The potential for hydropower to mitigate Climate Change impacts

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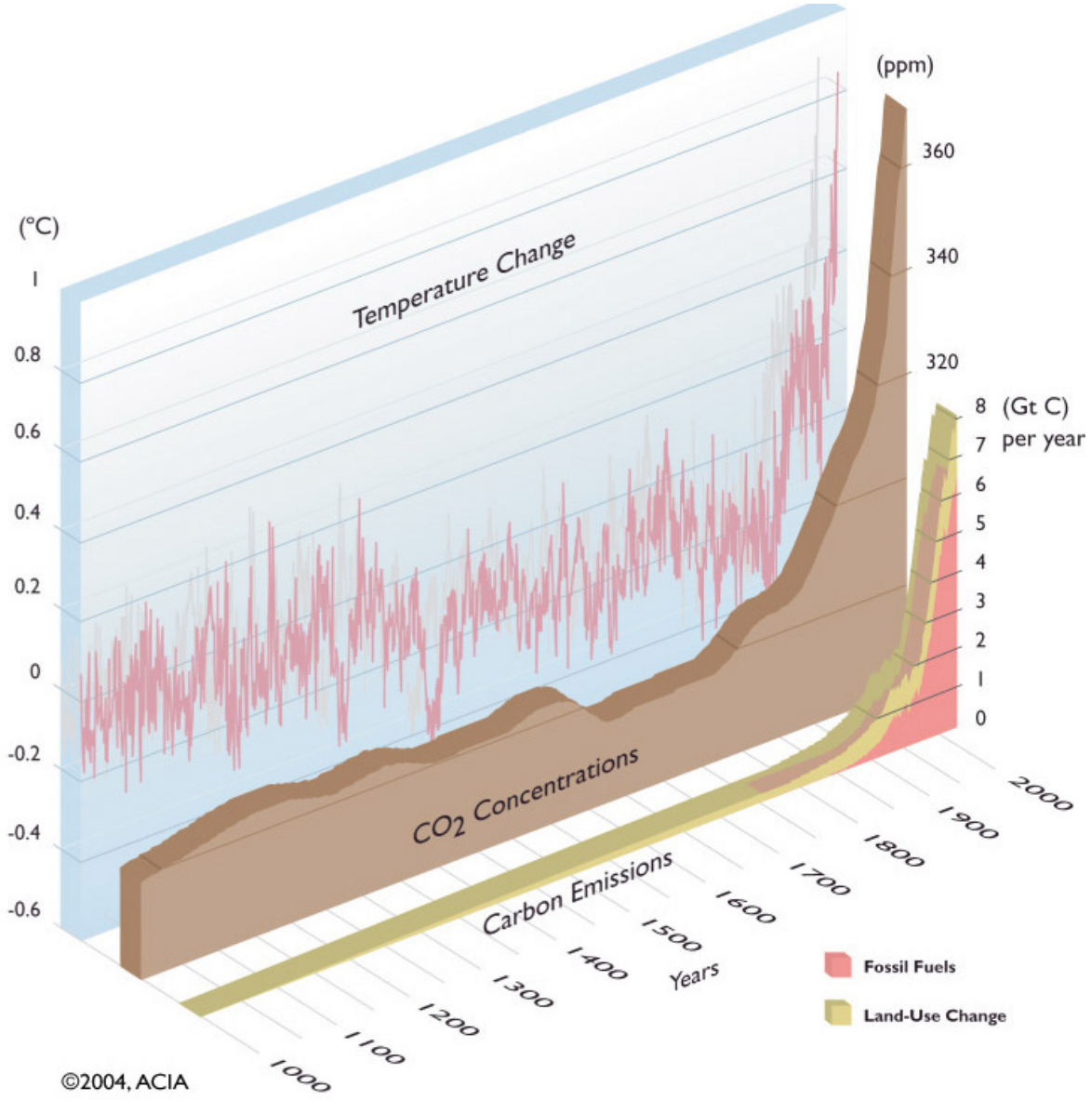
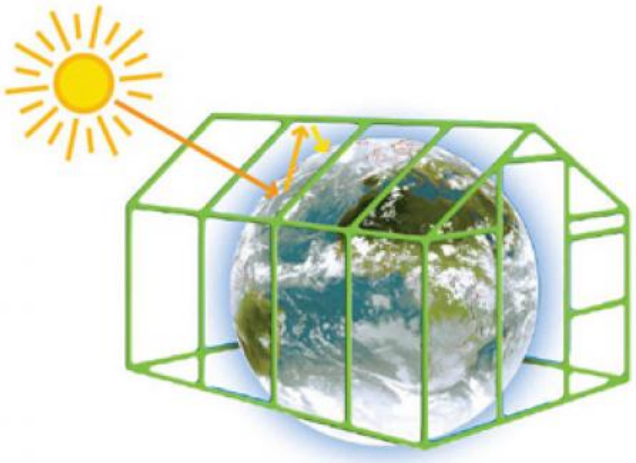
CEDREN/NTNU

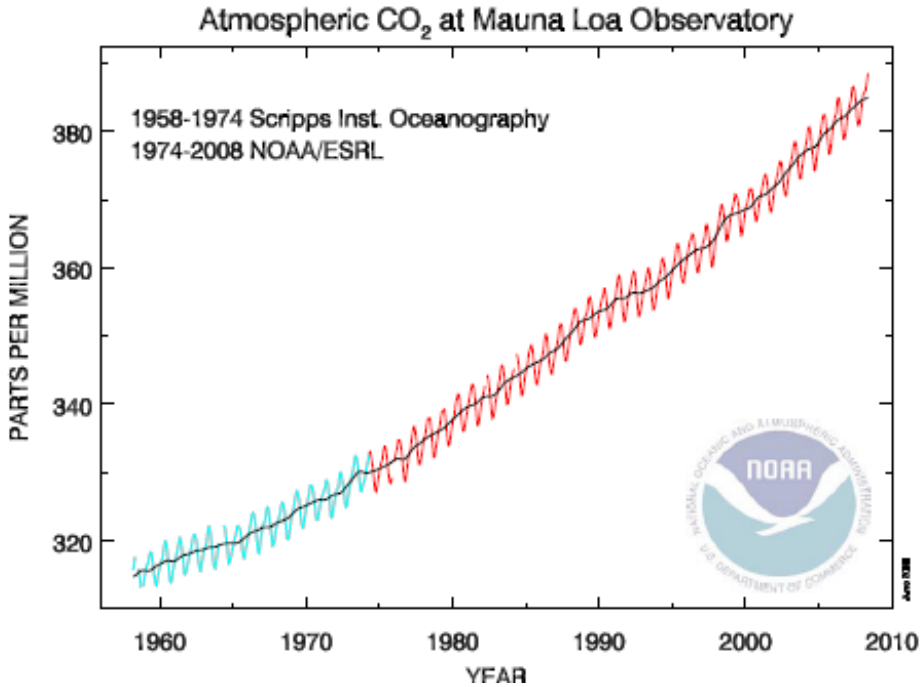
International seminar on large scale balancing from Norwegian Hydropower
Ryfylke fjordhotell, Sand, Tuesday 11. September 2012

