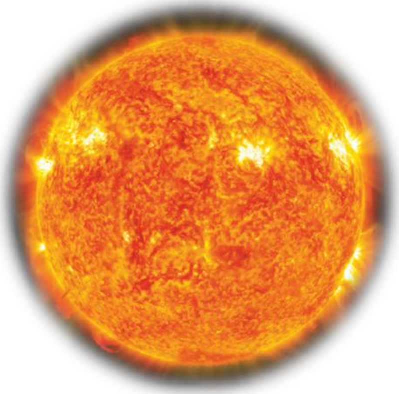


Synteettisen kaasun mahdollisuudet tulevaisuuden energiajärjestelmässä

Suomen Kaasuyhdistyksen kaasupäivä 18.11.2014,
Kämp Kansallissali

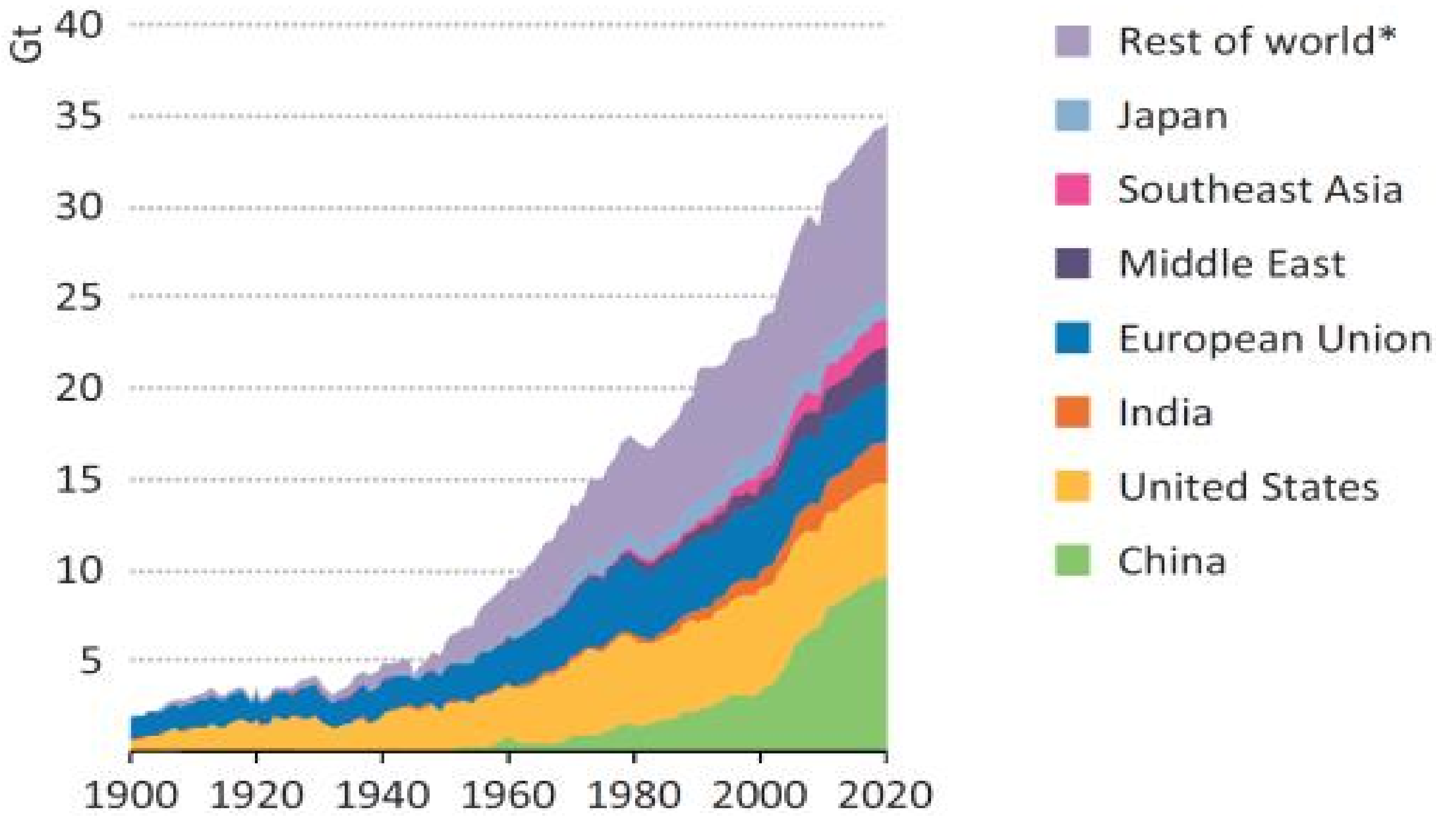
TkT Pasi Vainikka

VTT Technical Research Centre of Finland

Content

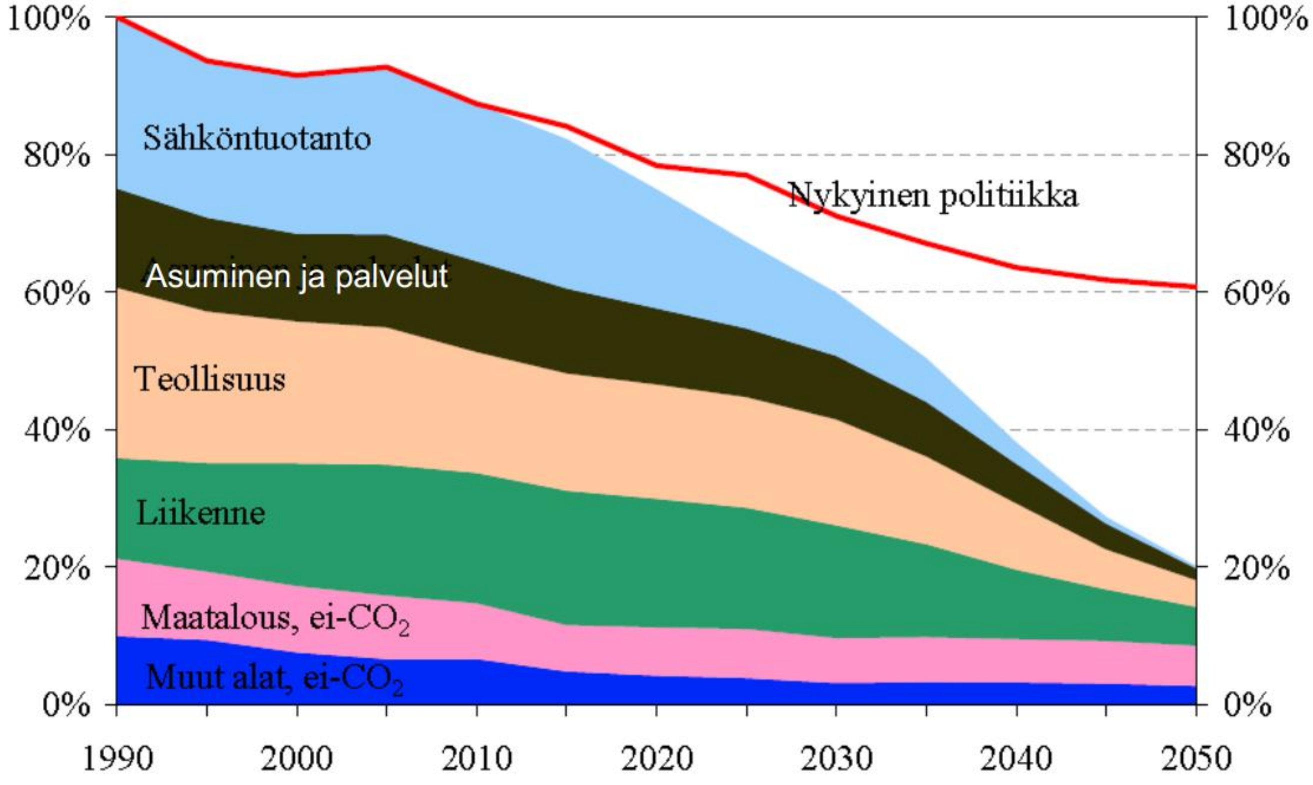
- Choices for energy sources
- Status in renewables
- The different types of storages
- The role of energy storages
- State-of-the-art in ‘Power-to-Gas’ and the role of ‘P2G’
- How ‘100% renewable’ electricity system works

