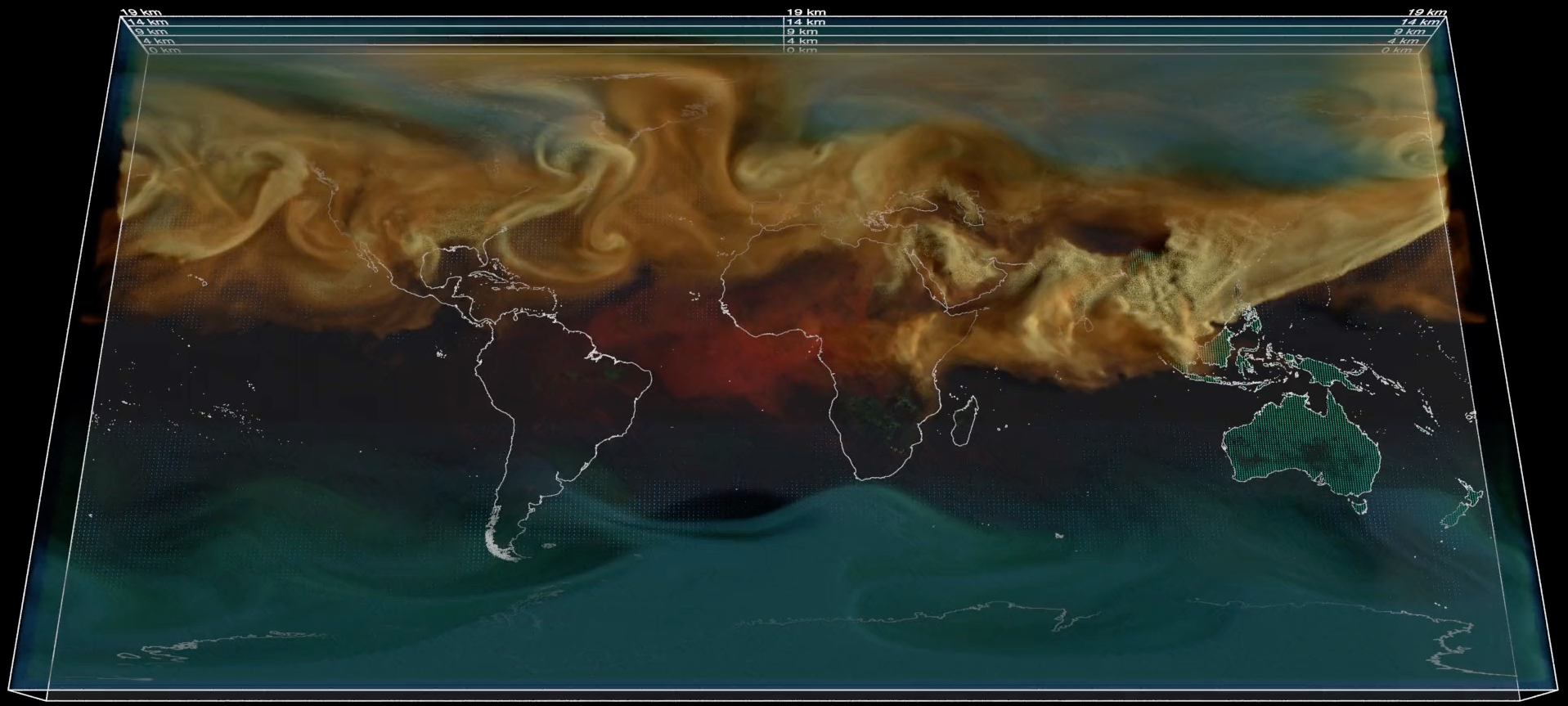
Cours « Conversion d'énergie »
Partie I

The “Big Energy” challenge

Génie Electrique et Electronique
2024-2025
Bachelor semestre 5

Prof. Mario Paolone
Laboratoire de Systèmes Electriques Distribués l’EPFL

Drivers – The CO_2 emissions

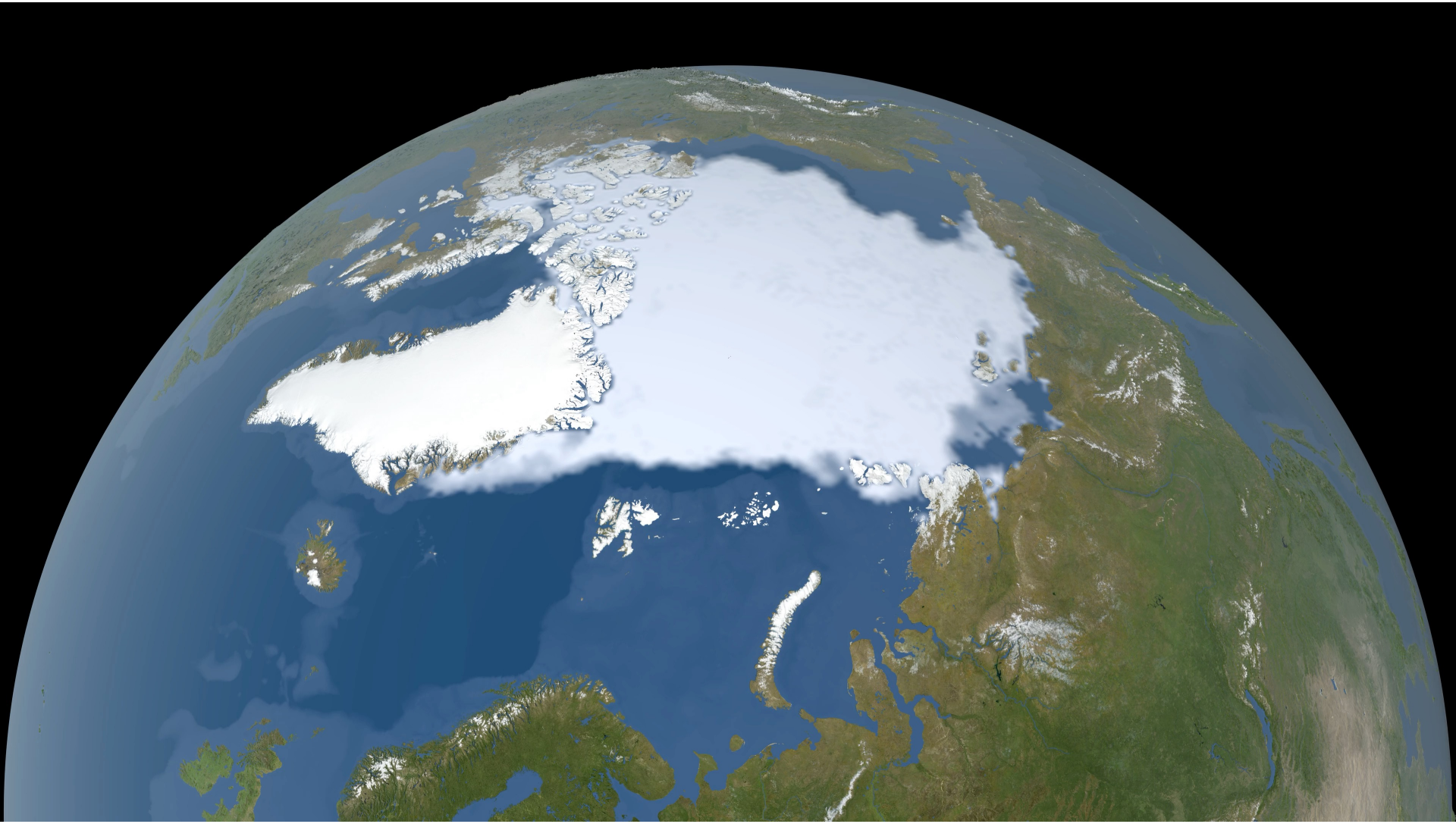


Source: NASA Goddard Space Flight Center - https://svs.gsfc.nasa.gov/5110