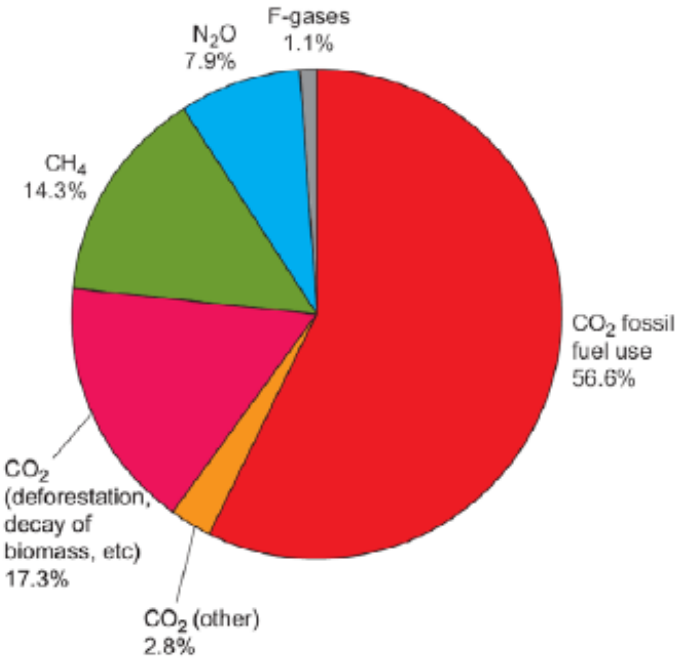
The background – The changing climate



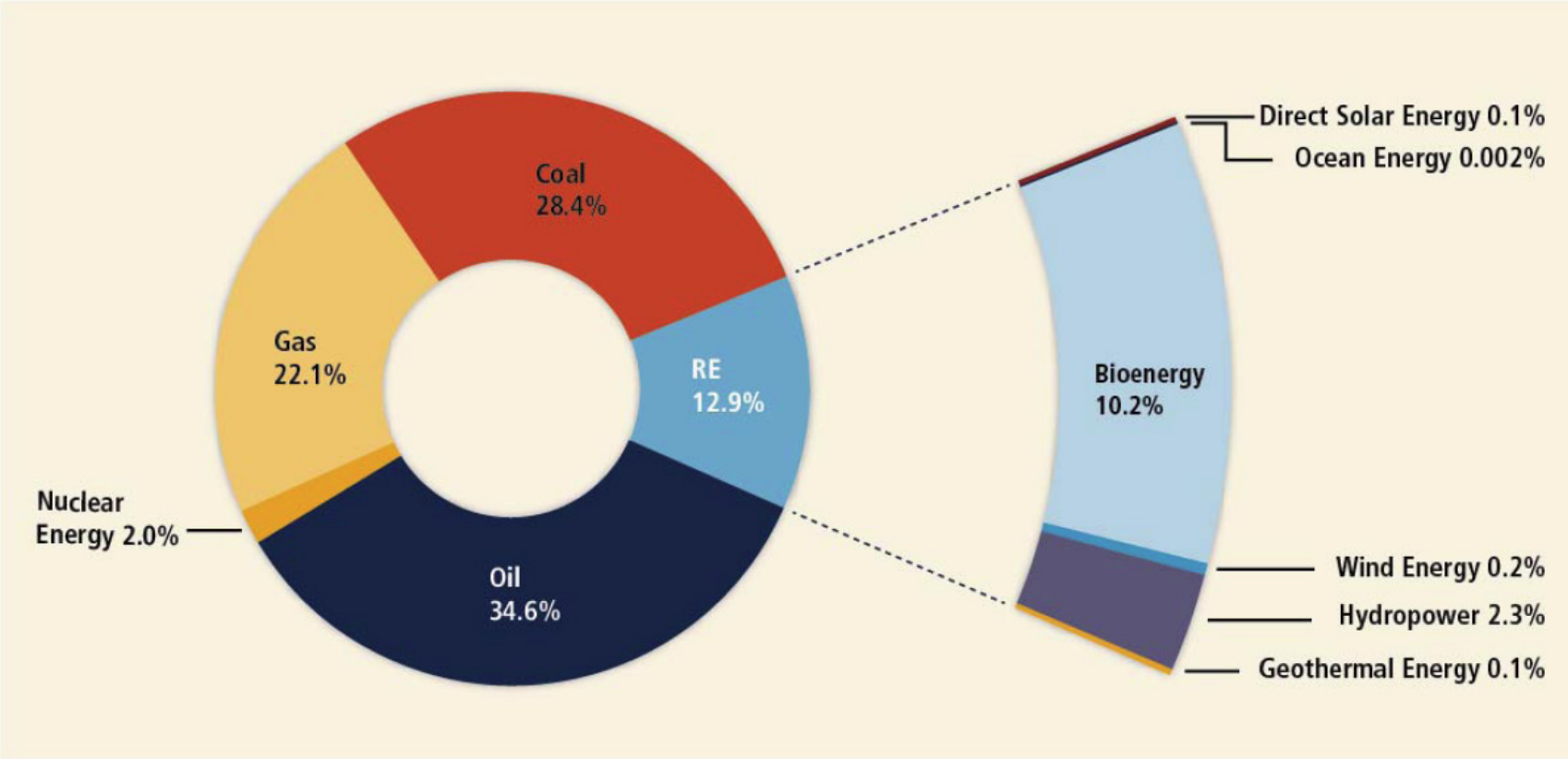
Probably caused by increasing Greenhouse gas (GHG) emissions (?)





