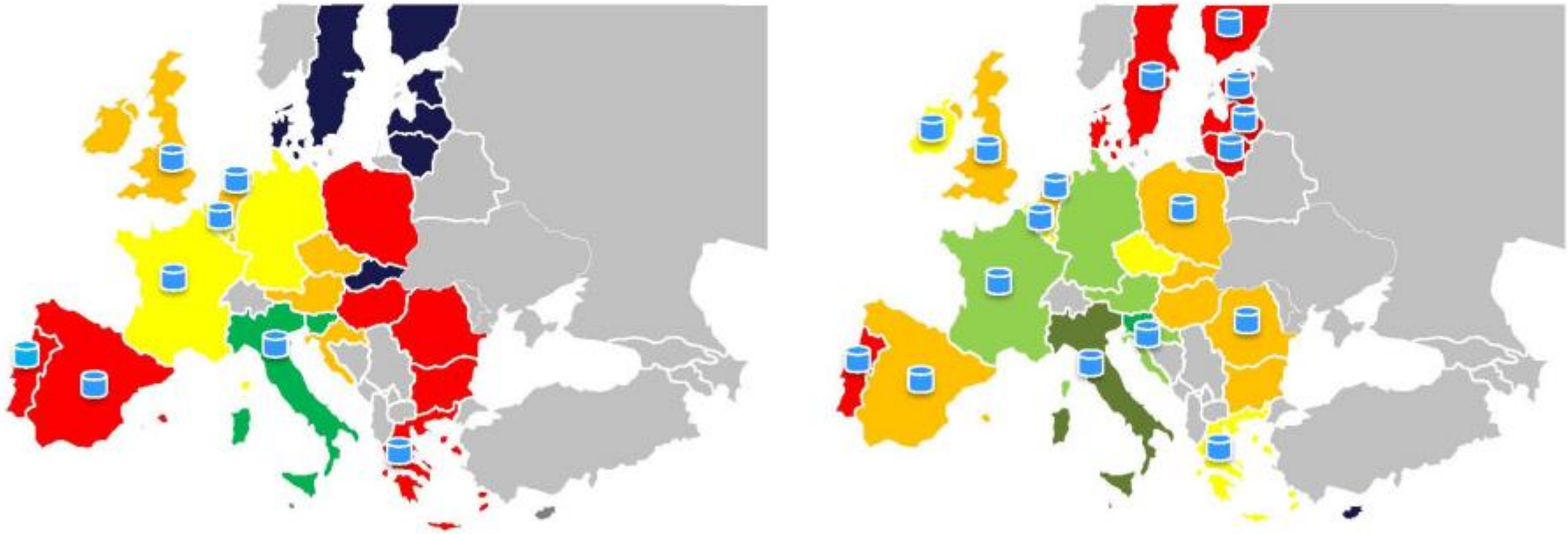
Source: European Commission

European Commission

Connecting Gas Markets

NOW

AFTER 2022



Number of supply sources a country may potentially access to through infrastructure (at least 5% share)

1 2 3 4 5 6 7 *Presence of Liquefied Natural Gas Terminal(s)*

Supply Sources: Azerbaijan (new source), Algeria, Libya, Norway, Russia, EU Production, LNG (treated as one source)

Reference year 2013

Source: European Commission

The EU Commission proposes:

- doing more to ensure that Member States implement and **enforce existing legislation**
- passing legislation to increase gas and electricity **supply security** and other measures to reduce Europe's reliance on dominant suppliers
- setting up an Energy Infrastructure Forum to make sure major **infrastructure projects** are delivered where and when needed
- passing legislation to modernise the European energy market and reinforce the **regulatory framework** at regional and European level
- passing legislation to ensure the 2030 **climate and energy targets** are reached
- making energy **costs and prices more transparent**
- making **buildings more energy-efficient** and **de-carbonising the transport sector**
- putting an initiative on **global energy and climate technology** and innovation leadership in place

New market design

- Meeting the current challenges of the electricity market, in particular the integration of variable renewable energy and ensuring security of supply, requires a market design that provides for **coordination of capacities at regional level, storage and more flexibility in demand response**, enabling consumers to better participate in markets and allowing energy to be exchanged across borders with more ease



Research, innovation & competetivness

- Being the world leader in developing the next generation of **renewable energy technologies**, including environment-friendly production and use of biomass and biofuels, together with **energy storage**
- Facilitating the participation of consumers in the energy transition through **smart grids**, smart home appliances, **smart cities**, and home automation systems
- Efficient energy systems, and harnessing technology to make the **building stock energy neutral**
- More **sustainable transport systems** that develop and deploy at large scale innovative technologies and services to increase energy efficiency and reduce greenhouse gas emissions.
- CCS
- Nuclear energy safety, security and waste management