Drivers – The global warming

Source: NASA Scientific Visualization Studio - https://svs.gsfc.nasa.gov/14396/

Drivers – Artic ocean ice coverage

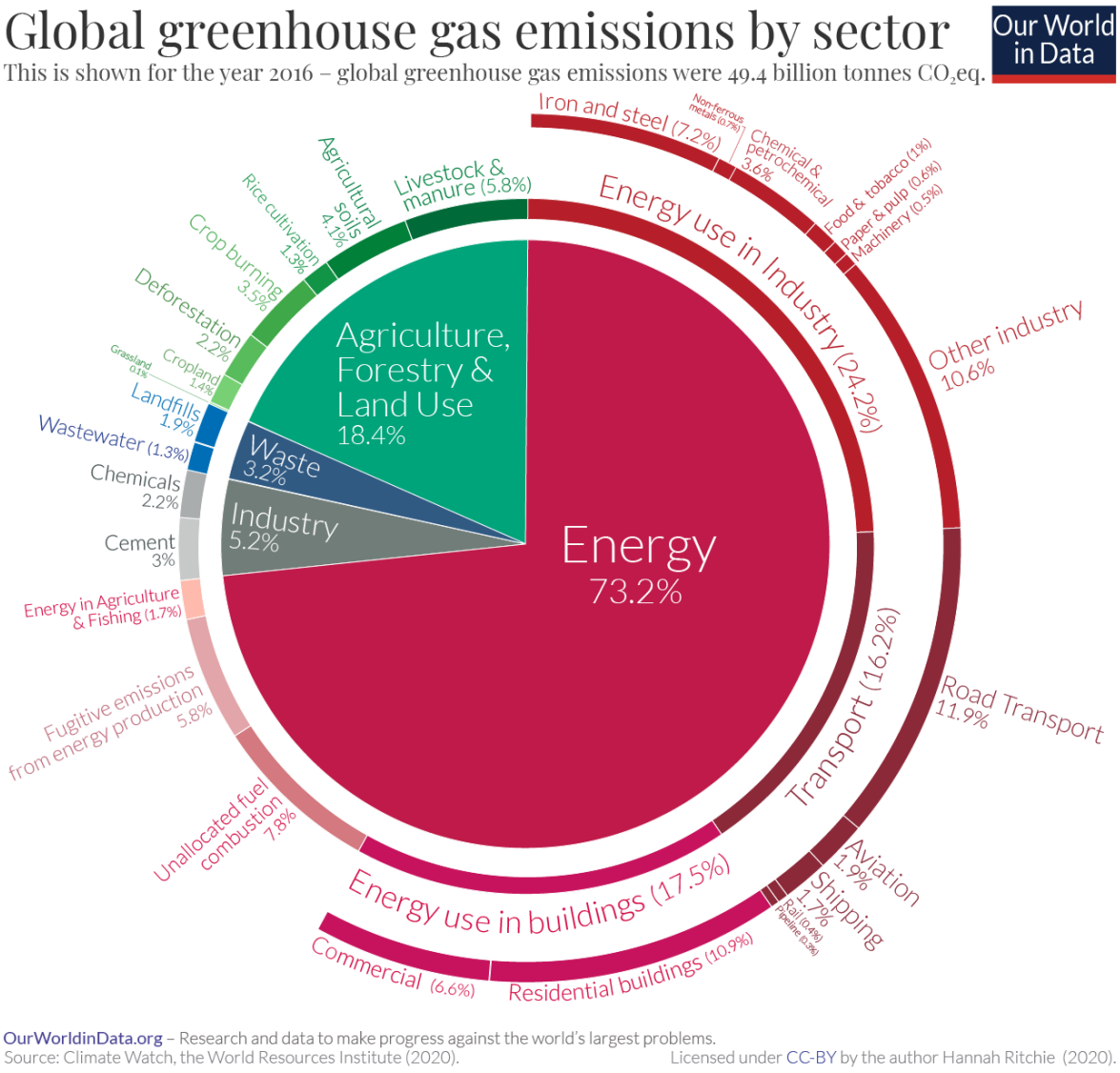


Source: NASA Visualization Explorer
https://science.nasa.gov/resource/video-annual-arctic-sea-ice-minimum-1979-2022-with-area-graph/

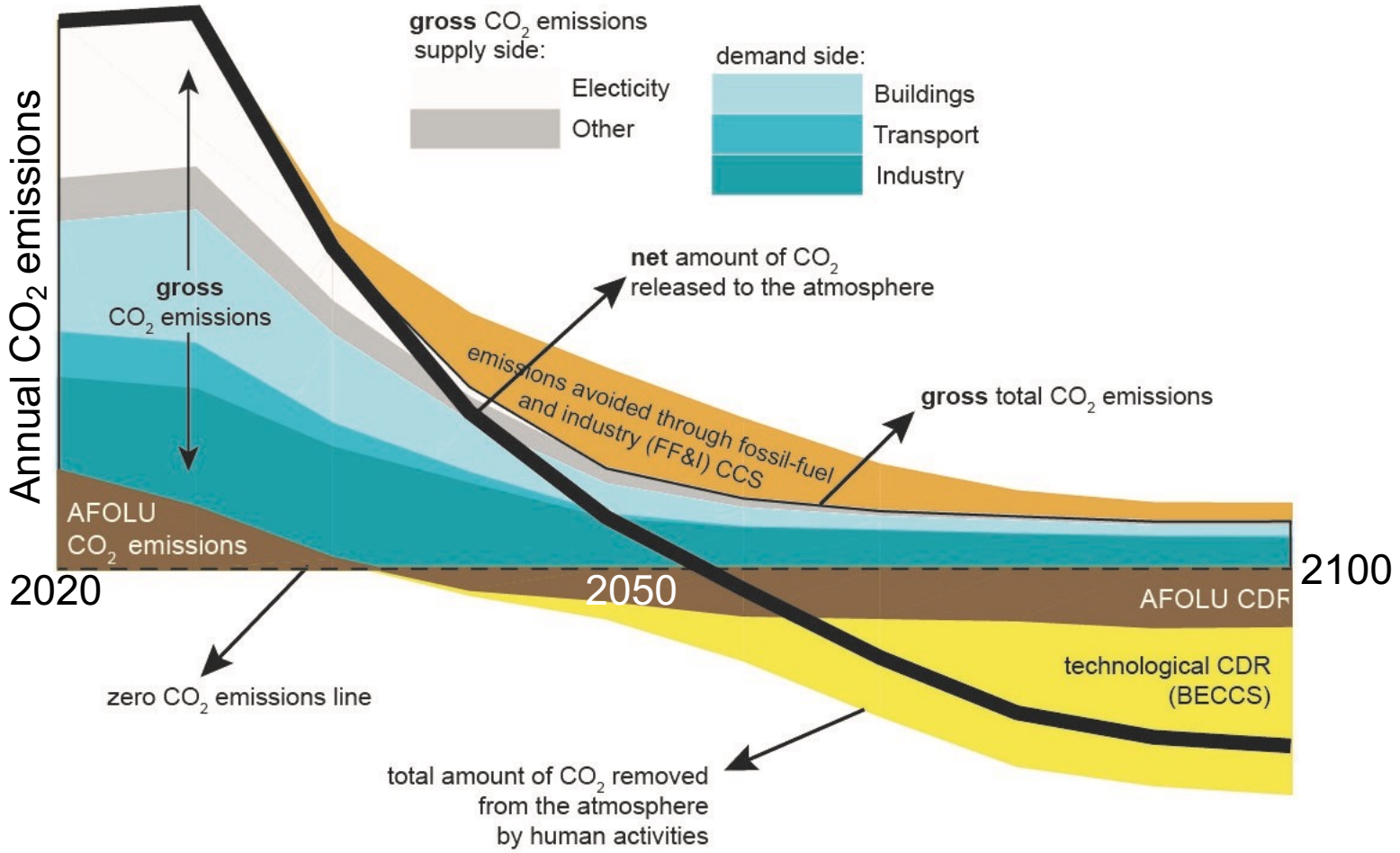
Global greenhouse emissions by sector in 2016