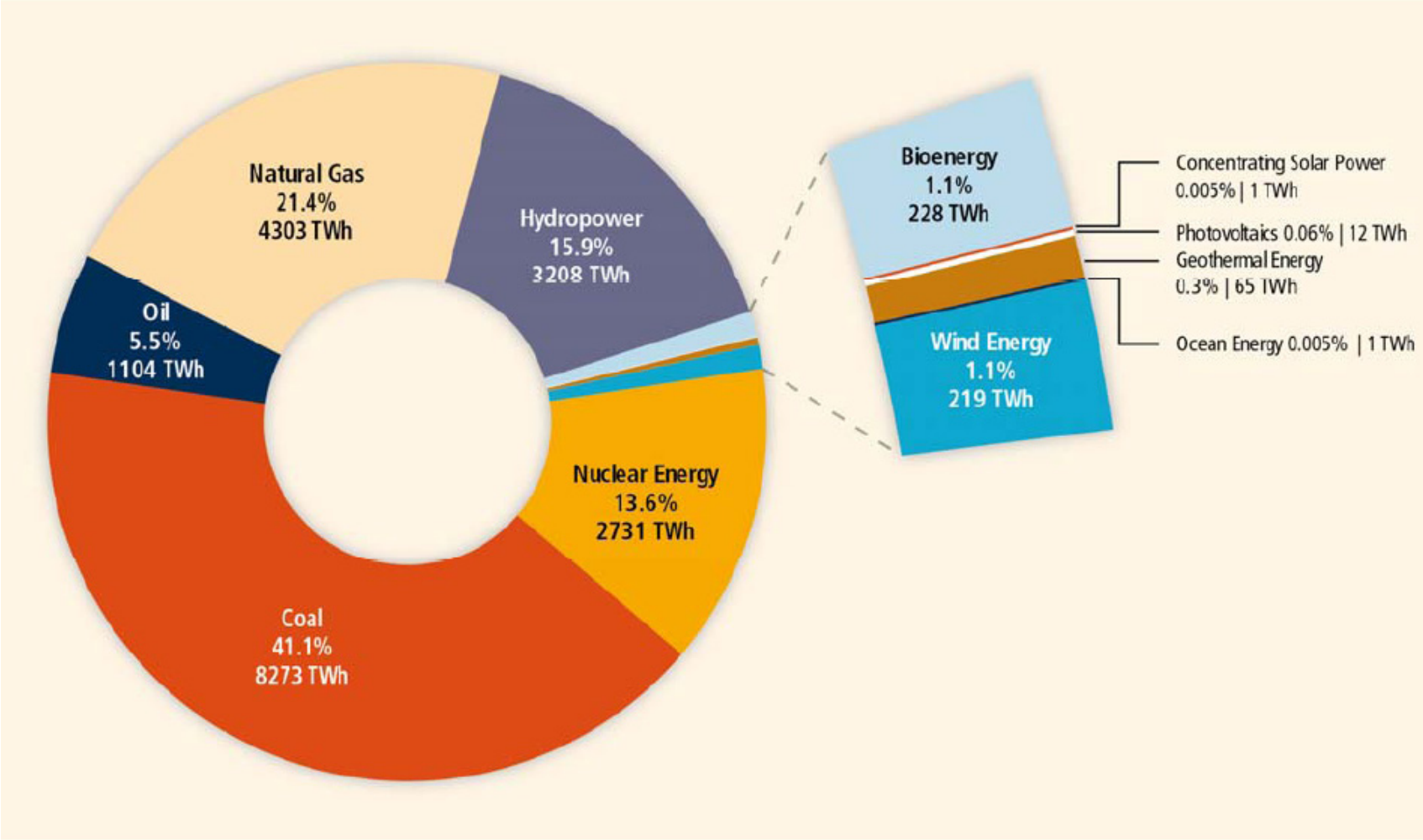


The current global energy system is fossil fuel dominated

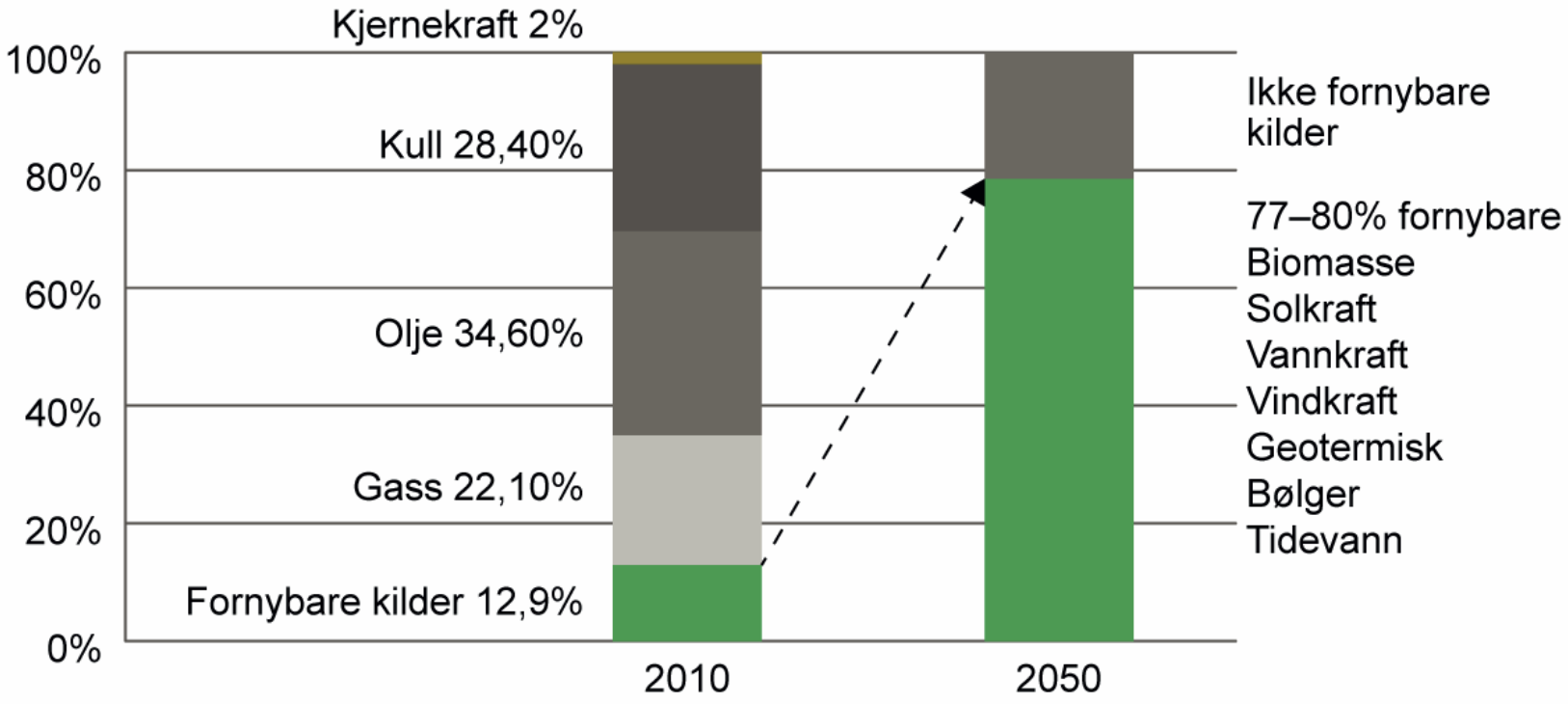


Shares of energy sources in total global primary energy supply in 2008 (492 EJ) Modern biomass contributes 38% of the total biomass share. Underlying data for figure has been converted to the 'direct equivalent' method of accounting for primary energy supply

Share of World Electricity Production (2008)

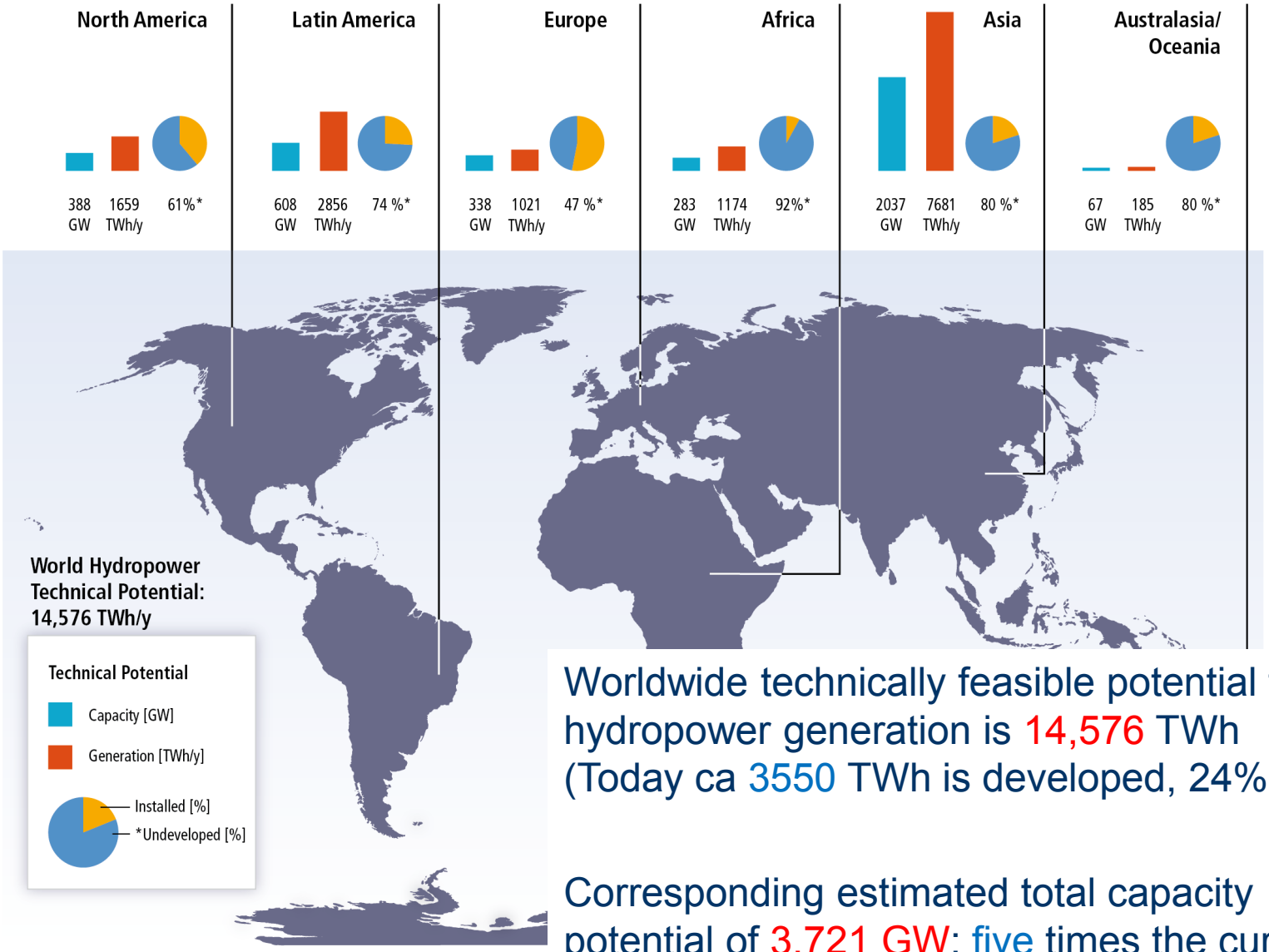


Renewable energy could stabilize global warming at + 2°C by bringing down emissions by up to 80% in 2050