Horizon2020

- LCE-04-2017: Demonstration of smart transmission grid, storage and system integration technologies with increasing share of renewables
  - **Large scale storage** relevant to the transmission network (GWh scale), potentially including several storage technologies addressing different time scale (e.g. daily, seasonal), ramping rates and volumes, managed centrally or in a distributed way

- LCE-07-2016-2017, Hydropower 2017:
  - The refurbishment and simultaneous upgrading of hydropower stations offers a huge potential to increase renewable electricity production; the challenge is to **leverage the storage potential of hydropower for grid balancing** on the base of new technologies, finally allowing plant operators to operate successfully in the modern power markets and to make a significant contribution to European renewable energy objectives and policies.

India: 100GW solar PV by 2022

- What to do when the sun is not shining?

India

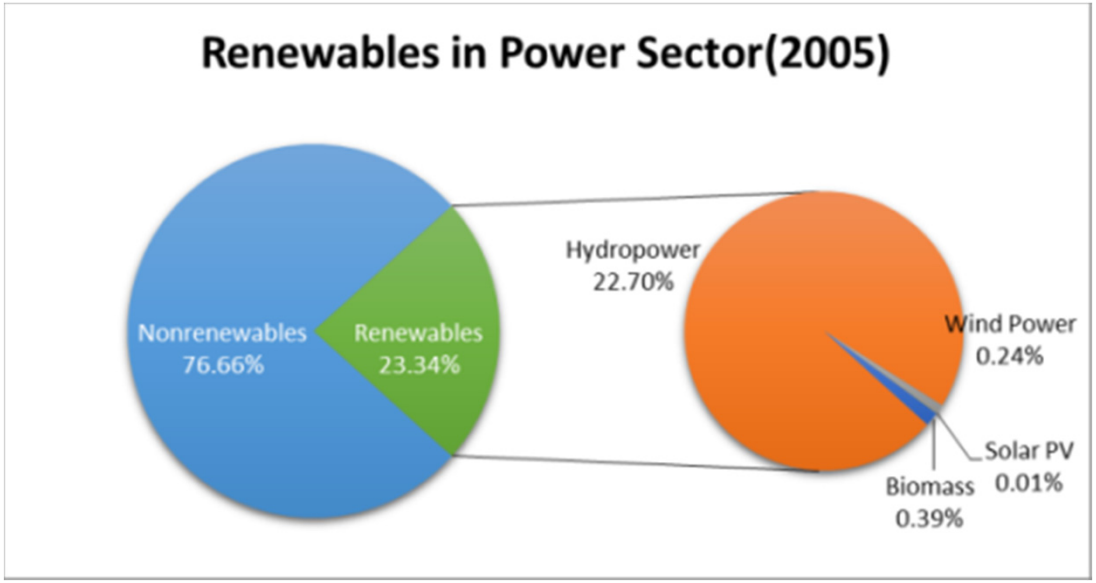
- Large hydro resources
- Reservoirs for balancing ?
- Multi-purpose use of reservoirs

- Reservoir, run-of-river and small hydropower for energy production
- Reservoir hydropower for balancing other renewables