Global energy related CO_2 emissions



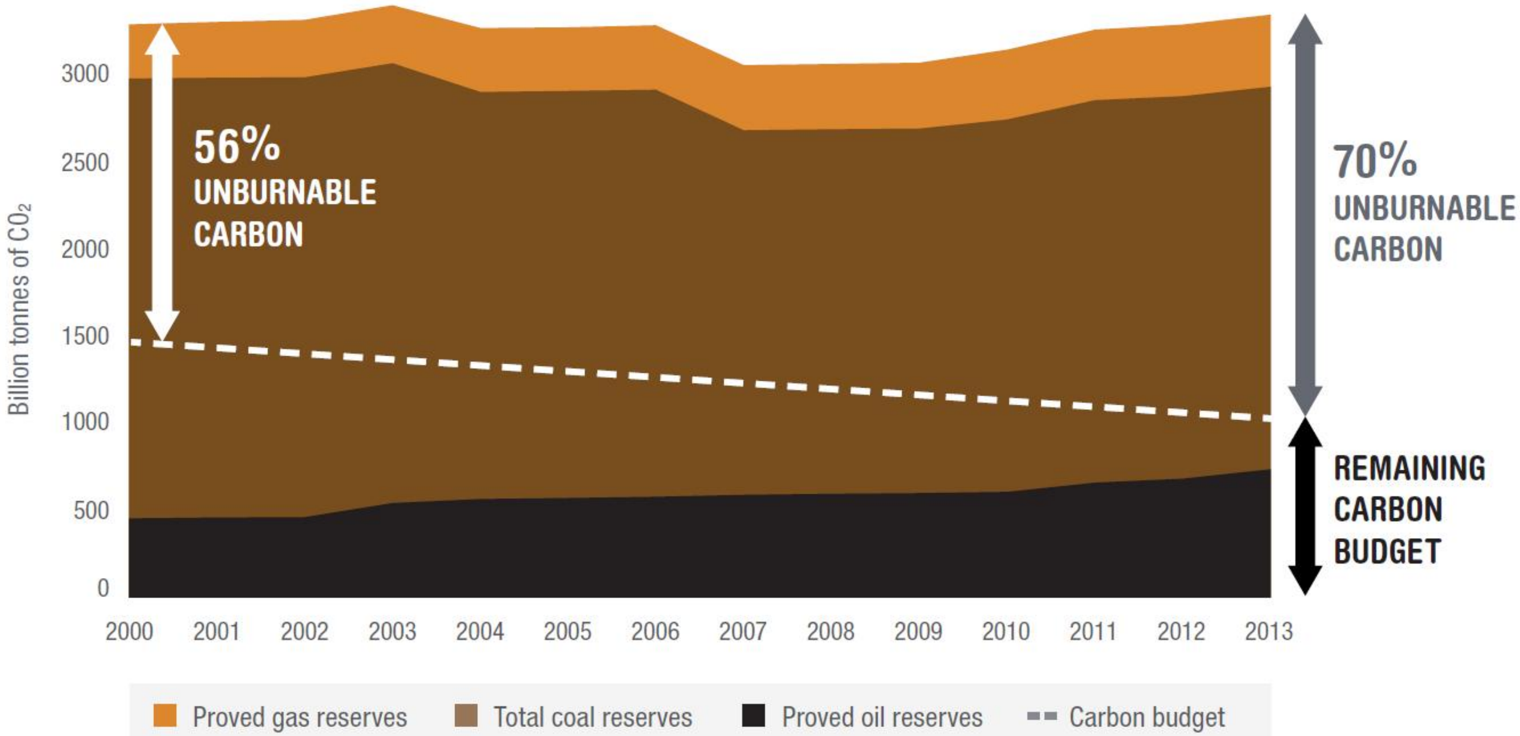
Source: **IEA, 2013. World Energy Outlook 2014**