Source:

https://github.com/owid/co2-data



Evolution and break down of global anthropogenic CO_2 emissions until 2100



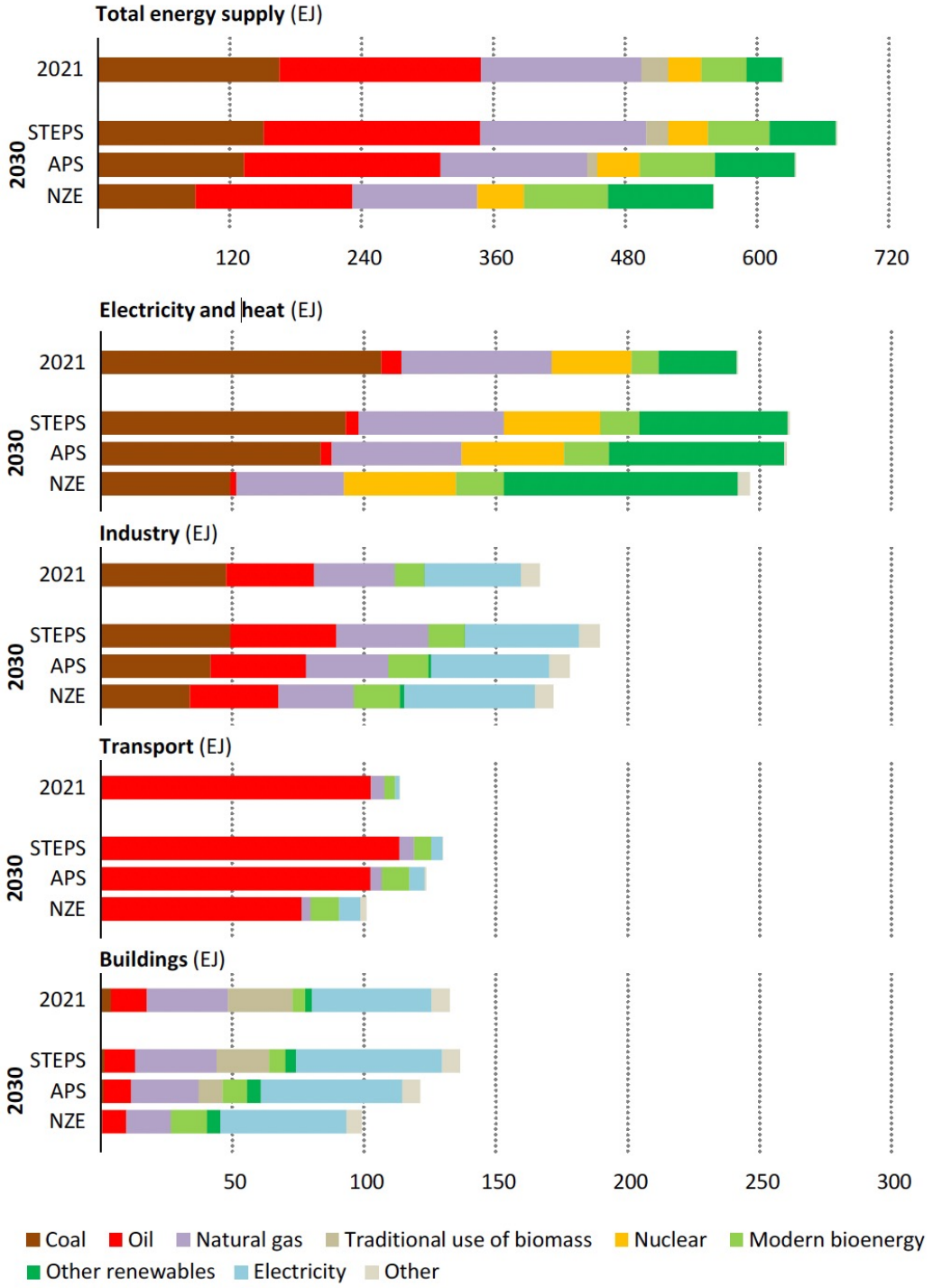
Source: IPCC Special report "Global warming of 1.5 degC"
https://www.ipcc.ch/site/assets/uploads/sites/2/2019/01/Figure-2.5.jpg
The IPCC is the Intergovernmental Panel on Climate Change (IPCC) of the United Nations (body in charge for assessing science-related aspects to climate change.

Global energy supply and demand by sector, scenario and fuel

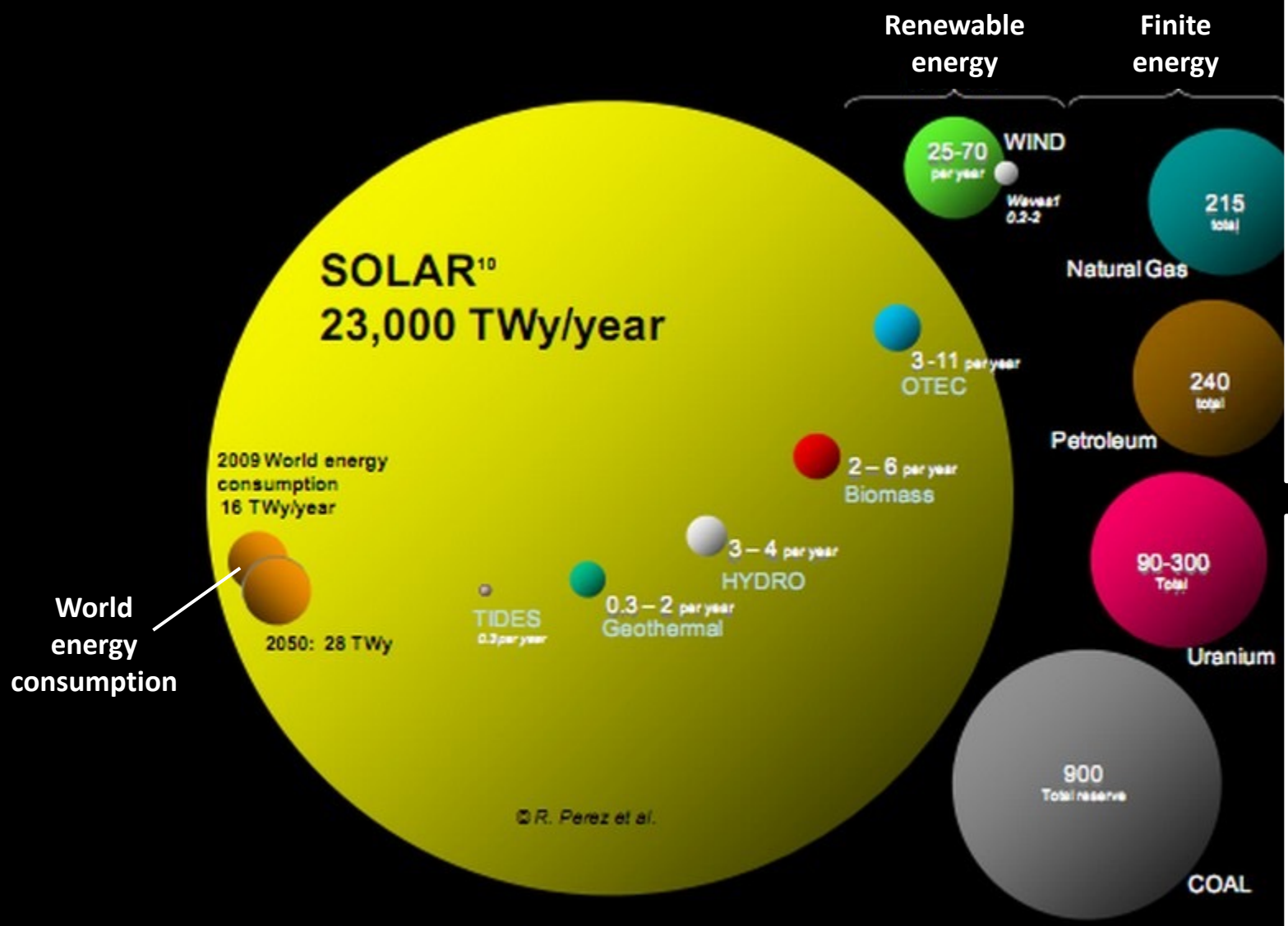
Scenario acronyms:

- STEPS (Stated Policies Scenario): trajectory implied by today's policy settings.
- APS (Announced Pledges Scenario): assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals.
- NZE (Net Zero Emissions) hard net-zero by 2050.

Source: IEA World Energy Outlook, 2022



Global availability of energy resources in [TWy]



"Comparing finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables." (source: Perez & Perez, 2009a)

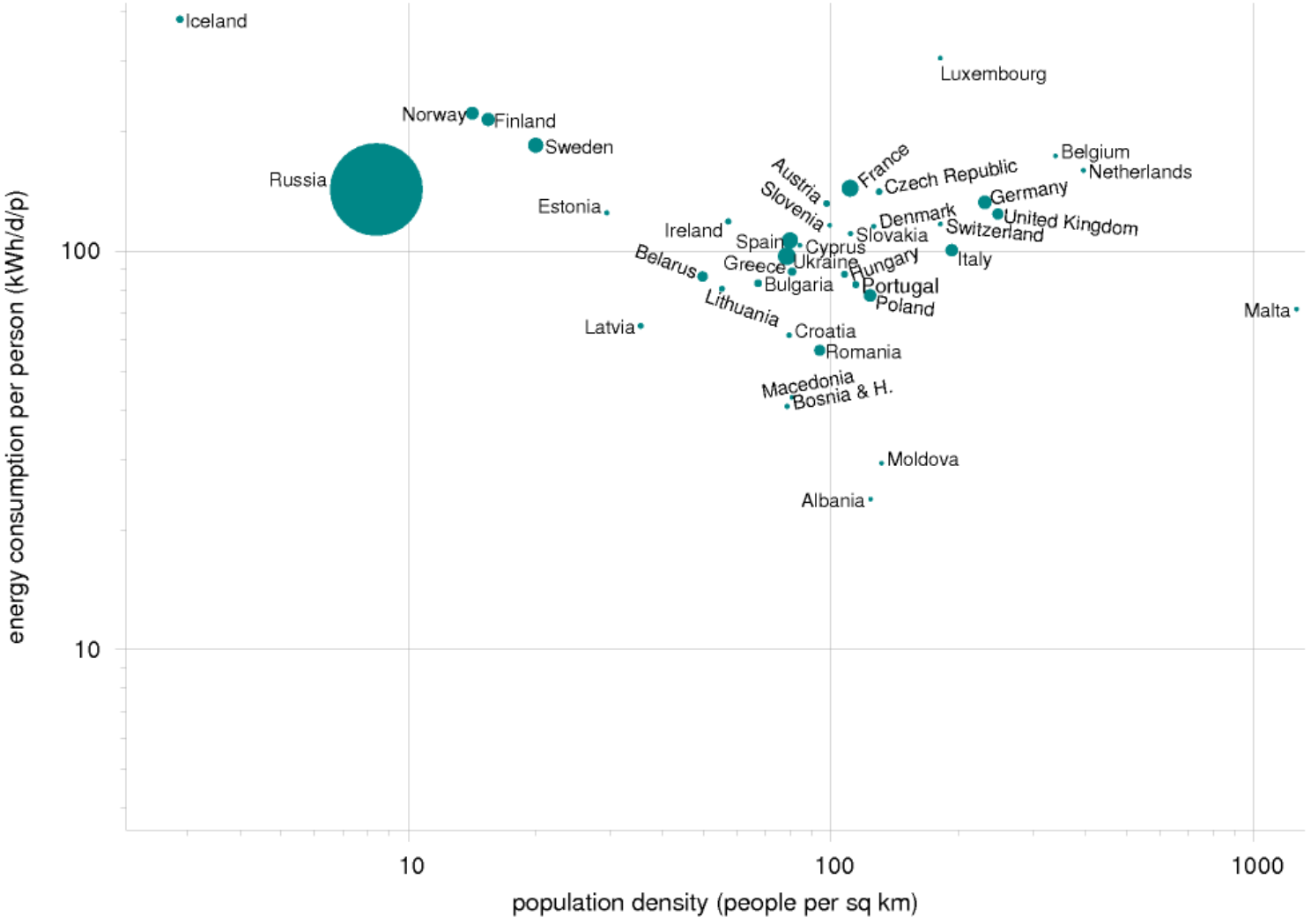
WORLD ENERGY CONSUMP-TION FACTS

- 87% from finite energy
- 13% from renewable energy

IPCC REPORT (2013)

- 83% fossil fuels must be left in the ground to avoid catastrophic climate change