CEDREN in China

FutureHydro

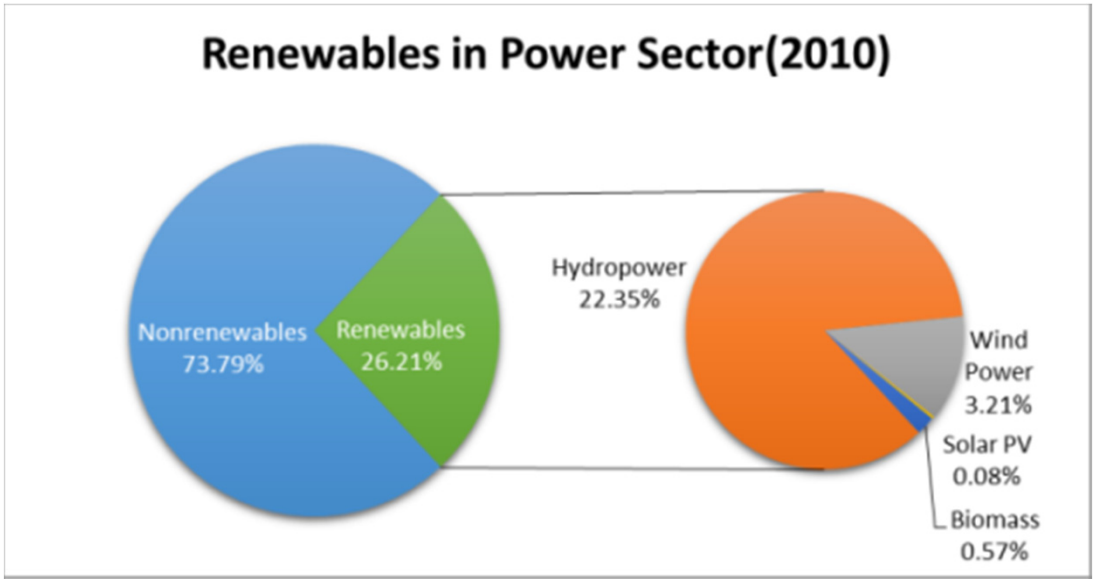
Tsinghua University, Beijing



2005

Renewables 23.34 %

- Hydropower 22.70 %
- Wind power 0.24 %
- Solar PV 0.01 %
- Biomass 0.39 %



2010

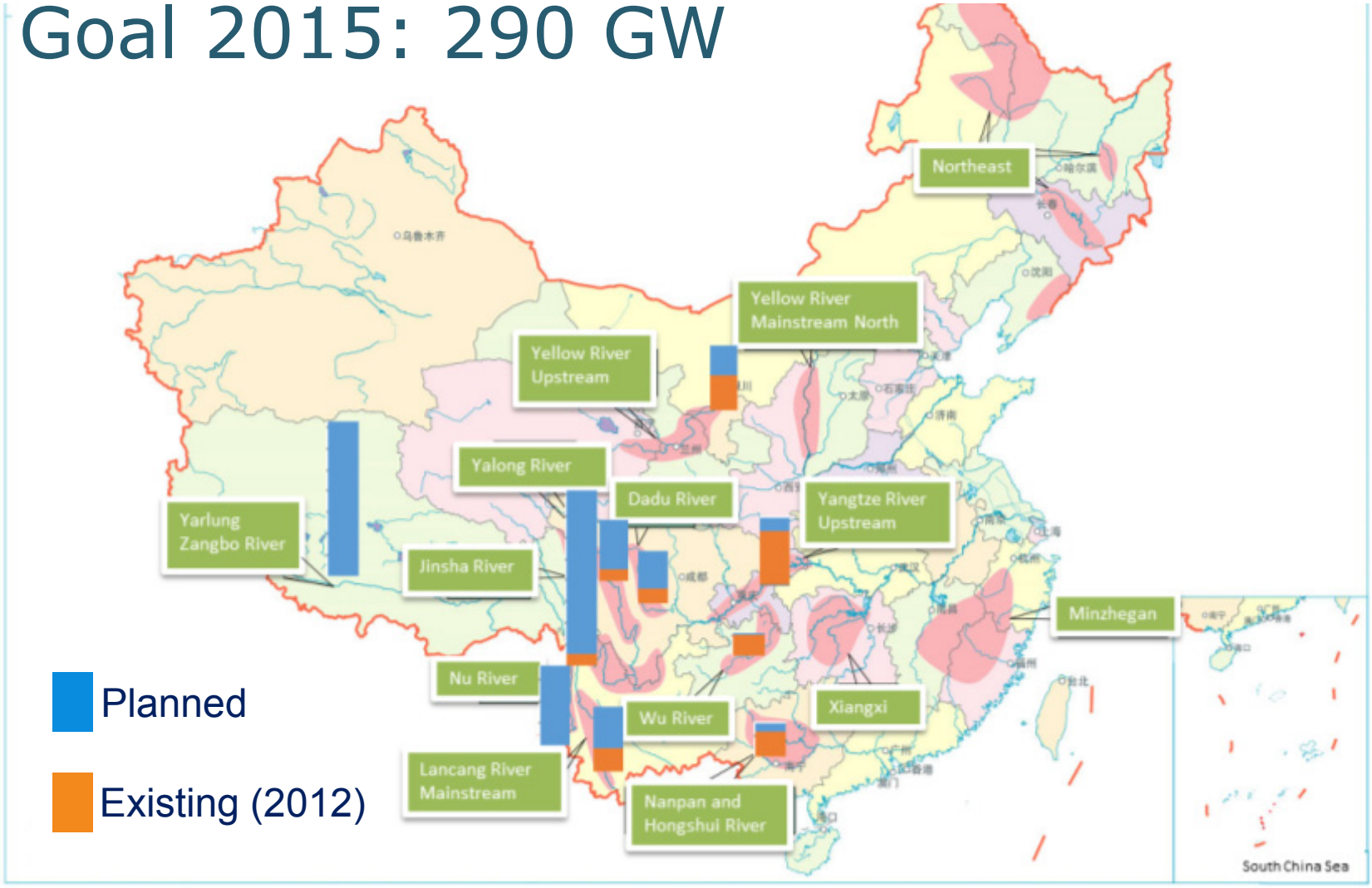
Renewables 26.21 %

- Hydropower 22.35 %
- Wind power 3.21%
- Solar PV 0.08 %
- Biomass 0.57 %

Data source: NEA 2012; Xu 2007; CEC 2011

Hydropower in China – large rivers