Target 2050, GHG



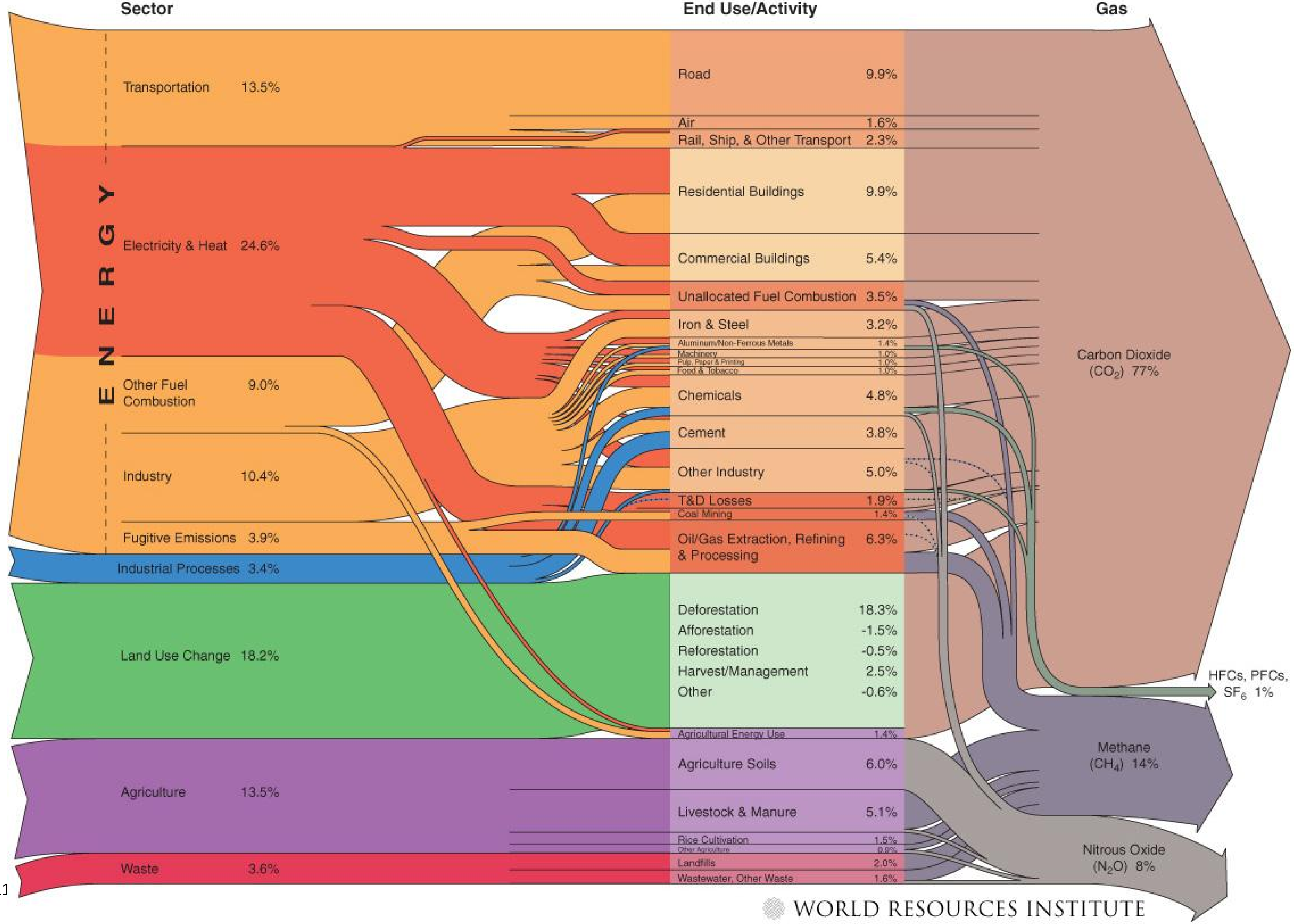
Implication

- As much as 80% of the coal, oil and gas reserves are ‘unburnable,’ and this unburnable carbon represents potentially ‘stranded’ assets.

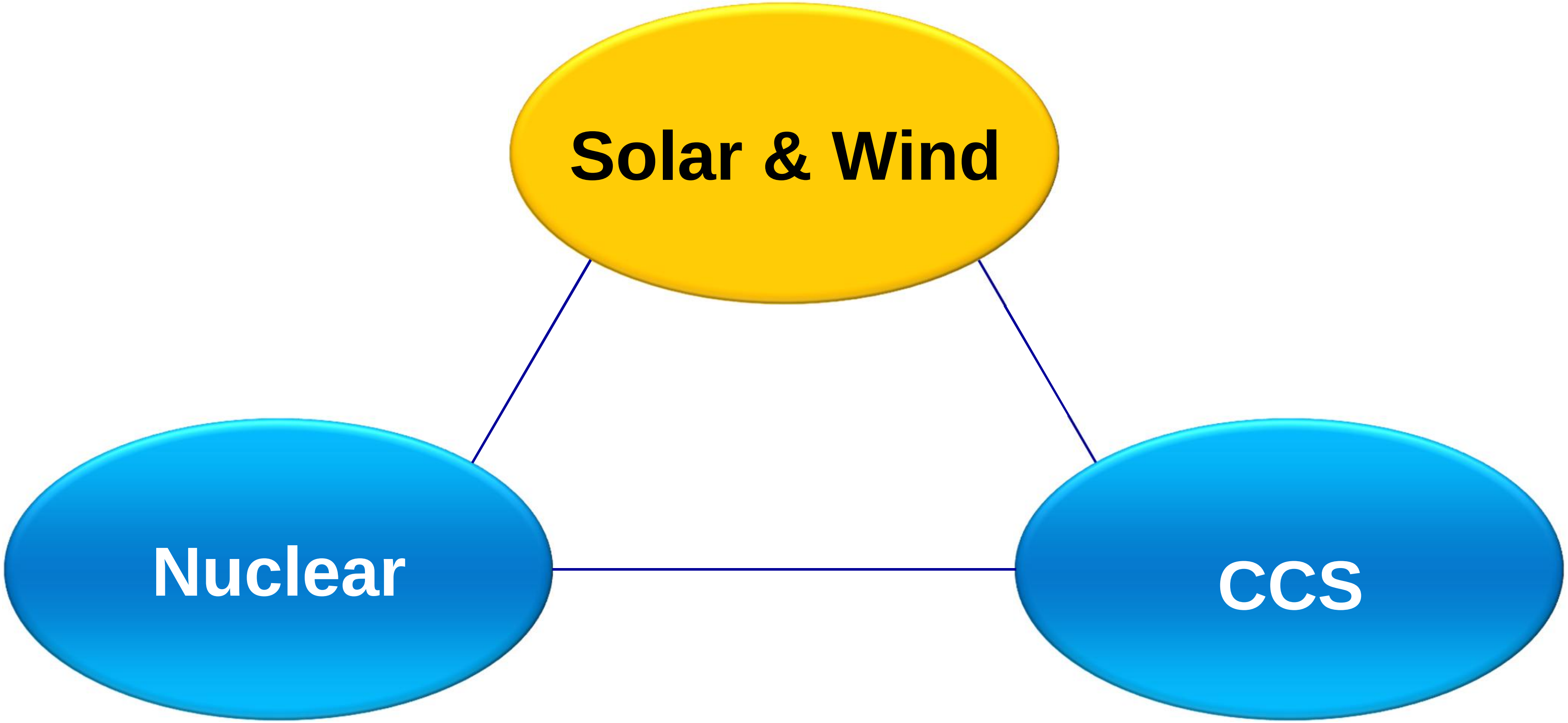


Source: **The fossil fuel bailout: G20 subsidies for oil, gas and coal exploration**
Overseas Development Institute, Oil Change International