Energy consumption vs population density



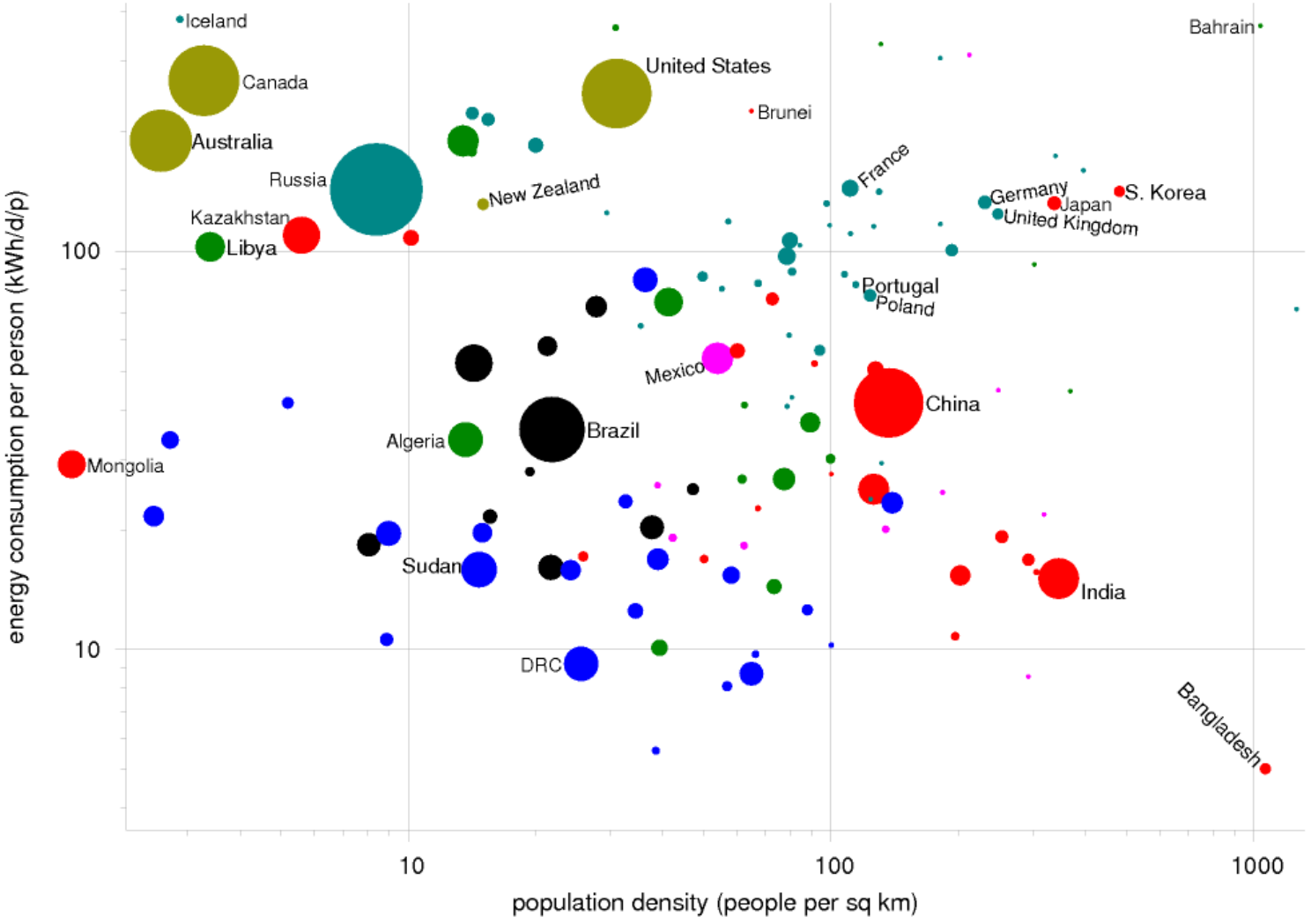
Source: D. MacKay TEDx Warwick talk March 2012

(point size shows land area)

Energy consumption vs population density

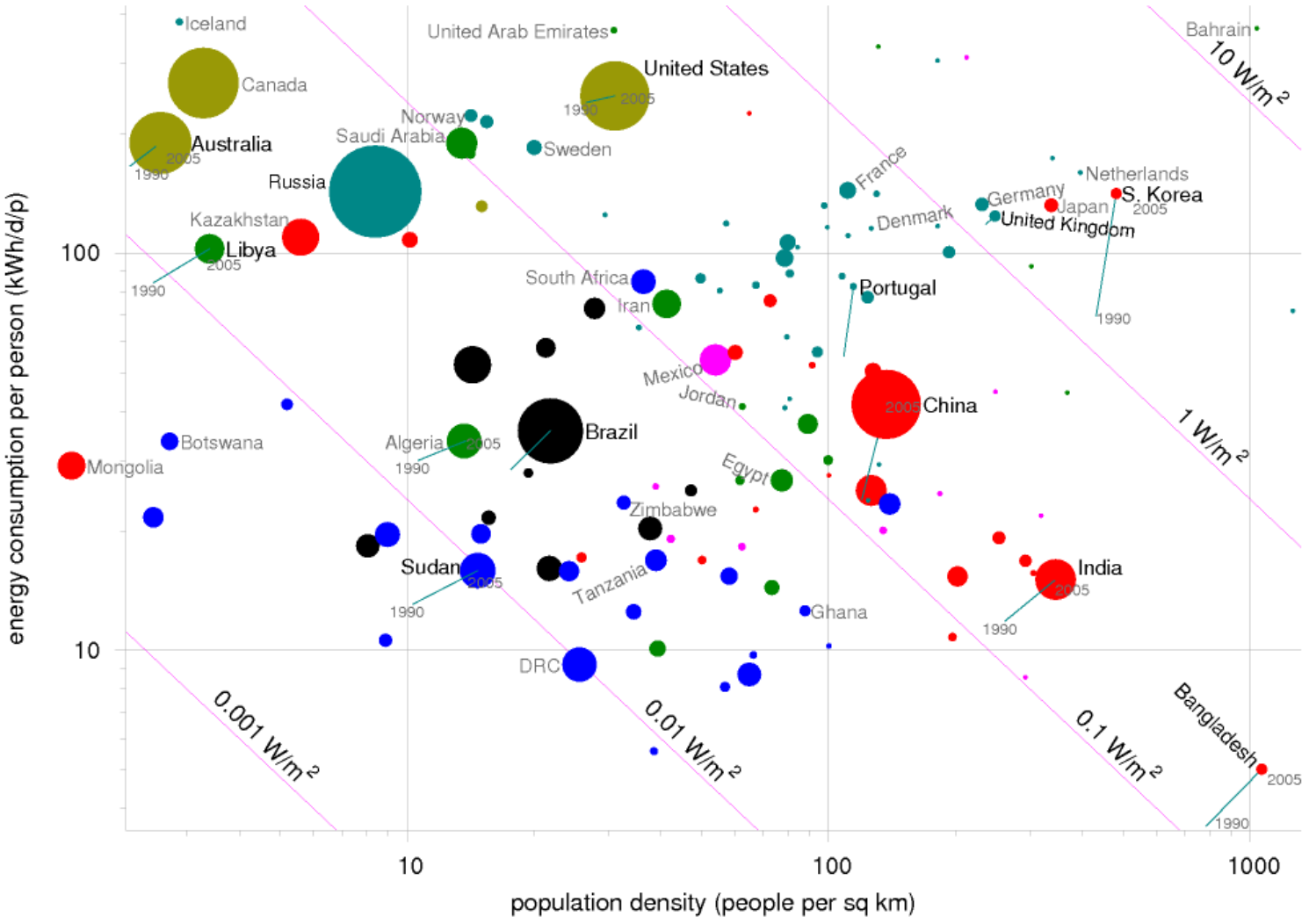
Source: D. MacKay TEDx Warwick talk March 2012