Kilde: IPCC SRREN 2012 and Statkraft 2012

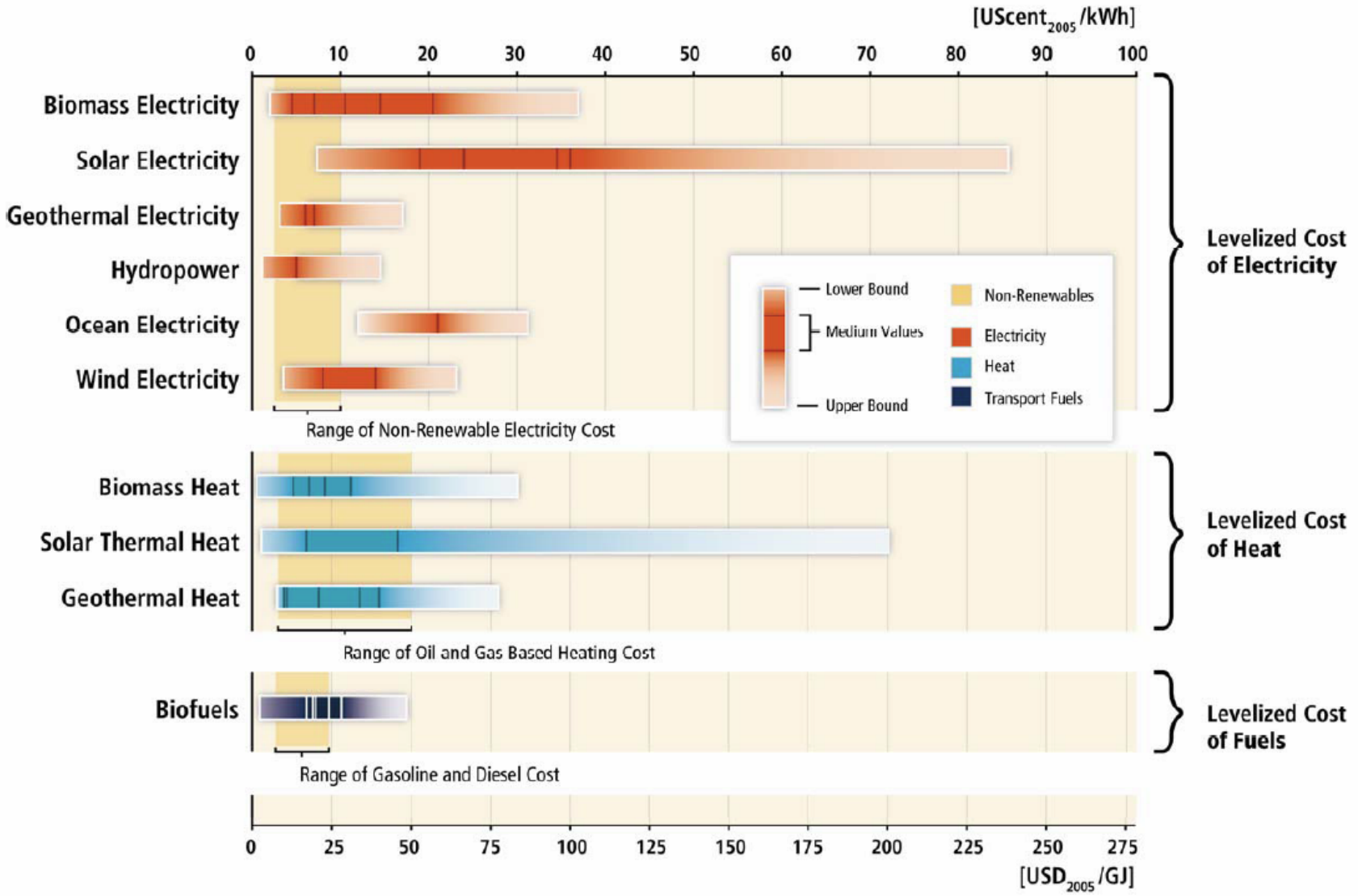
Hydropower Potential – A Global overview



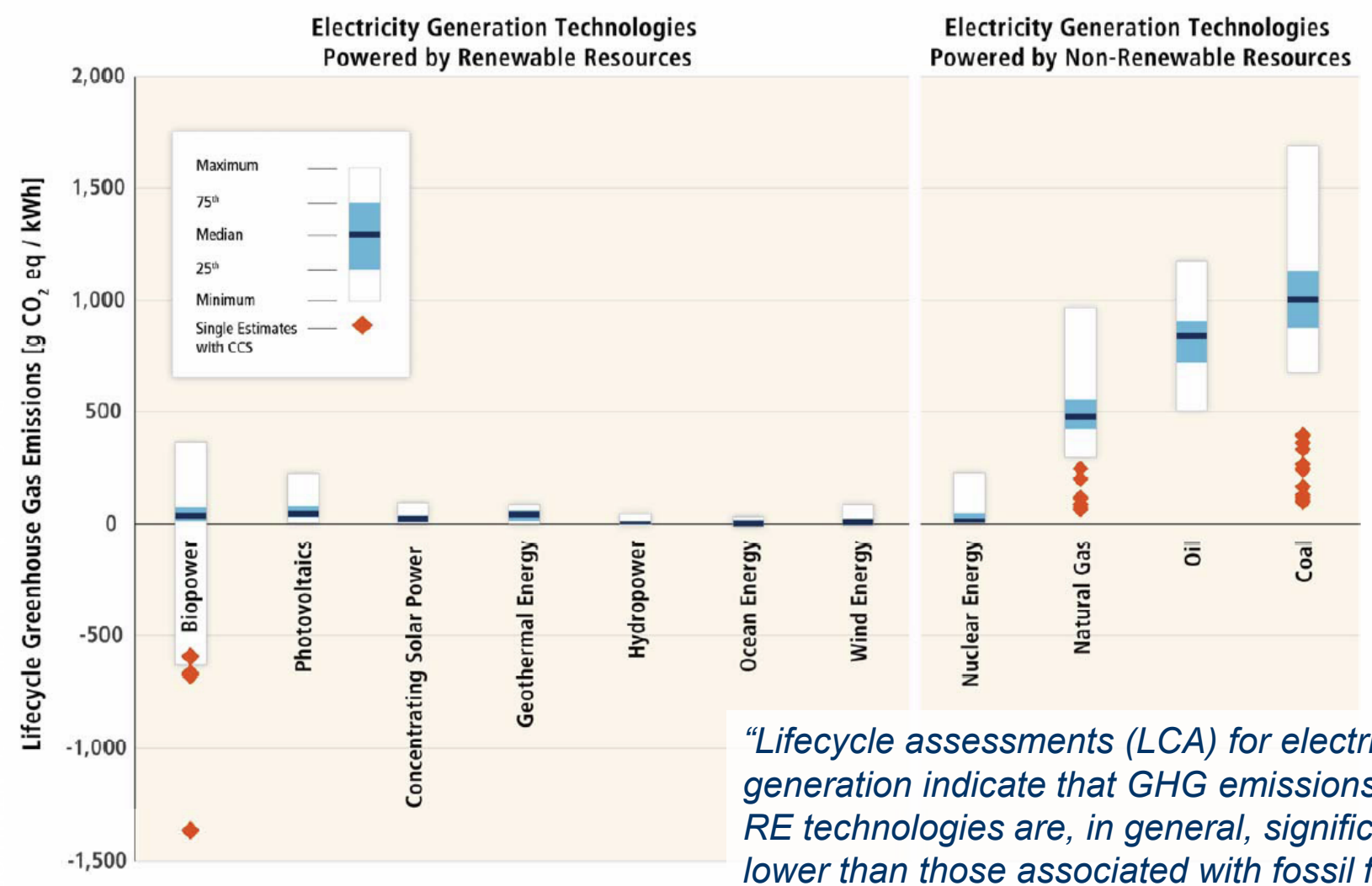
Worldwide technically feasible potential for hydropower generation is 14,576 TWh (Today ca 3550 TWh is developed, 24%)

Corresponding estimated total capacity potential of 3,721 GW; five times the current installed capacity of 926 GW (2009)

Levelized Cost of Energy (LCOE) for various types of RE



Lifecycle GHG emissions of RE technologies



"Lifecycle assessments (LCA) for electricity generation indicate that GHG emissions from RE technologies are, in general, significantly lower than those associated with fossil fuel options, and in a range of conditions, less than fossil fuels employing CCS"

EU is recognizing Climate Change as a reality

"Climate Change is happening"

"The overwhelming scientific consensus is that the cause is emissions of greenhouse gases from human activity"

"Climate Change needs to be slowed down and eventually halted"

EU. (2005). Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee for the Regions. "Winning the Battle Against Global Climate Change"

CC and Transition to Renewable Energy in Europe

1997 Input to Kyoto meeting (RES-E White paper)
2001 RES Directive (12% RE by 2010)
2007 White Paper - 20/20/20 Targets by 2020
2009 New RES Directive (Climate and Energy Package)
2011 Norway accepted RES Directive (67.5% RE)

Up to 2020 Binding agreements for EU-27 + EEA countries
RE 20% (32.6% of Electric)