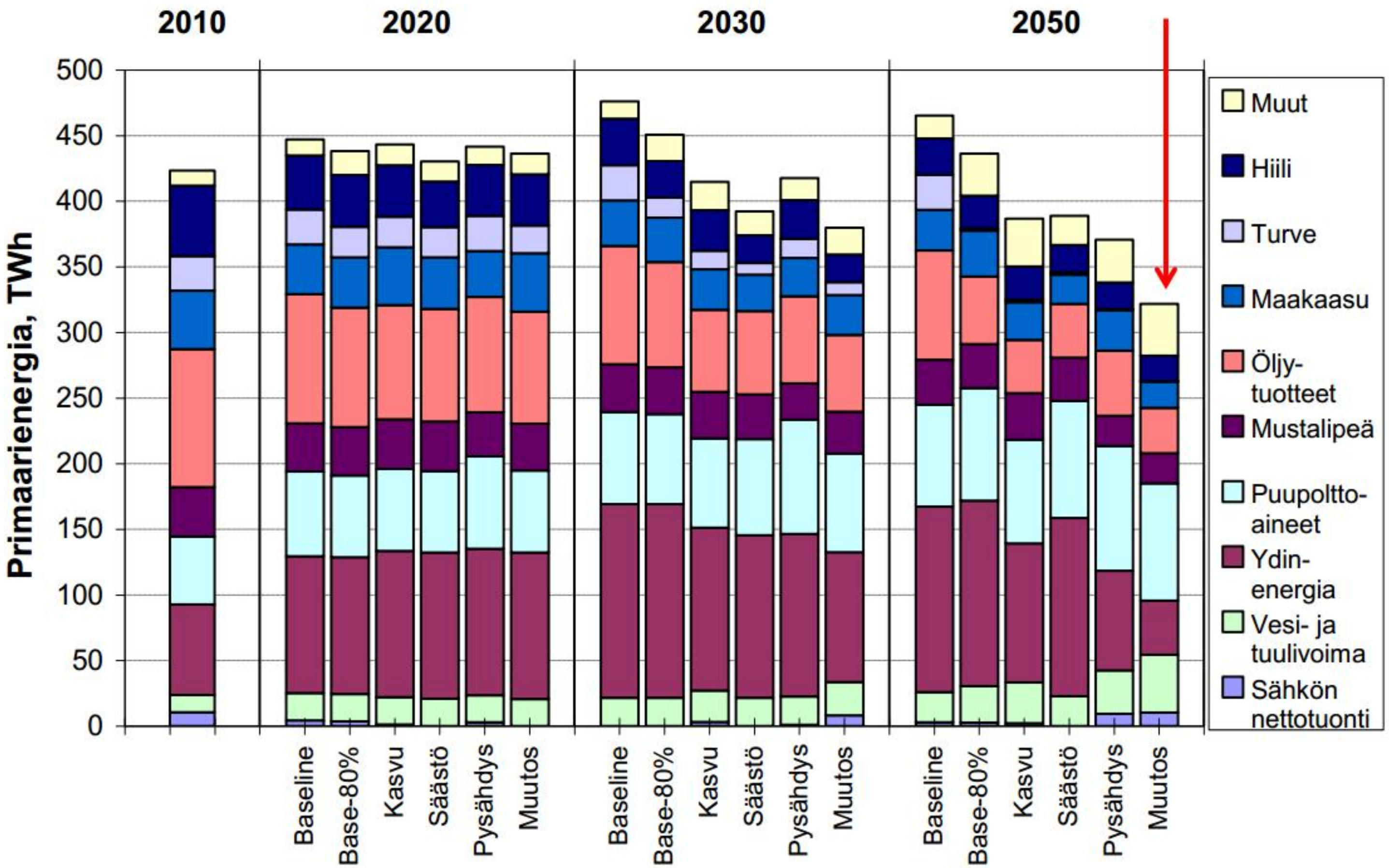
World GHG Emissions Flow Chart



Options

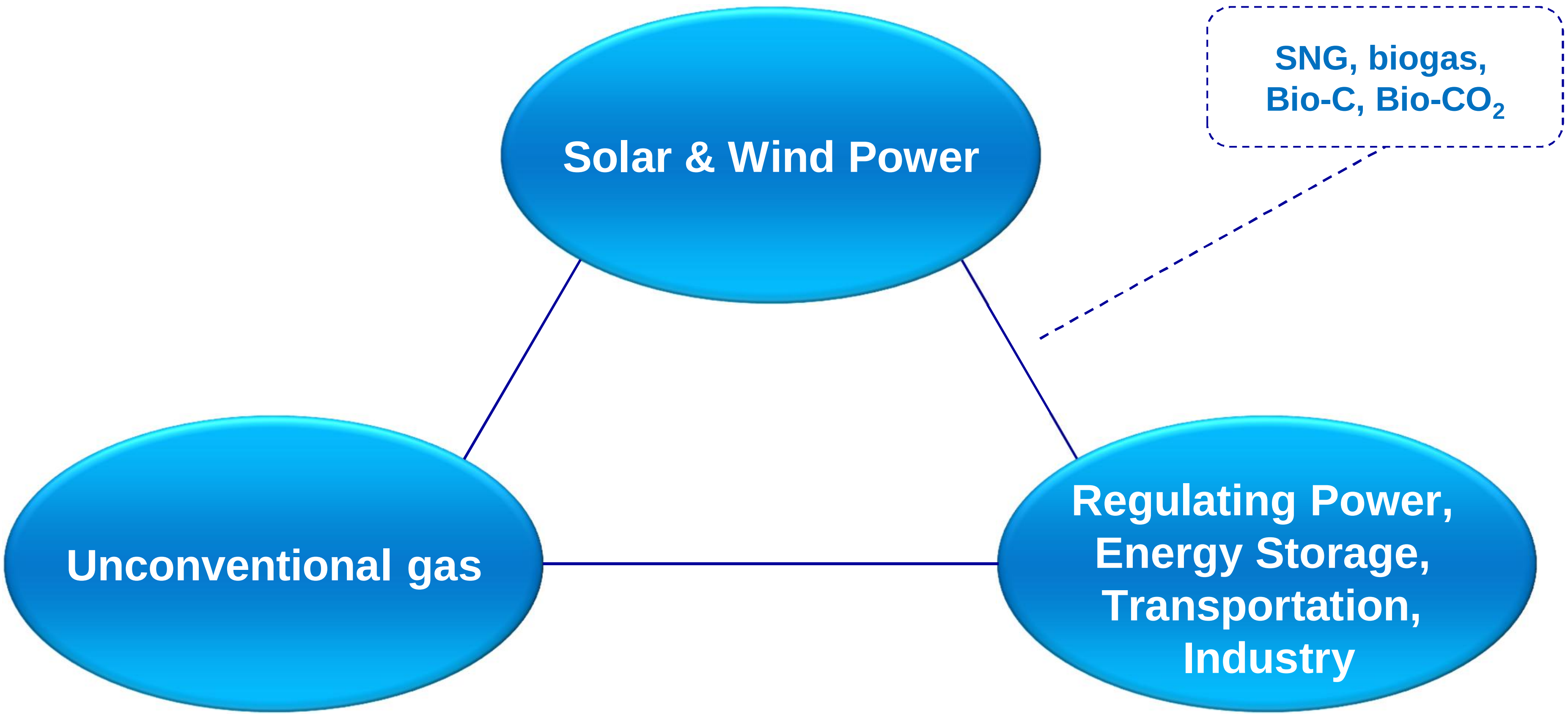


Proposed solutions

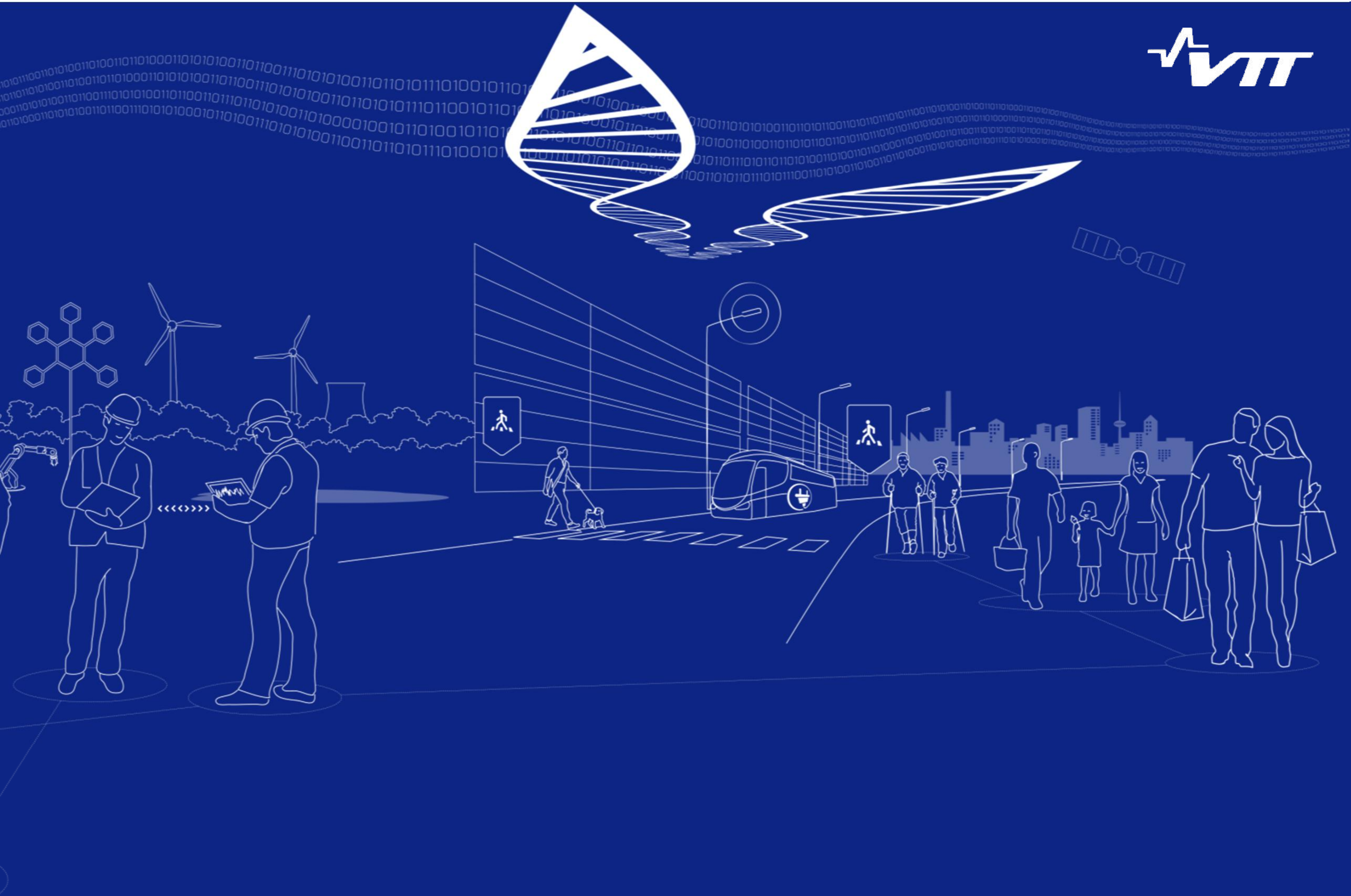


Source: Low Carbon Finland 2050 -platform (LCFinPlat)