Energy consumption vs population density



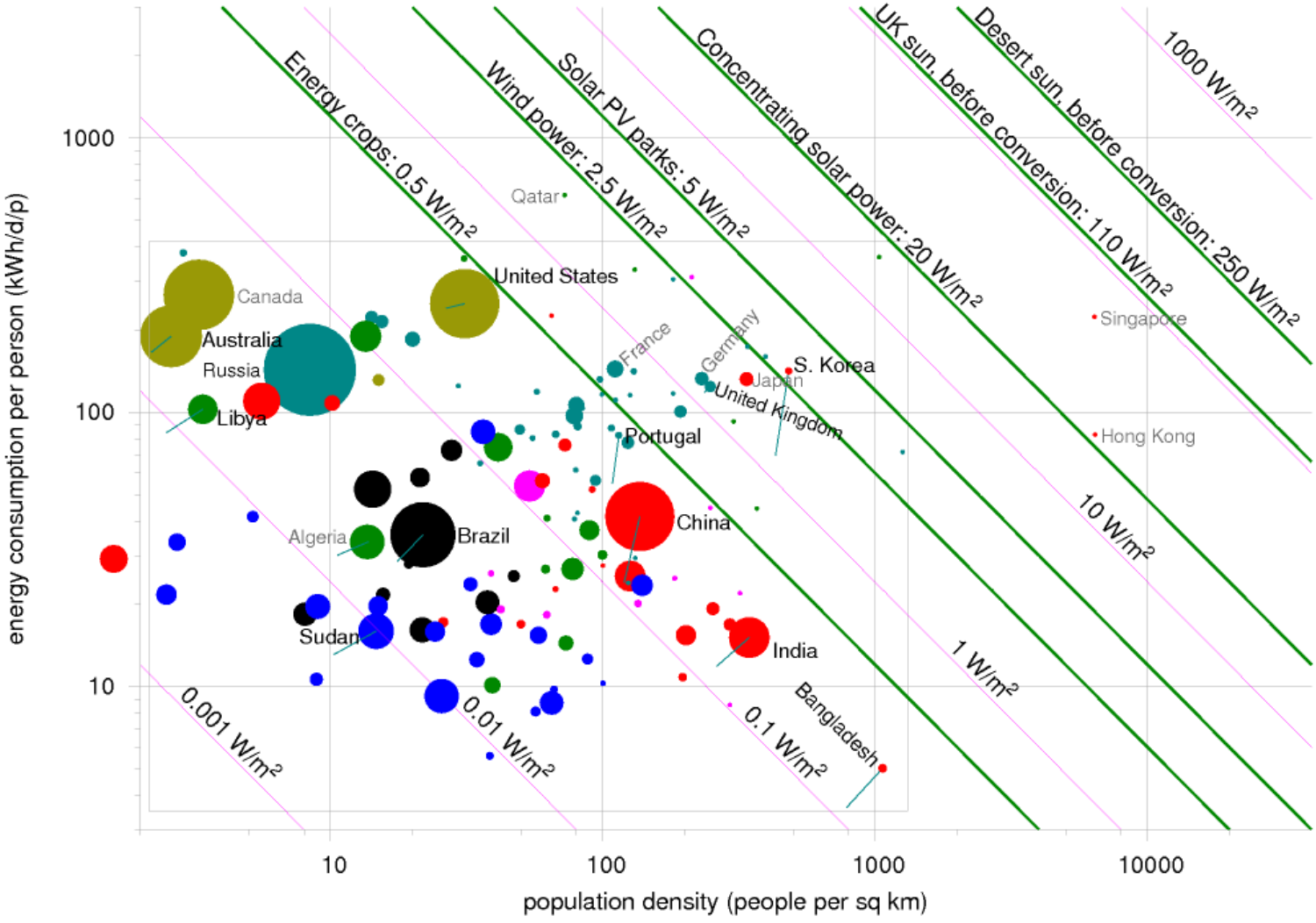
Source: D. MacKay TEDx Warwick talk March 2012

Energy consumption vs population density



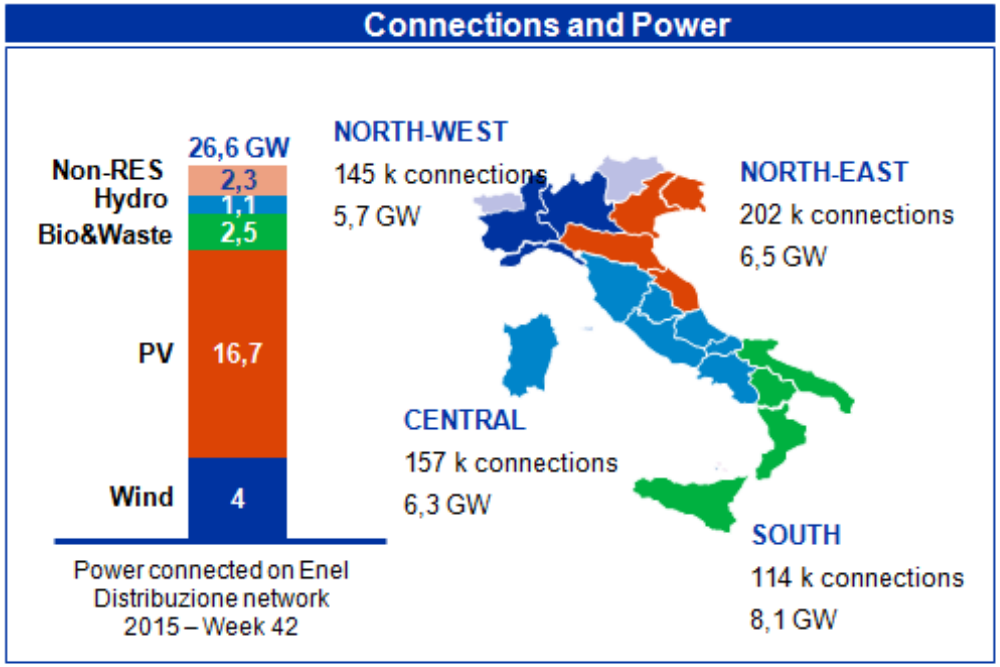
Source: D. MacKay TEDx Warwick talk March 2012

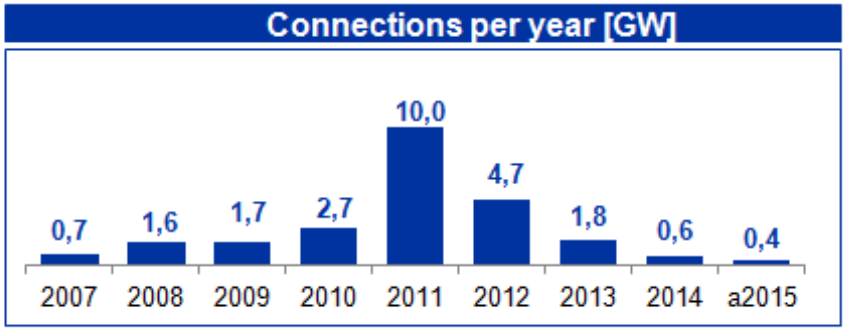
Energy consumption vs population density