Up to 2030 Projections – Planning has started
RE 36.1%

Up to 2050 SET Plan and Energy Roadmap
Vision 80-95% reduced GHG

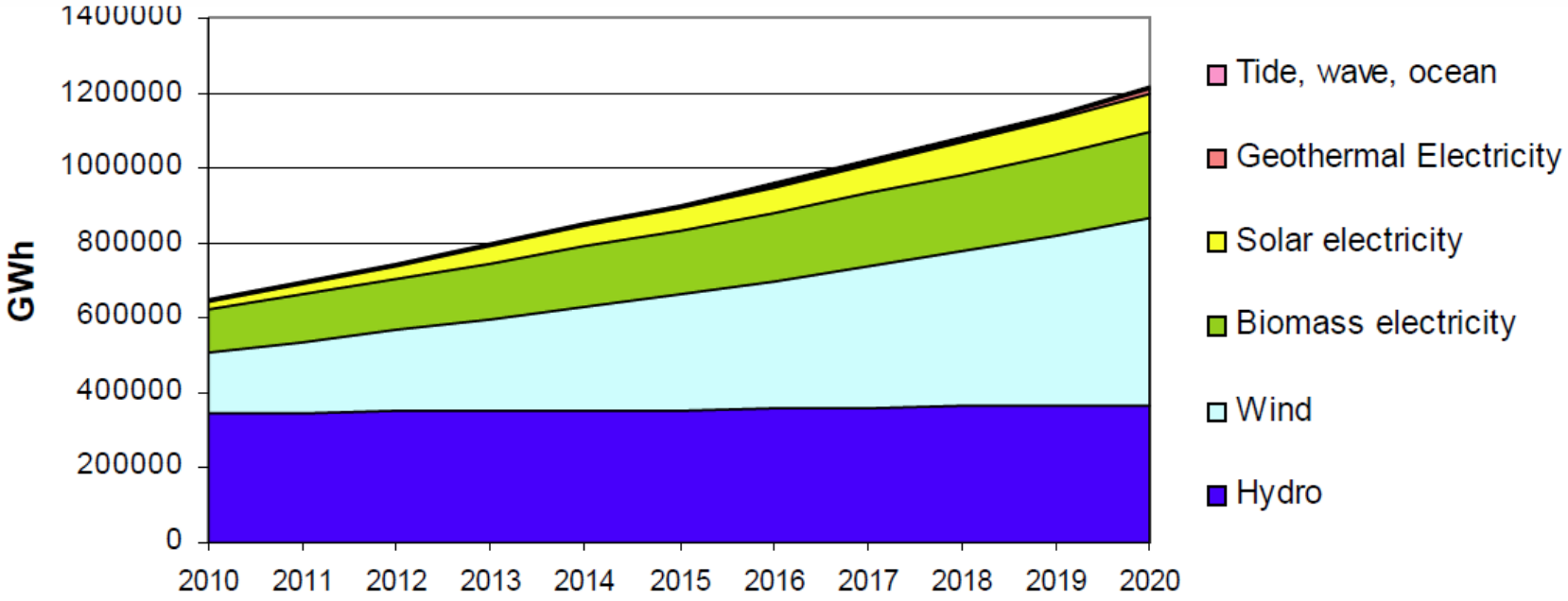
Transition to Renewable Energy in Europe

"The energy challenge is one of the greatest tests faced by Europe today"

"Key decisions have to be taken to reduce drastically our emissions and fight climate change"

G. Oettinger (EU)
Strategy report Energy 2020

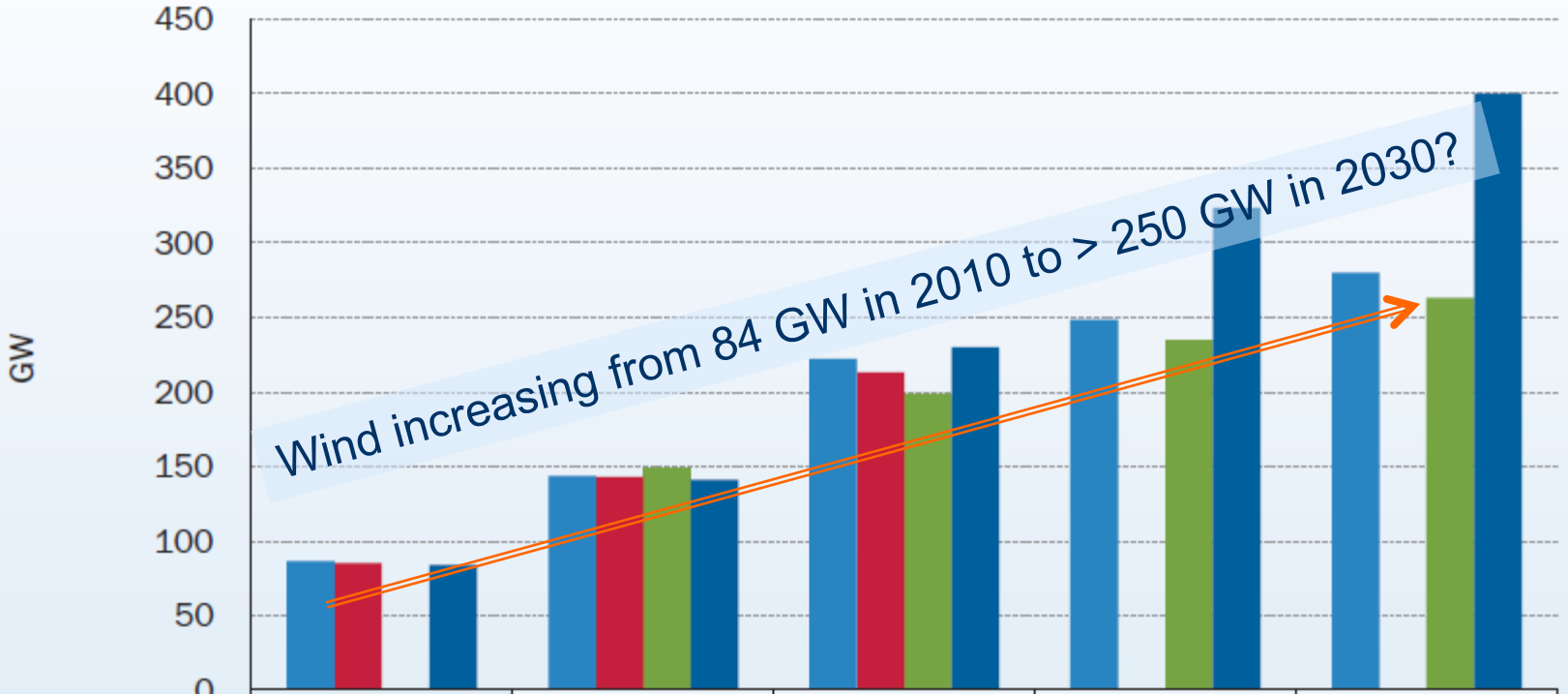
Implementation of the RES-directive (20/20/20 Goals)



Increase in RE production from **632** TWh in 2010 to **1152** TWh in 2020
Largest increase in wind (onshore/offshore) - ca 120 GW og 305 TWh
Large increase also in solar energy (ca 65 GW og 82 TWh)

➔ Large increase in highly intermittant power (wind, solar, small hydro)

FIGURE 4.1 LATEST WIND ENERGY SCENARIOS FOR EU-27 FROM THE EUROPEAN COMMISSION, THE MEMBER STATES, THE IEA AND EWEA (GW TOTAL INSTALLED CAPACITY)



	2010	2015	2020	2025	2030
EC 2009	86	144	222	248	280
NREAPs	85	143	213	-	-
IEA 2010		149	199	235	263
EWEA 2011	84	141	230	324	400

Source: EWEA, European Commission, International Energy Agency, National Renewable Energy Action Plans.

Integration of RE
into present and future Energy Systems

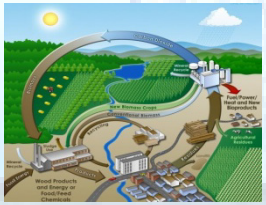
RE integration can be characterized based on these parameters:

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

RE integration into the future energy system

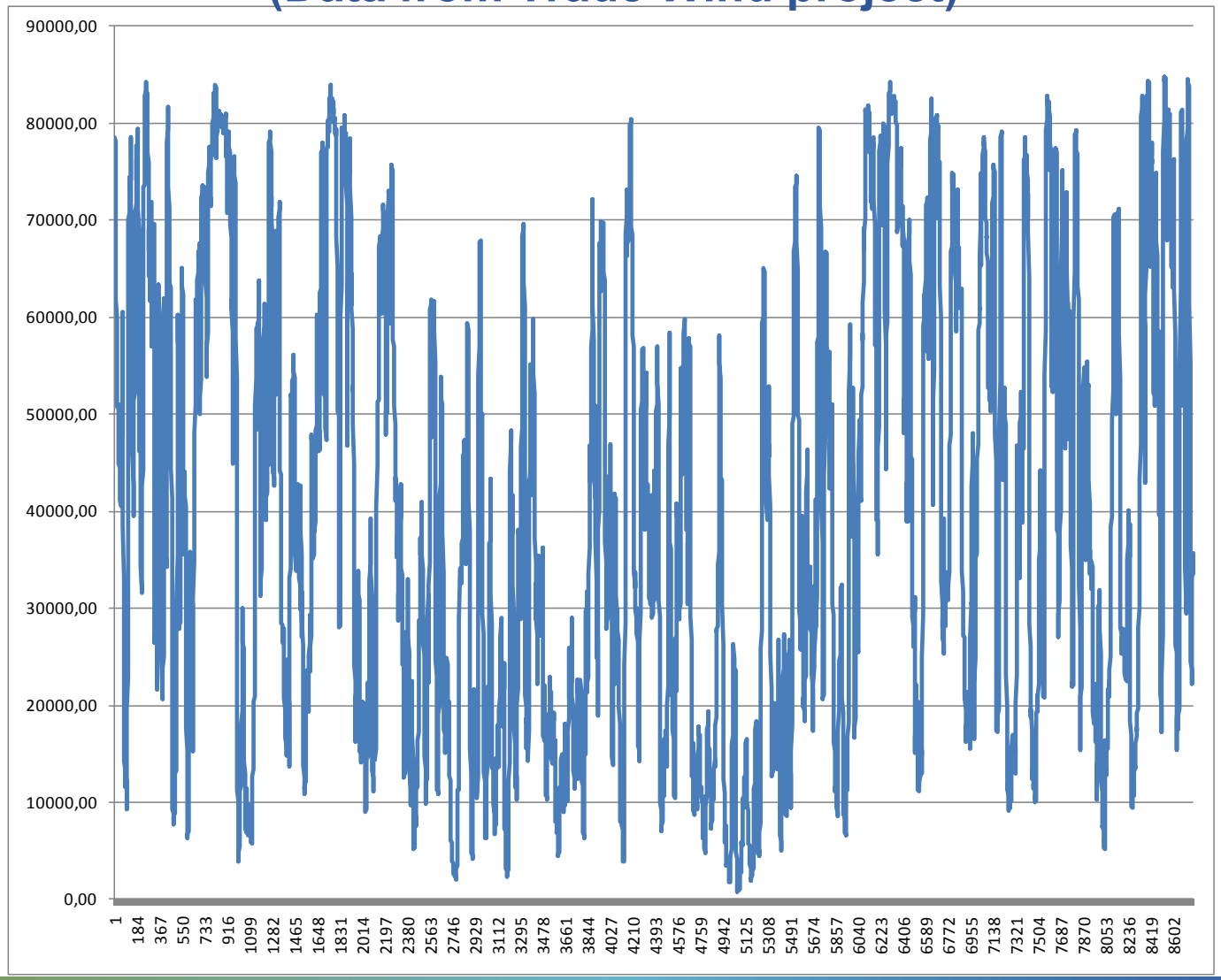
Few, if any, fundamental technical limits exist to the integration of a majority share of RE, but advancements in several areas are needed:

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

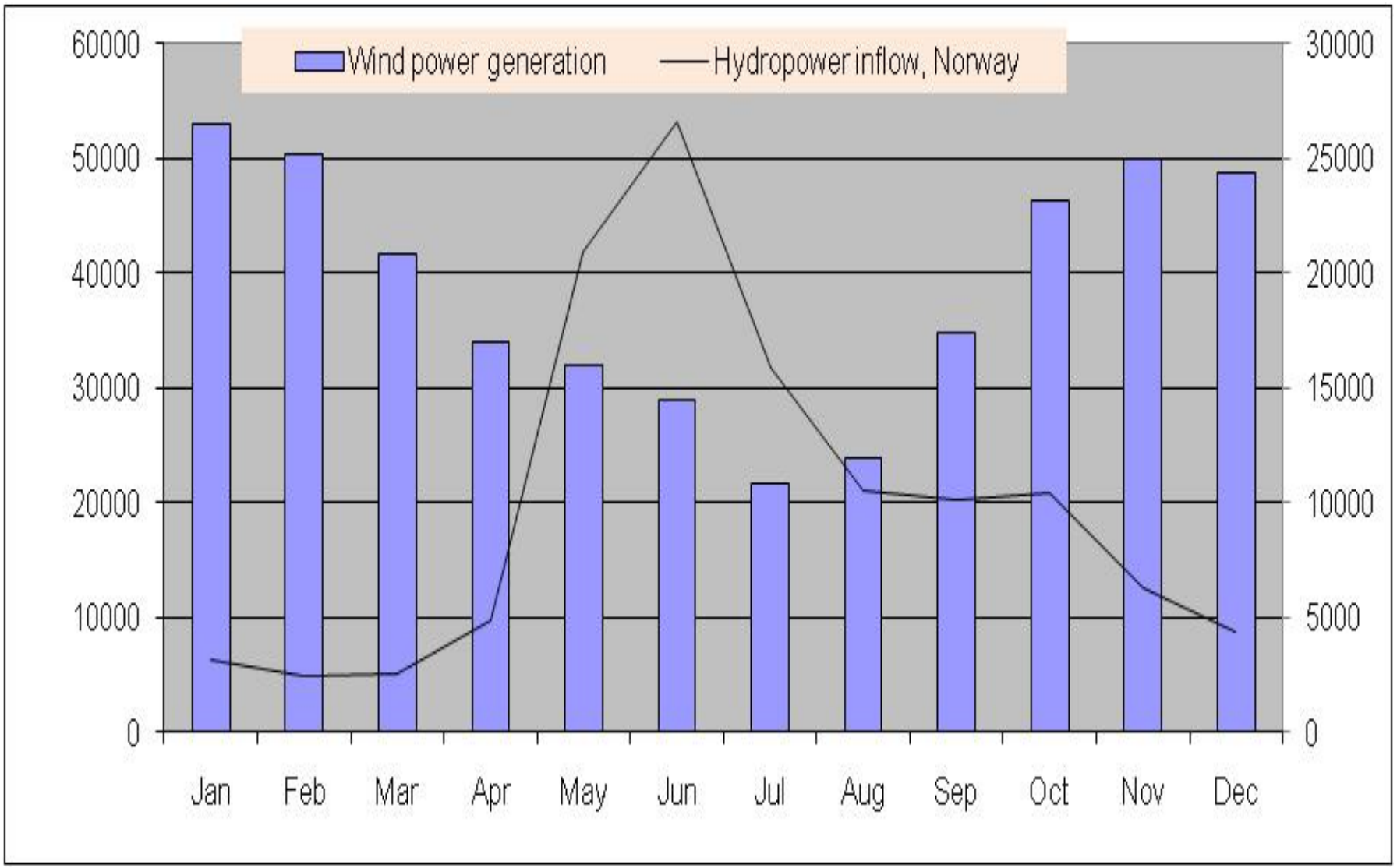





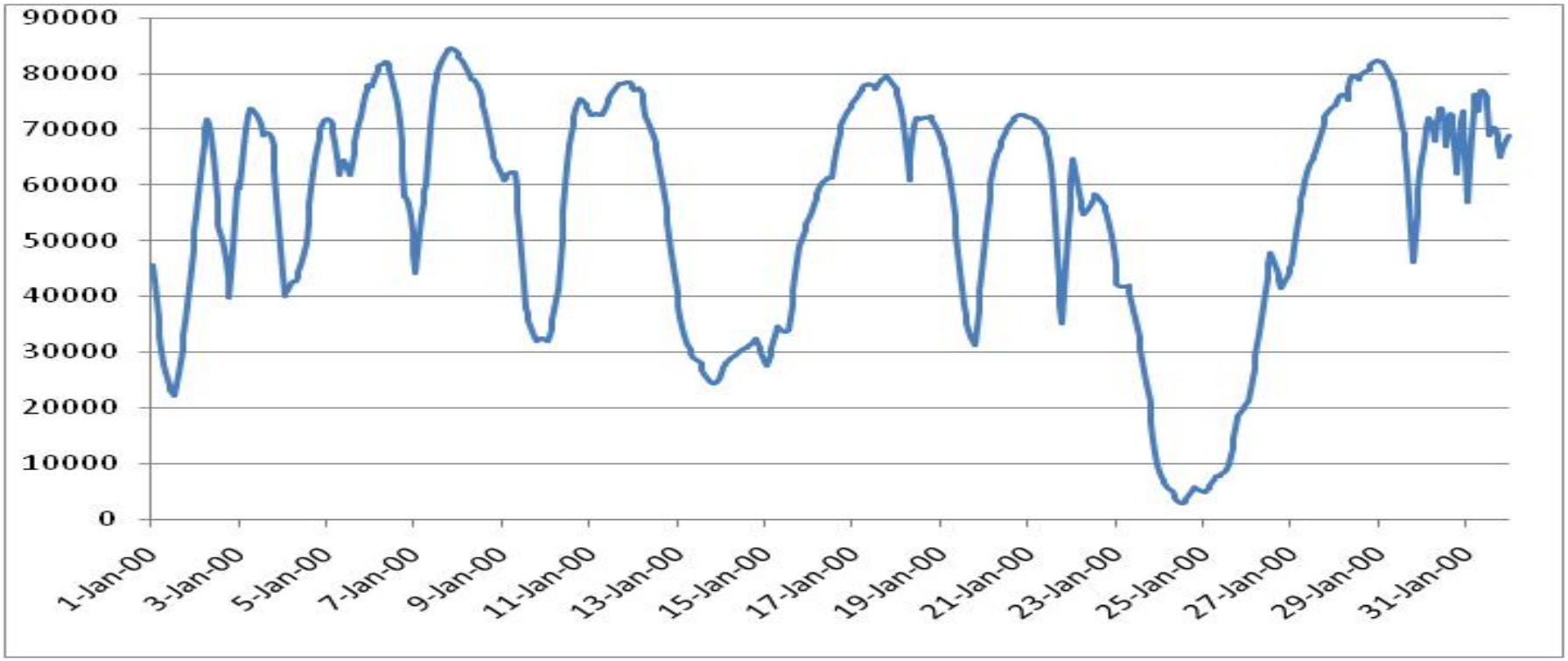
Simulated Wind Power production in North-Sea Region
Stadium 2030 – 94 000 MW installed capasity
(Data from Trade Wind project)