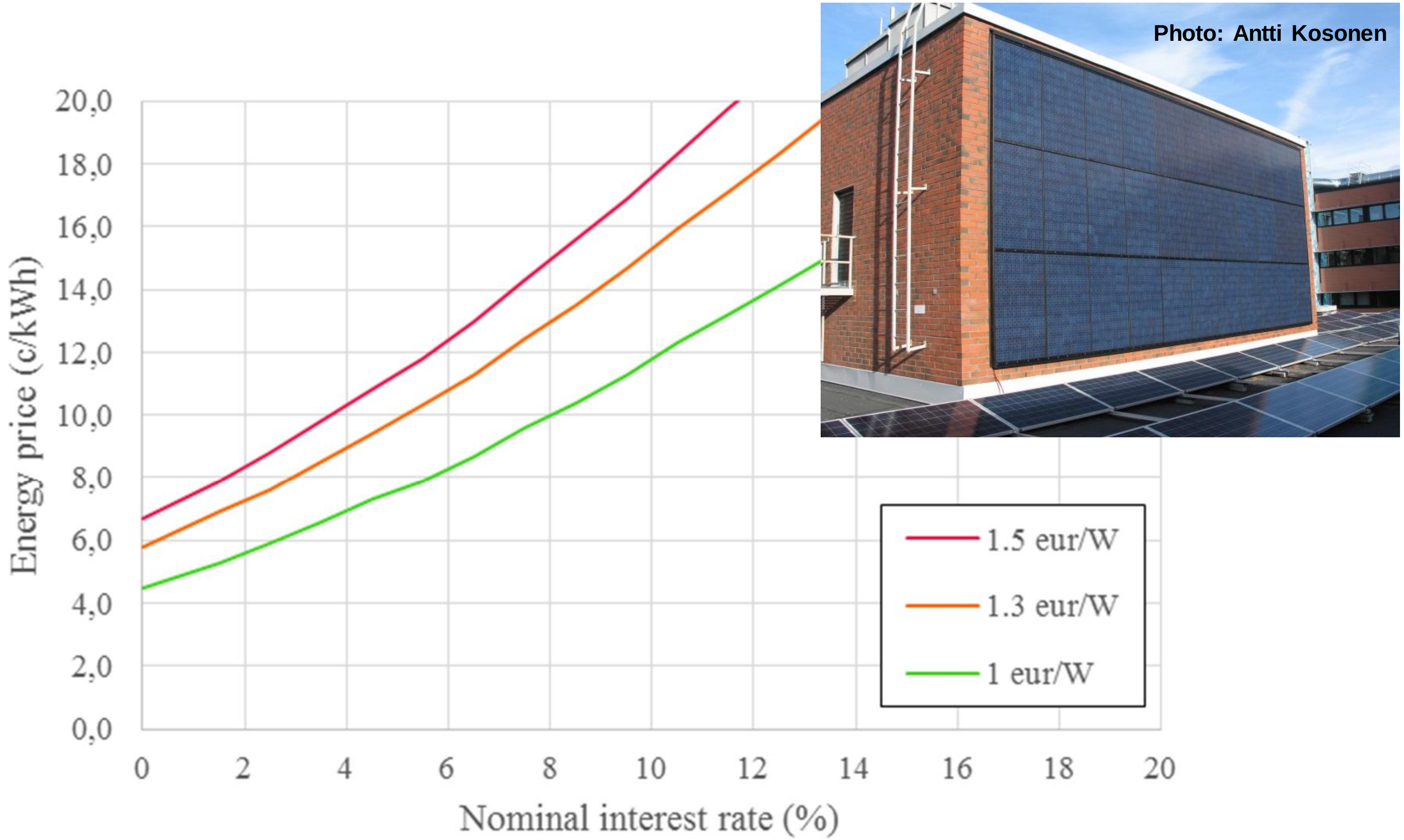
Trends



SNG, biogas,
Bio-C, Bio-CO_2
Solar & Wind Power
Unconventional gas
Regulating Power,
Energy Storage,
Transportation,
Industry



PV cost (in Finland), LUT solar power plant

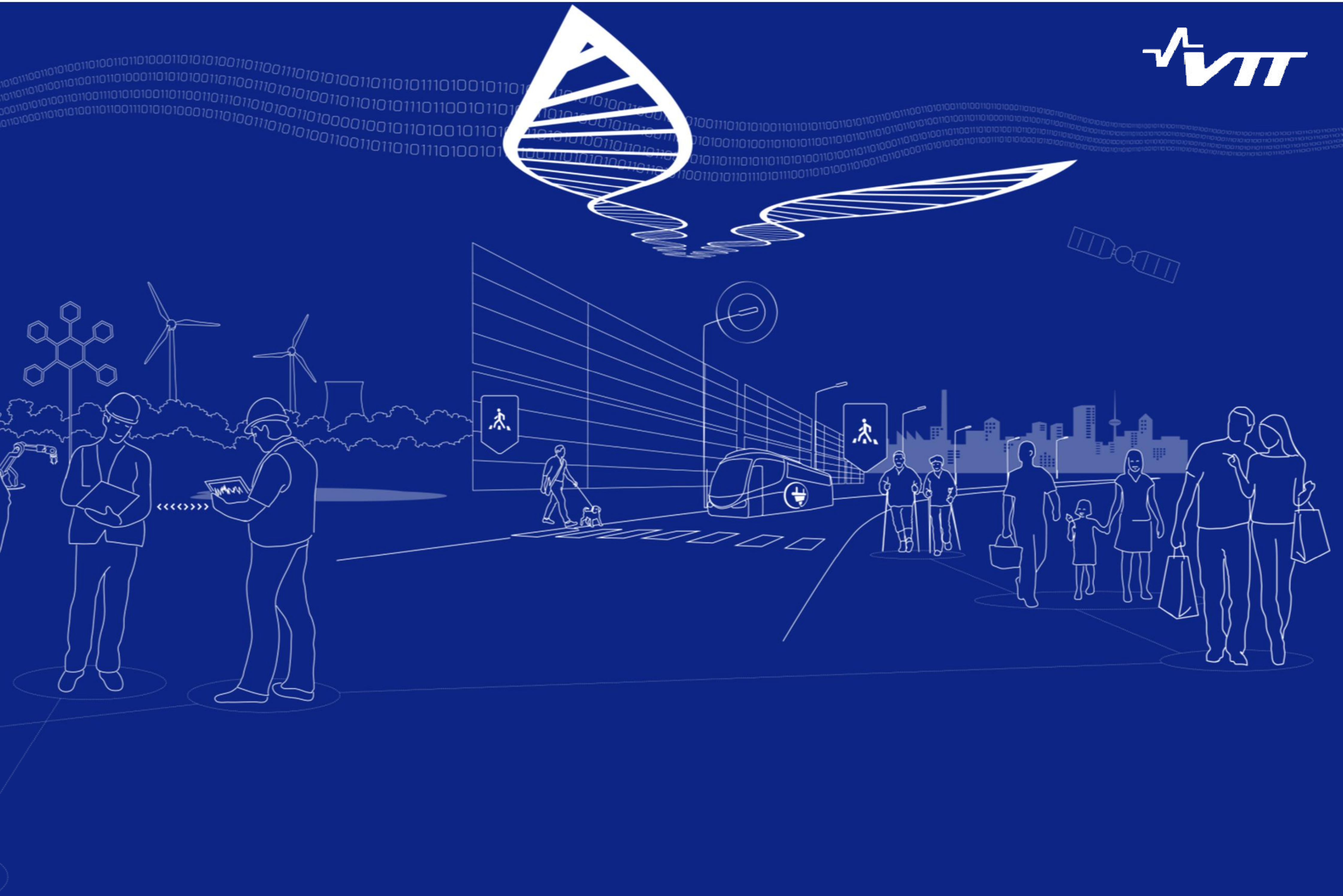


Source: **Antti Kosonen, Jero Ahola, Christian Breyer,**
Large Scale Solar Power Plant in Nordic Conditions.
EPE'14 ECCE Europe