Developed and planned hydropower Goal 2015: 290 GW



2010-2015 development plan in major watersheds
Data source: NEA 2012

Pumped hydro in China

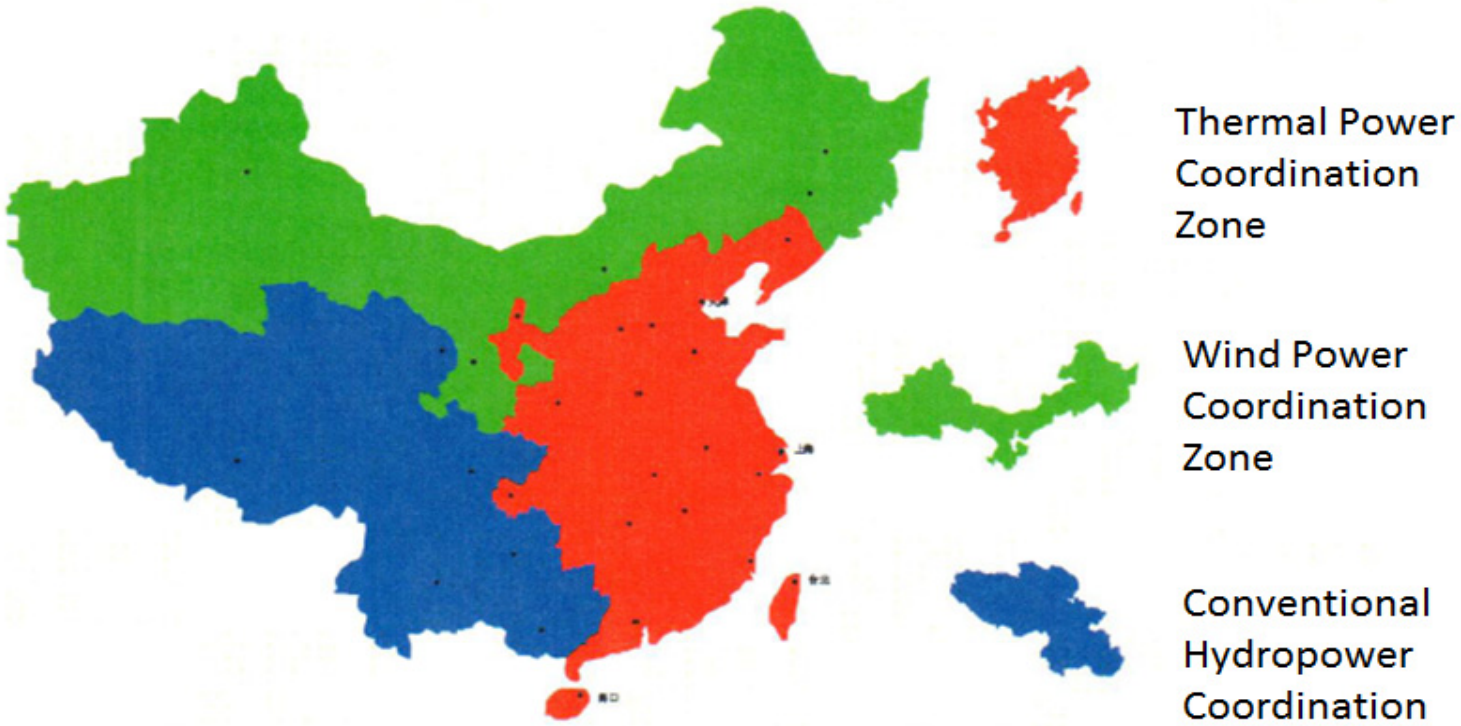
In operation

Proposes

Existing 2010: 17GW
Existing 2015: 33GW
Planned 2020: 50GW

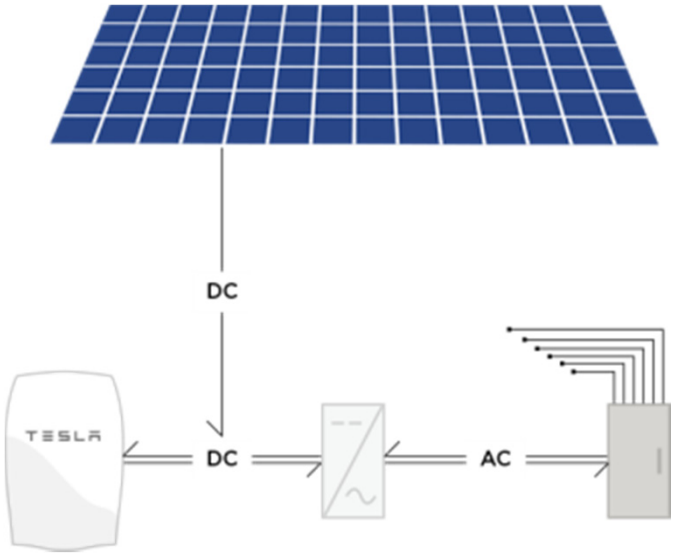
Locations of existing PHS station and PHS under construction. Source: Zeng *et.al* 2013