Wind and hydro looks like a good match



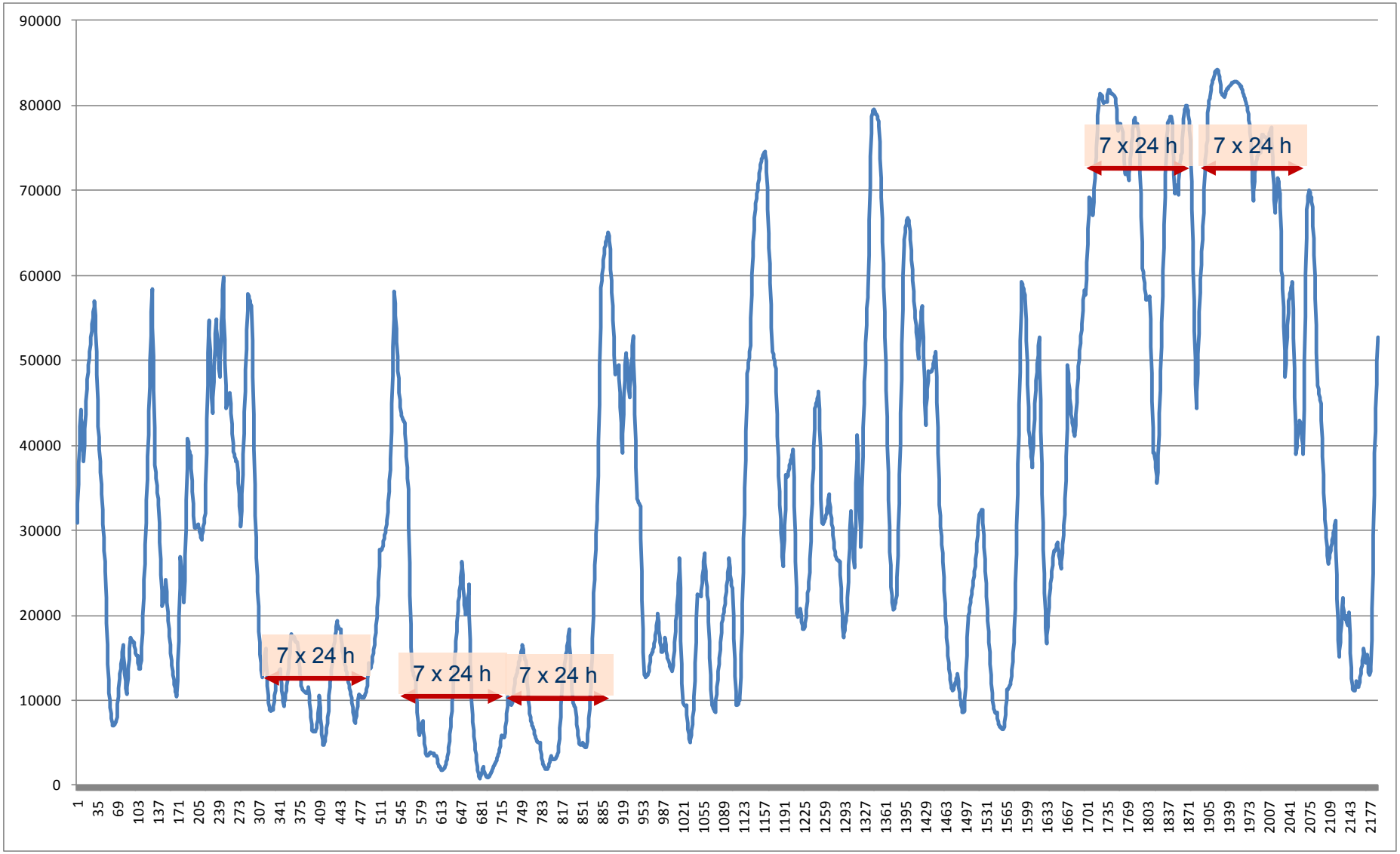
However – Wind power is highly variable



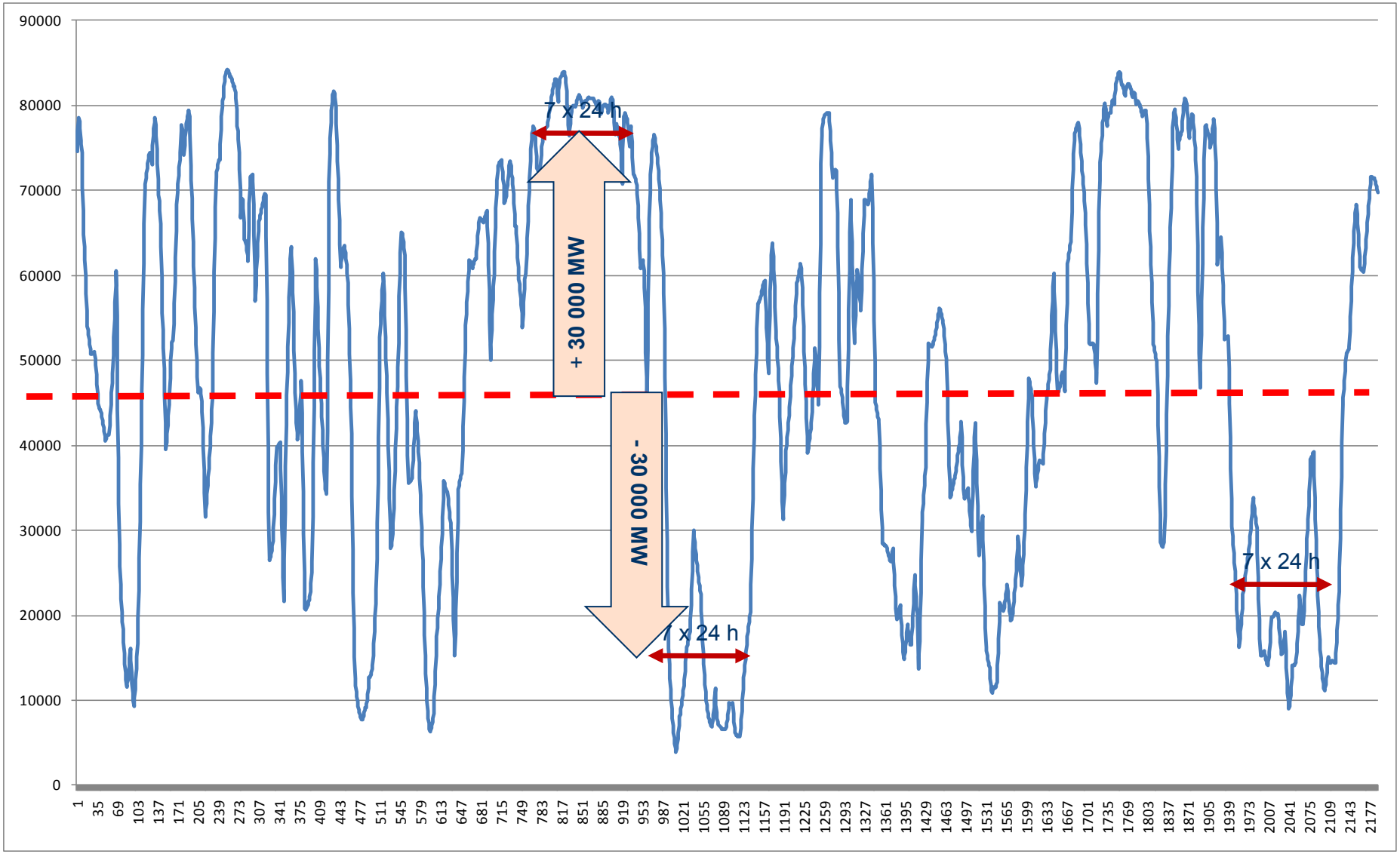
Simulated Wind energy production in a North-Sea system with 94000 MW Installed capacity (Stadium 2030)