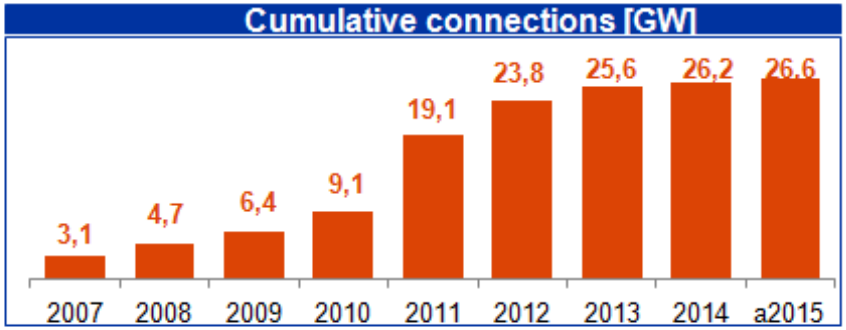


Source: D. MacKay TEDx Warwick talk March 2012

Renewables growth: the case of italy







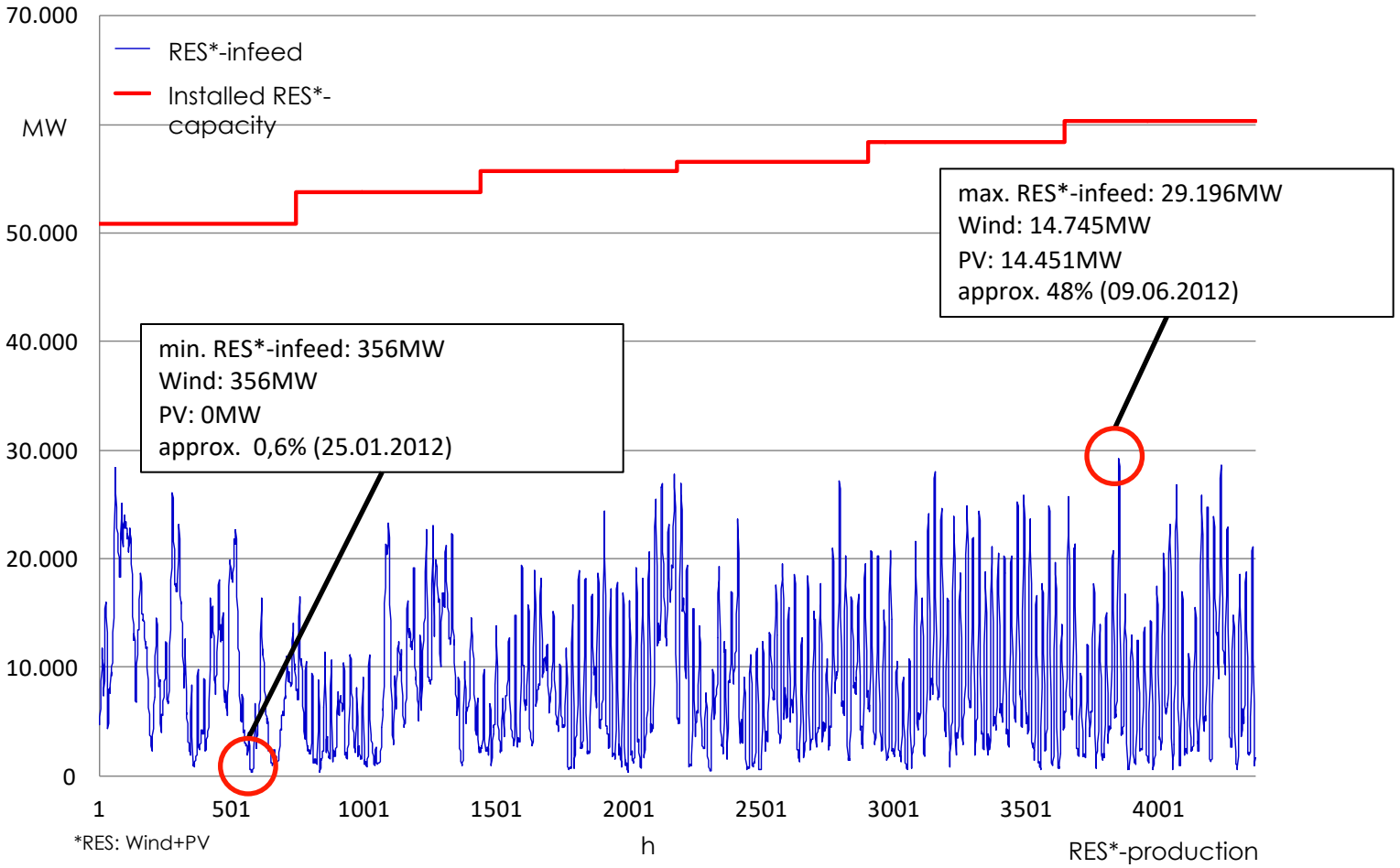
618.000 connections (26,6 GW) on Enel Distribuzione network

Data source C. D'Adamo, PSCC 2016

Time-scales of renewables volatility: intra-seasons

Seasonal volatility Jan 1st – Jun 30th 2012 (Wind+PV)
Installed capacity vs real infeed: the case of Germany