Pumped hydro storage zones



Tesla PowerWall© - 10kWh units for homes

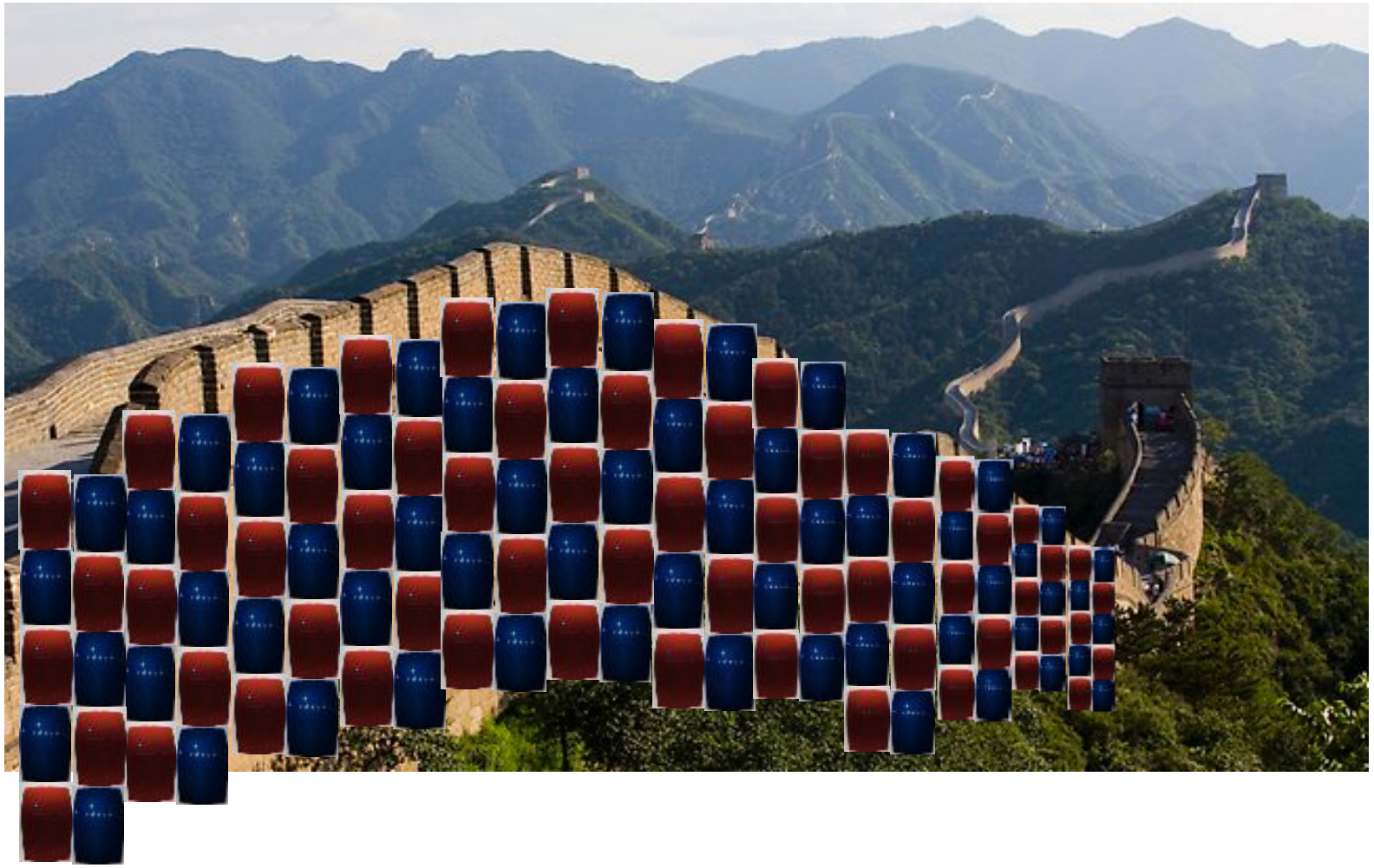
Roof-top solar panel or similar