Maximum:	84 448 MW
Minimum:	2774 MW
Average:	55427 MW

Wind Power North-Sea Region - July – September 2001



Wind Power North-Sea Region - Jan – March 2001

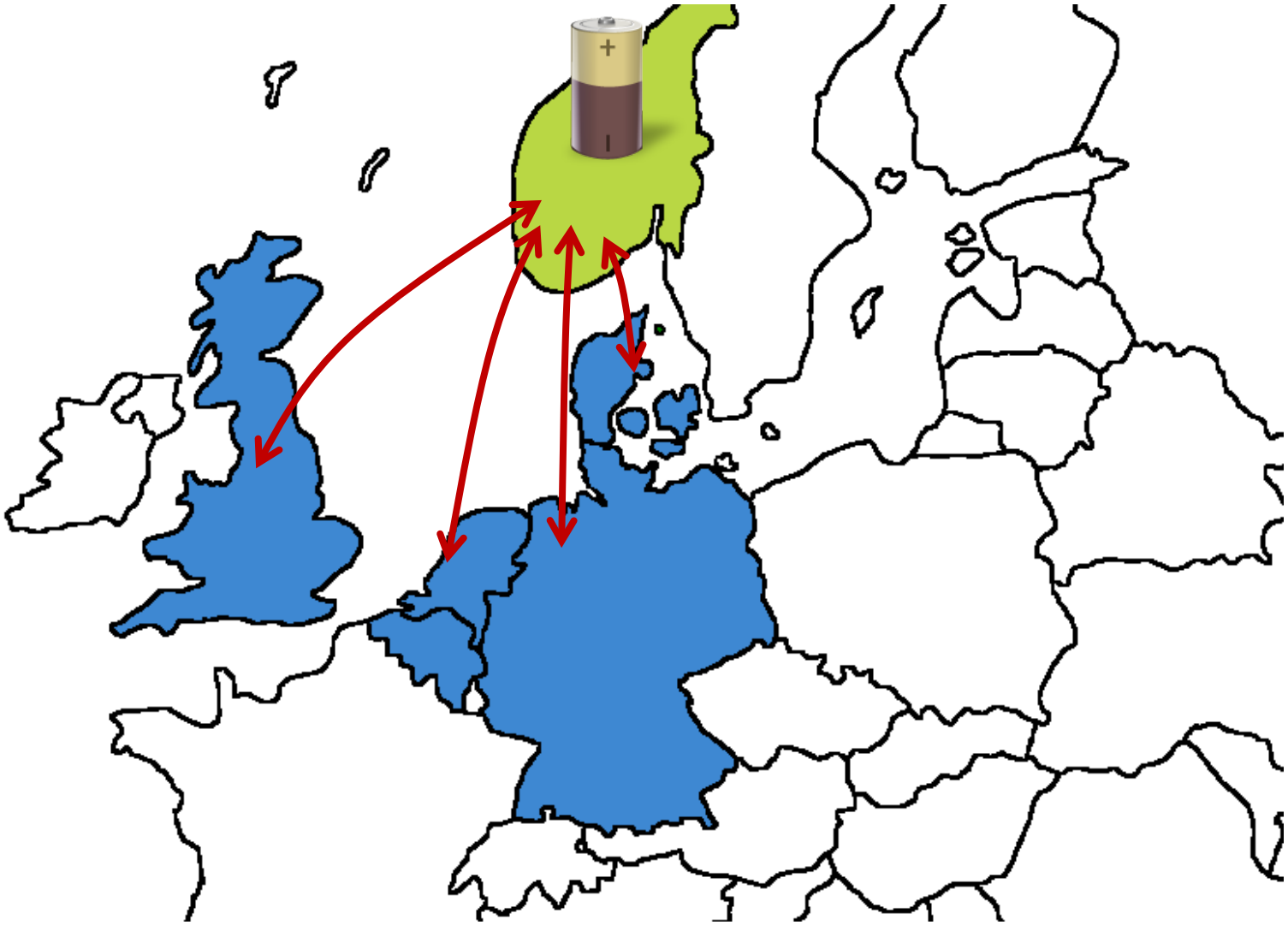


Large volumes of energy needs to be stored – up to +/-5 TWh in each cycle

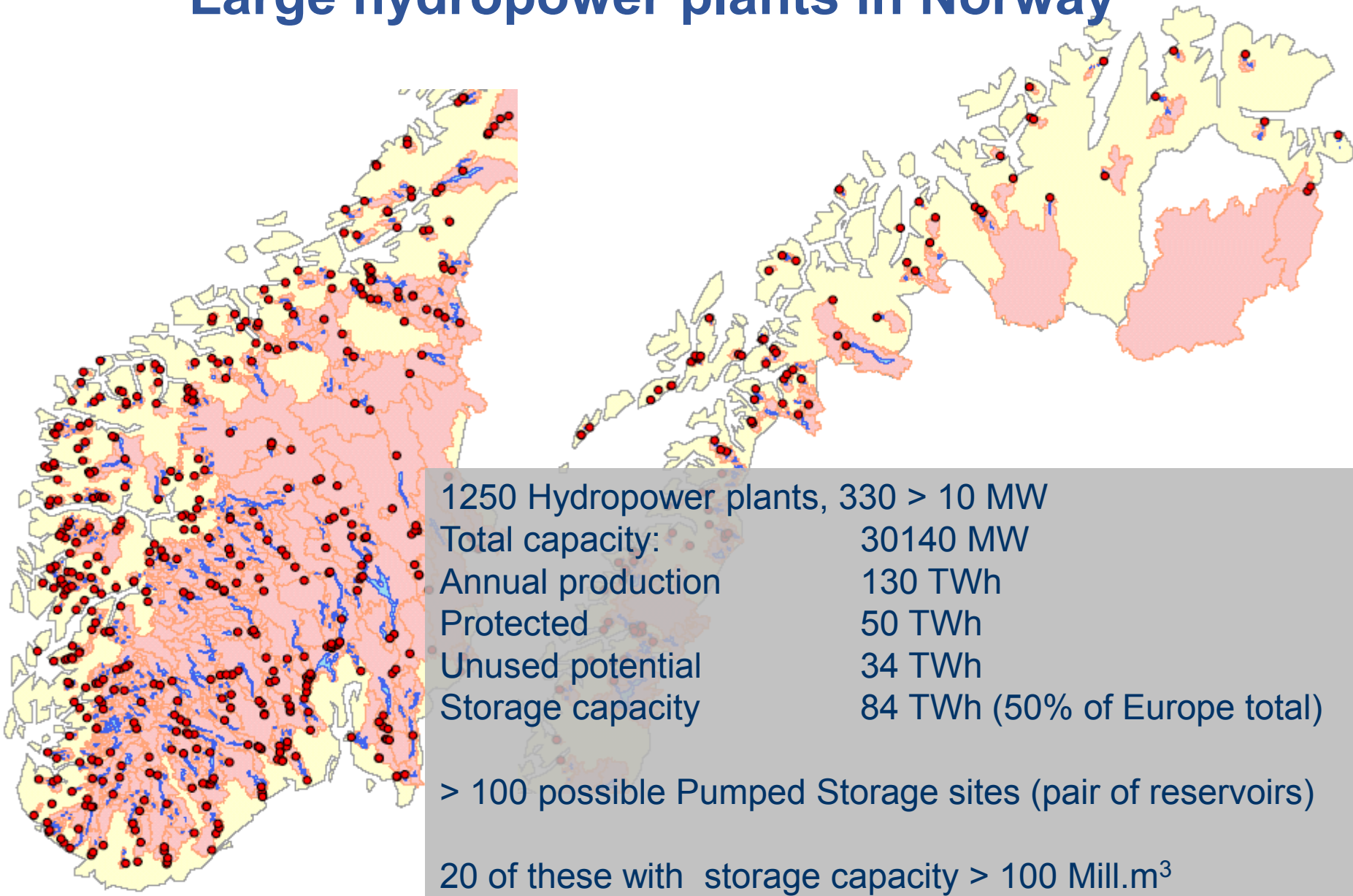
No existing storage technology in Europe can handle such volumes (Bulk storage)

Can Norway contribute?
How much?
Cost?

Norway – A green battery for Europe?



Large hydropower plants in Norway



1250 Hydropower plants, 330 > 10 MW

Total capacity:	30140 MW
Annual production	130 TWh
Protected	50 TWh
Unused potential	34 TWh
Storage capacity	84 TWh (50% of Europe total)

> 100 possible Pumped Storage sites (pair of reservoirs)

20 of these with storage capacity > 100 Mill.m^3

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http://www.cedren.no/