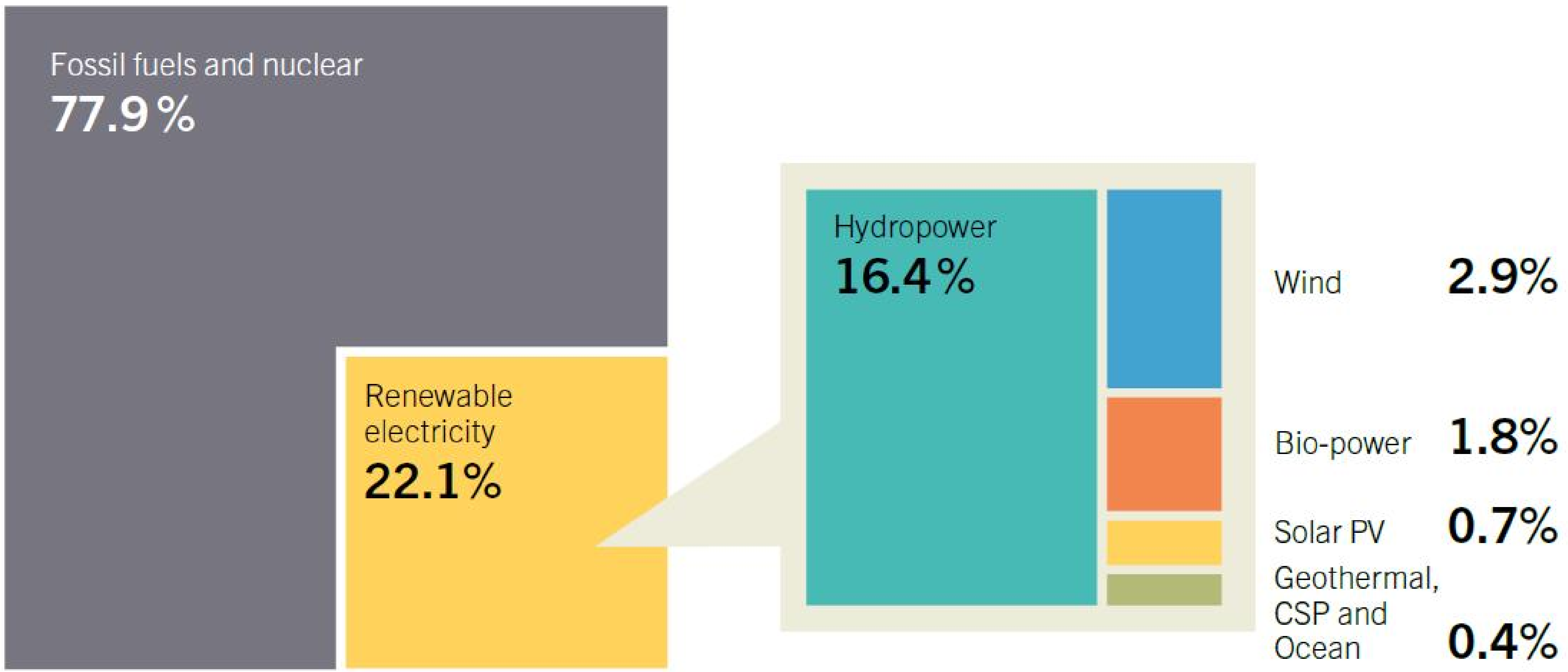
Levelised Cost of Energy Comparison

Source: Lazard estimates.