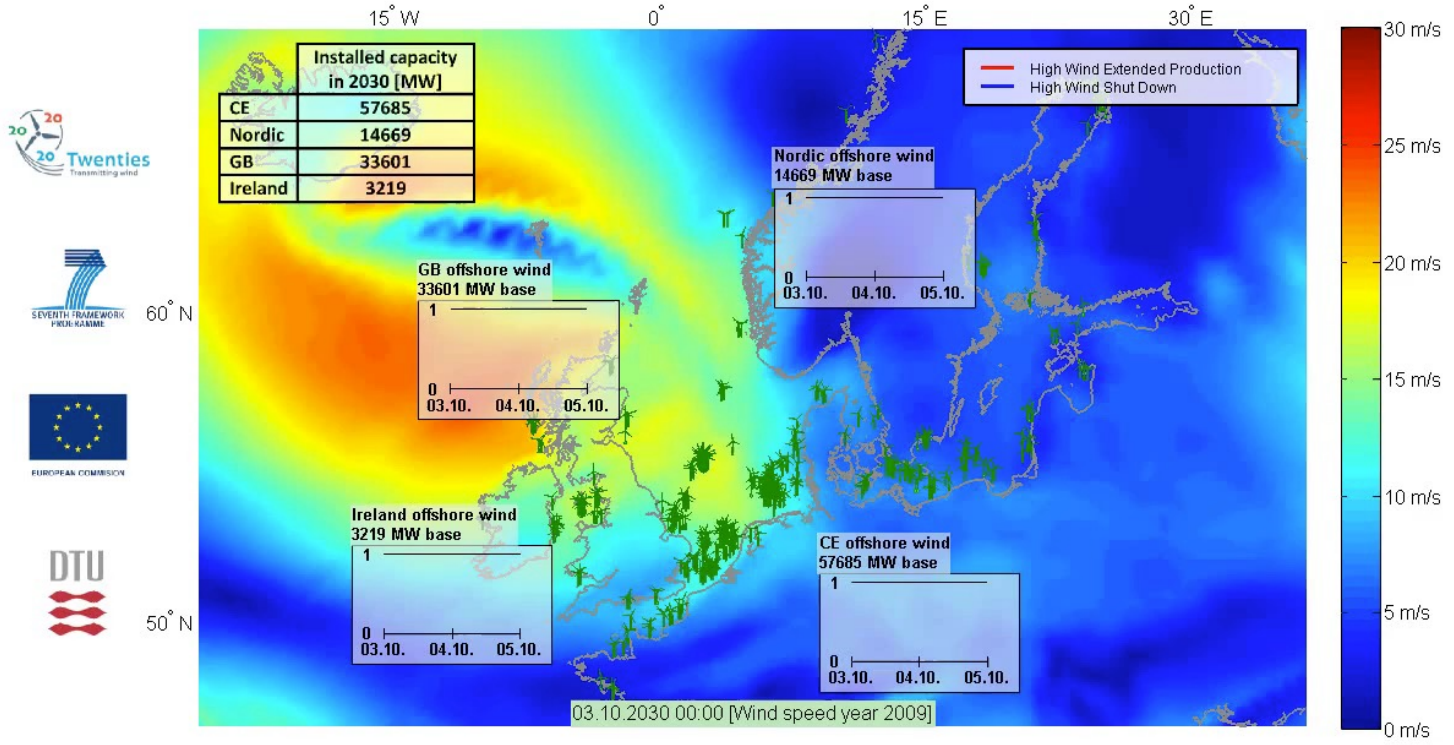
Source: G. Vanzetta



Time-scales of renewables volatility: days/hours

North European Offshore wind power variability in 2030

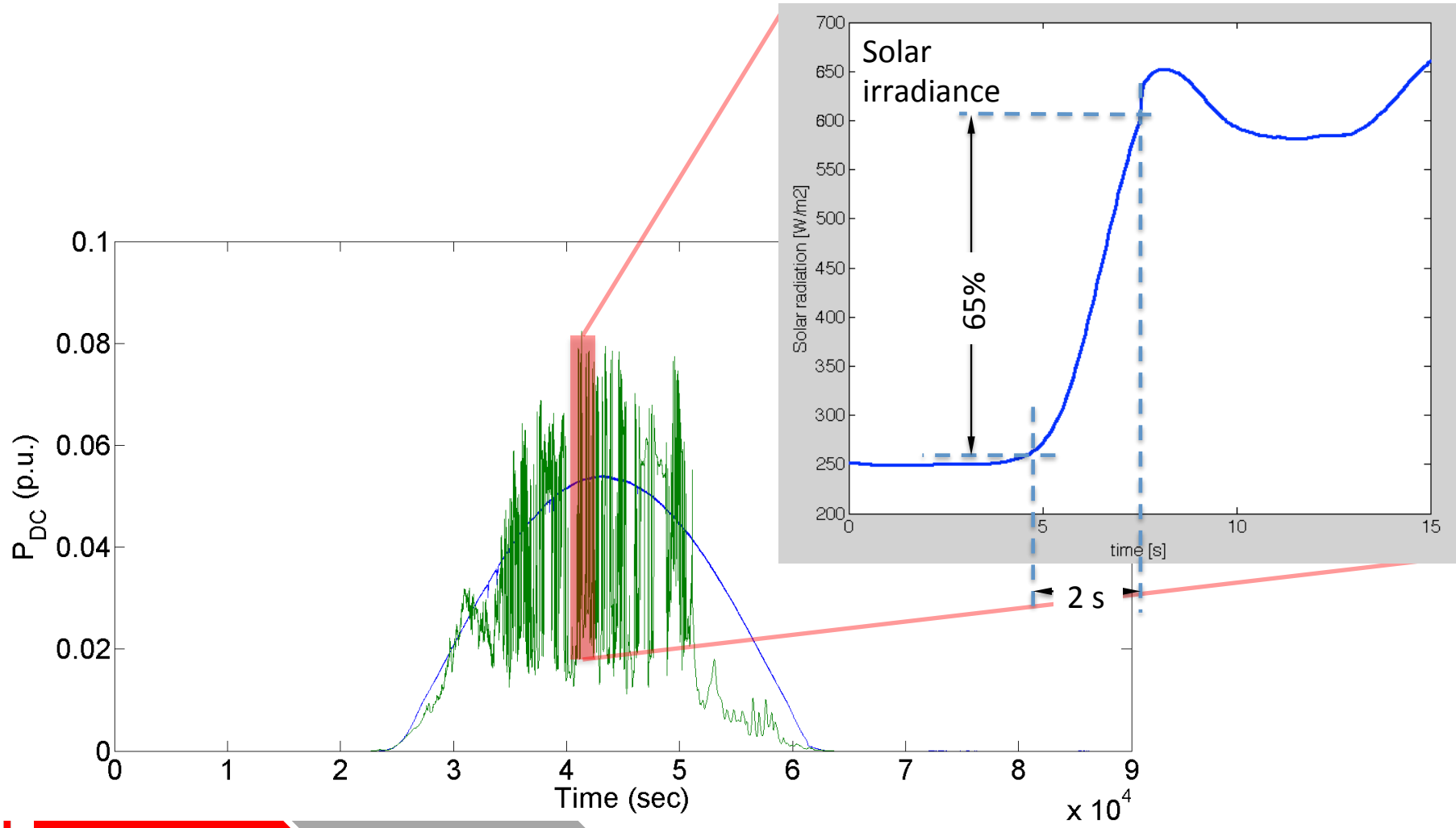
Wind power production aggregated at synchronous area level for offshore wind power in 2030 comparing the production for the High Wind Shut Down vs High Wind Extended Production.



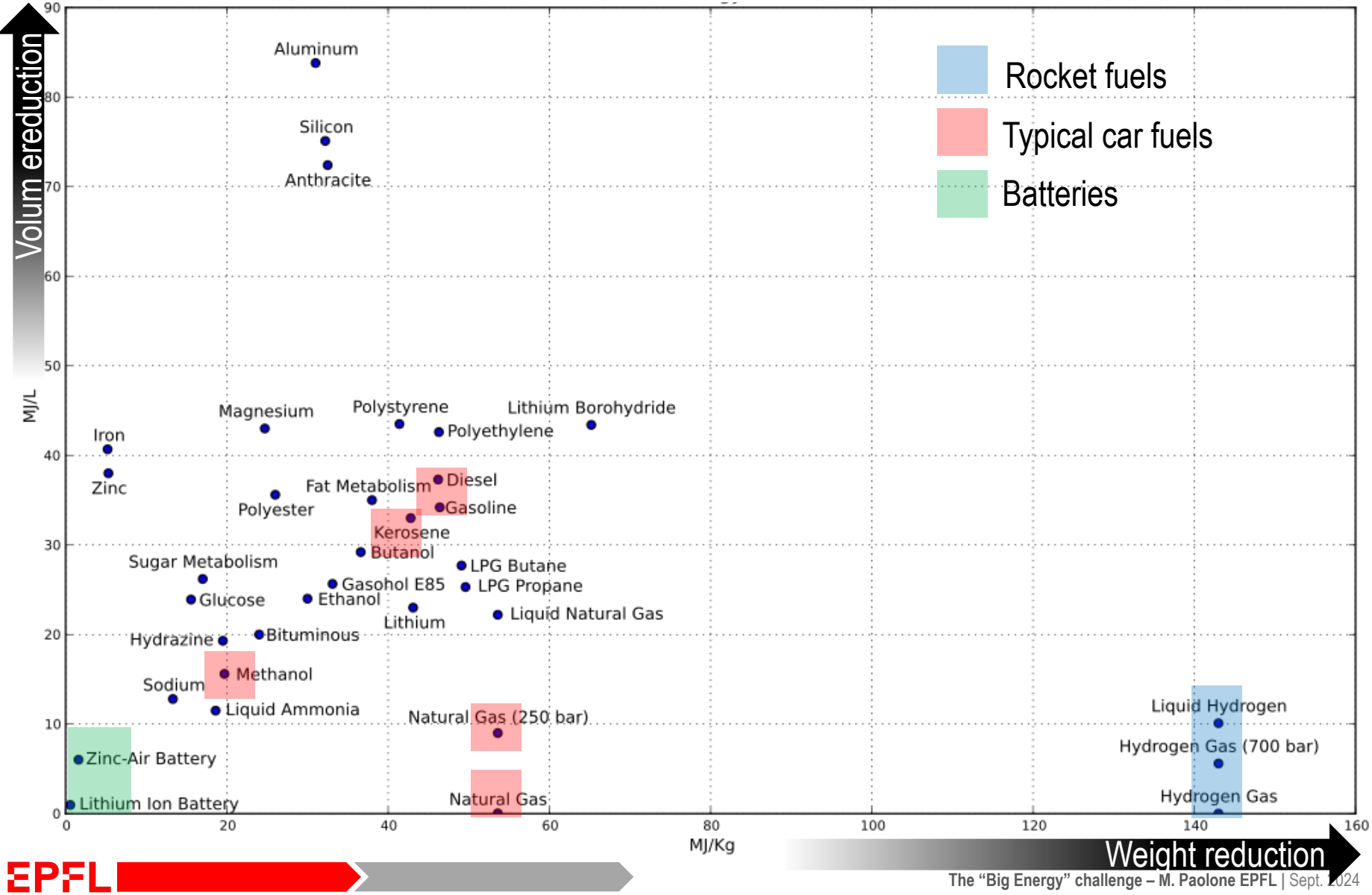
Adapted from: http://www.youtube.com/watch?v=TCfAcIz63sc

Time-scales of renewables volatility: seconds

Example of daily measured power injected by solar arrays at EPFL



Energy densities for storage systems



Energy systems