PowerWall©

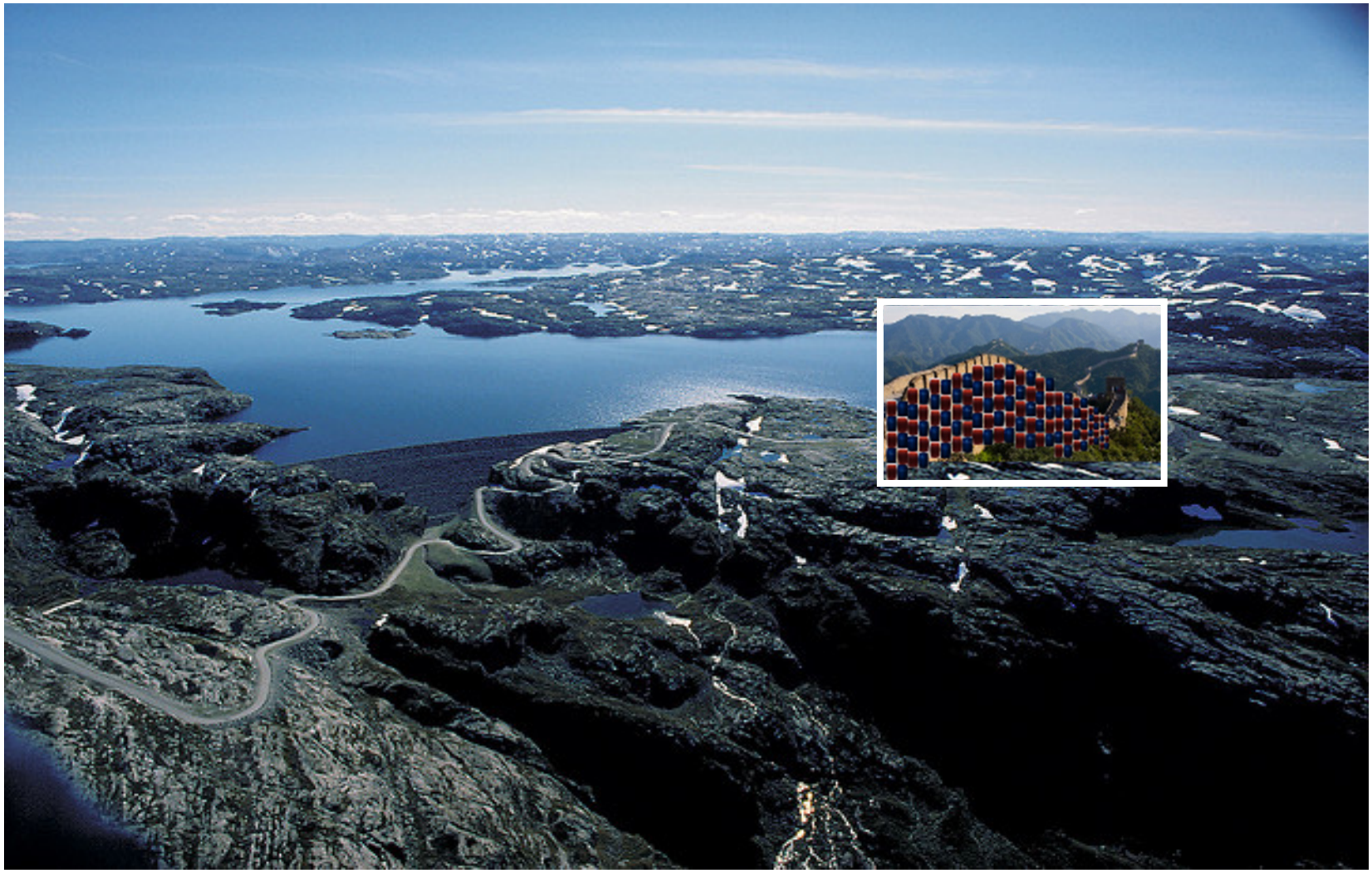
- Balancing solar energy
- Energy security
- Off-grid solutions