Source: Lazard's Levelized Cost of Energy Analysis ("LCOE"), September 2014

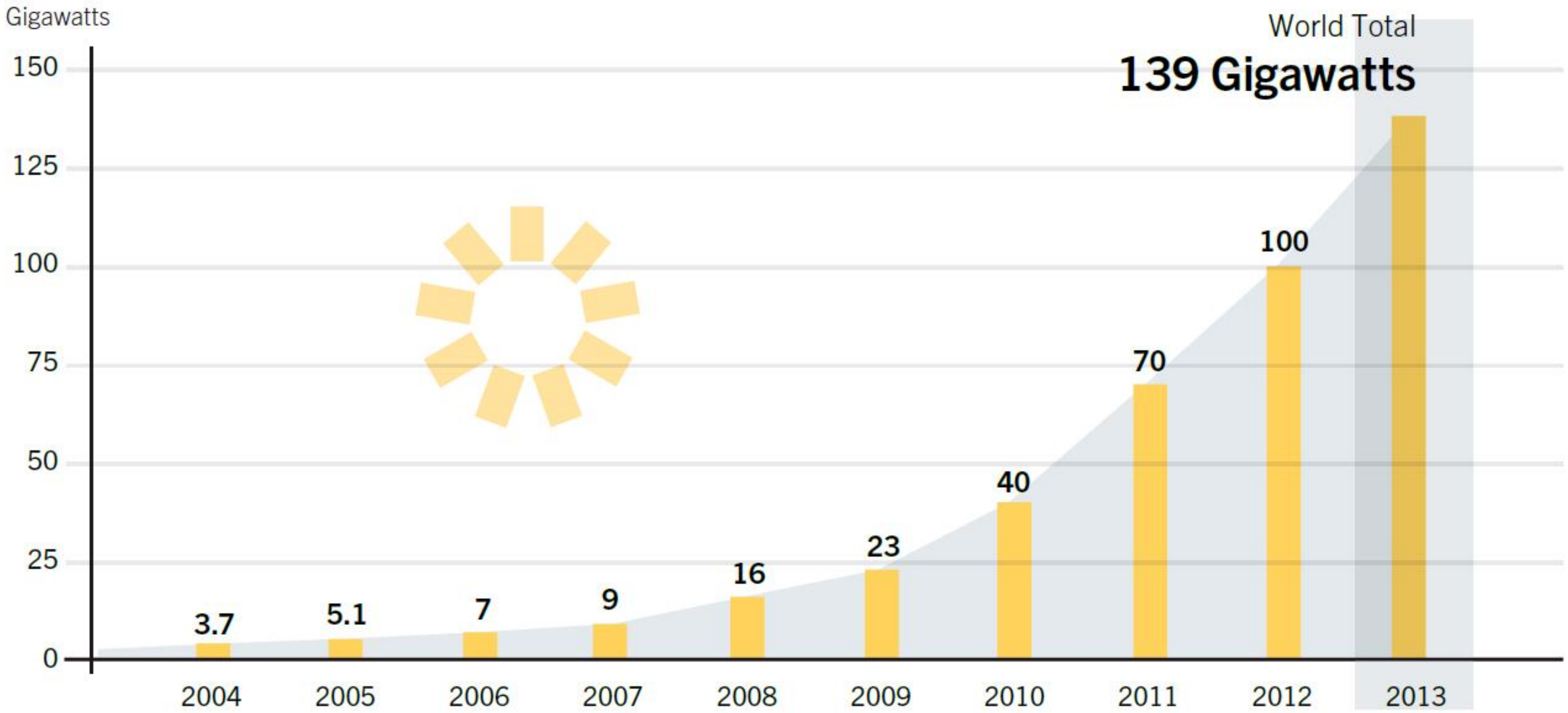


Estimated Renewable Energy Share of Global Electricity Production, End-2013