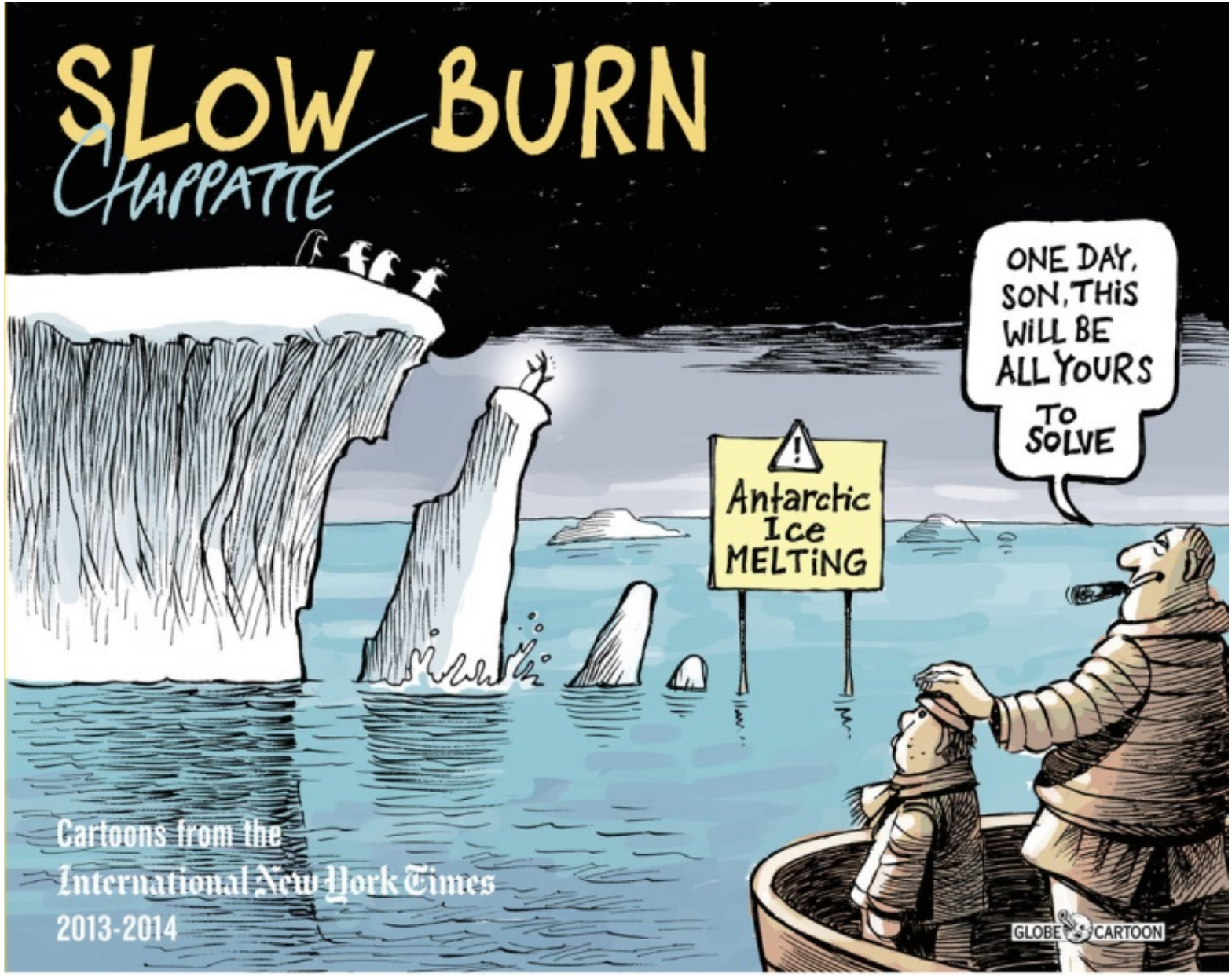
The Great Wall



Cover with Tesla PowerWall©

1,23 TWh = 15 % of Blåsjø




SLOW BURN
CHAPPATTE
ONE DAY, SON, THIS WILL BE ALL YOURS TO SOLVE
Antarctic Ice MELTING
Cartoons from the International New York Times
2013-2014
GLOBE CARTOON

The benefit of storage

Generation

Fluctuating
e.g. Wind, Solar


Heat
Process Heat

Non-fluctuating

Energy Conversion

Storage / Transmission / Transport

Electrochemical, Chemical, Thermal, Mechanical, Superconducting Magnetic

- Time-Shift
- Grid, Pipe, Wheels (TES)

Energy Conversion

Demand


Industry Energy Suppliers


Electro & Hybrid & Hydrogen

Energy Balancing –
Smoothing / Ramping

System stability
Voltage Regulation
Energy Service - Peak shaving,
Power Reliability -

Energy storage technologies

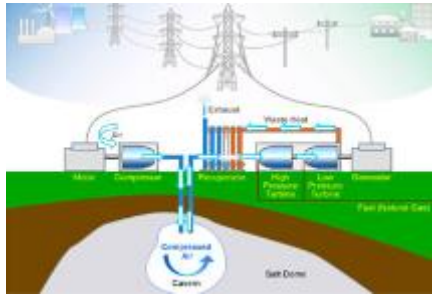
1) **Electrochemical Storage**
Batteries, Super Capacitors

2) **Chemical Storage**
Hydrogen, Methanol, Ammonia

3) **Thermal and Geothermal Storage**
Heat, Advanced Fluids, PCM, Cold

4) **Mechanical Storage**
Hydro, Flywheels, Compressed Air

5) **Superconducting Magnetic Energy Storage**

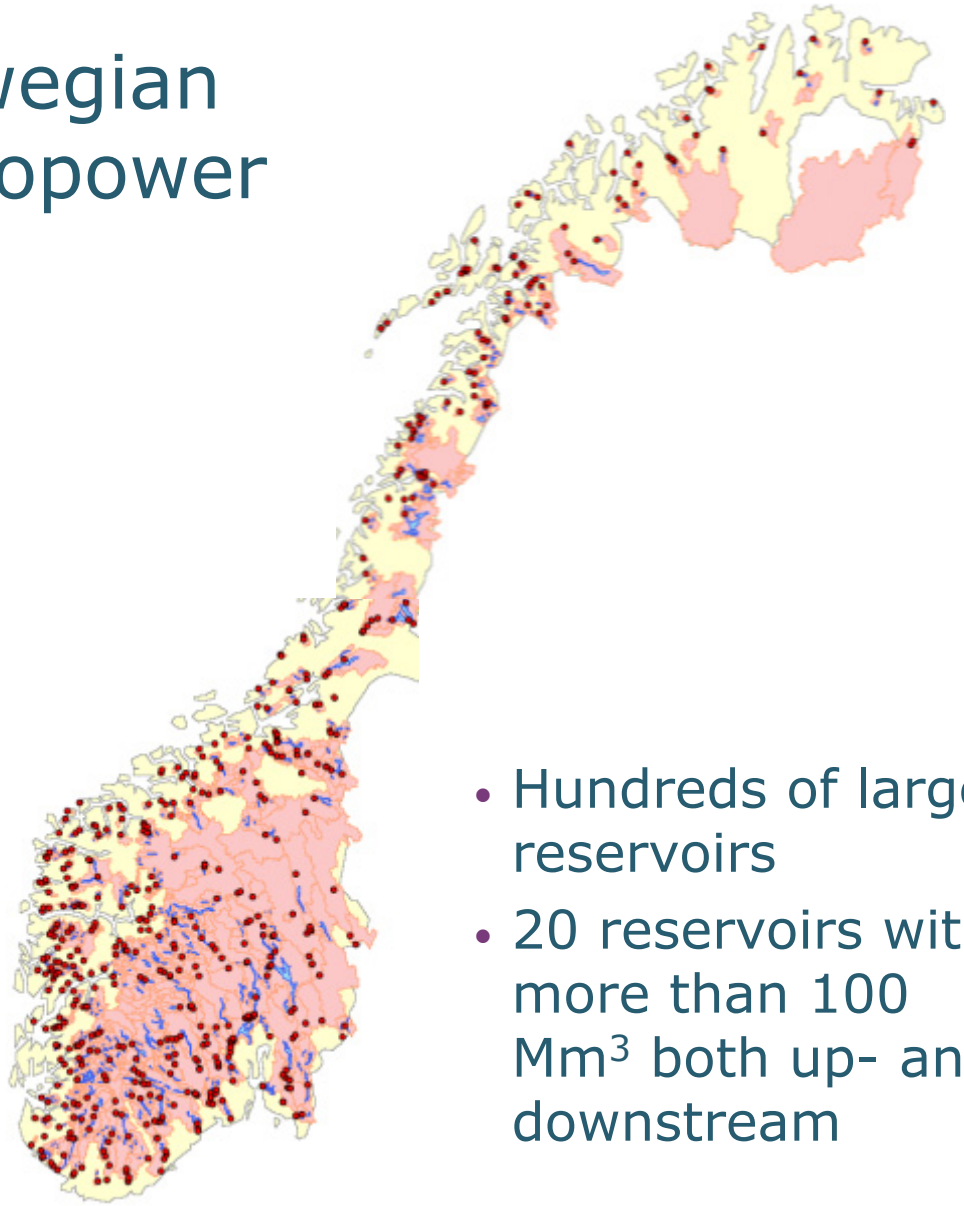


Hydropower in Norway – Resource base

Water, high head

Large natural reservoirs

Norwegian hydropower



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