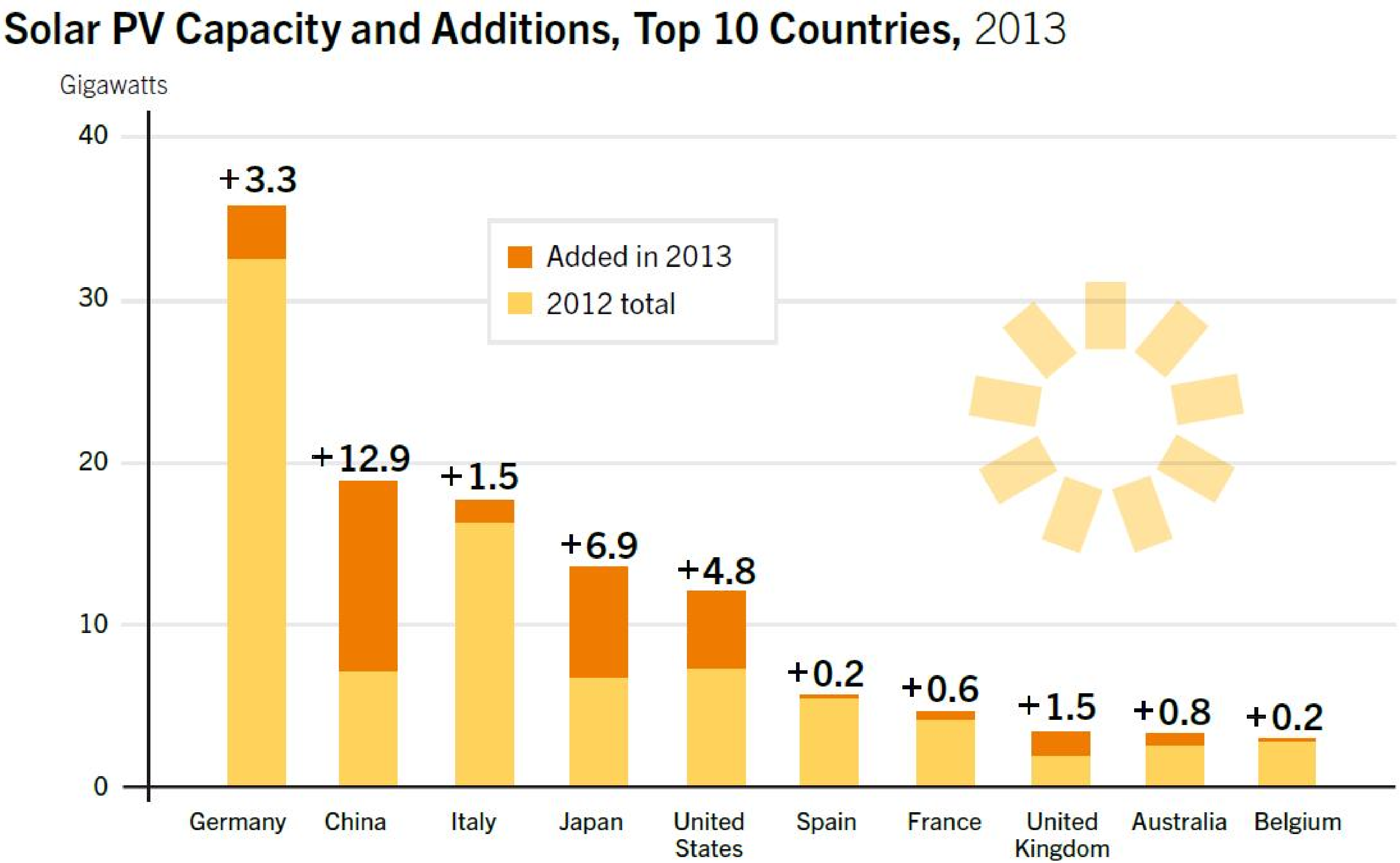


Source: REN 21, Renewables 2014 Global Status Report

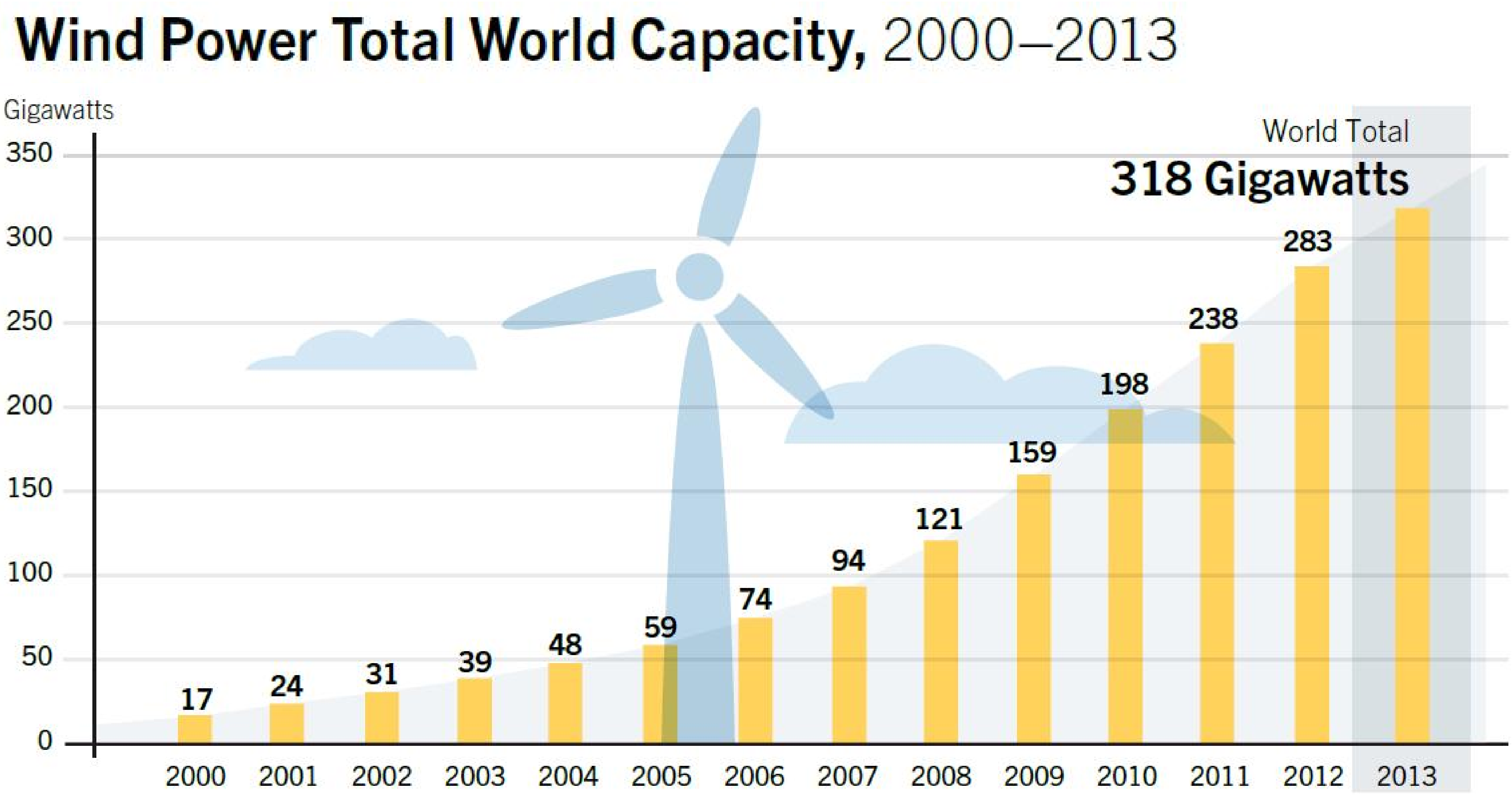
Solar PV Total Global Capacity, 2004–2013



Source: REN 21, Renewables 2014 Global Status Report

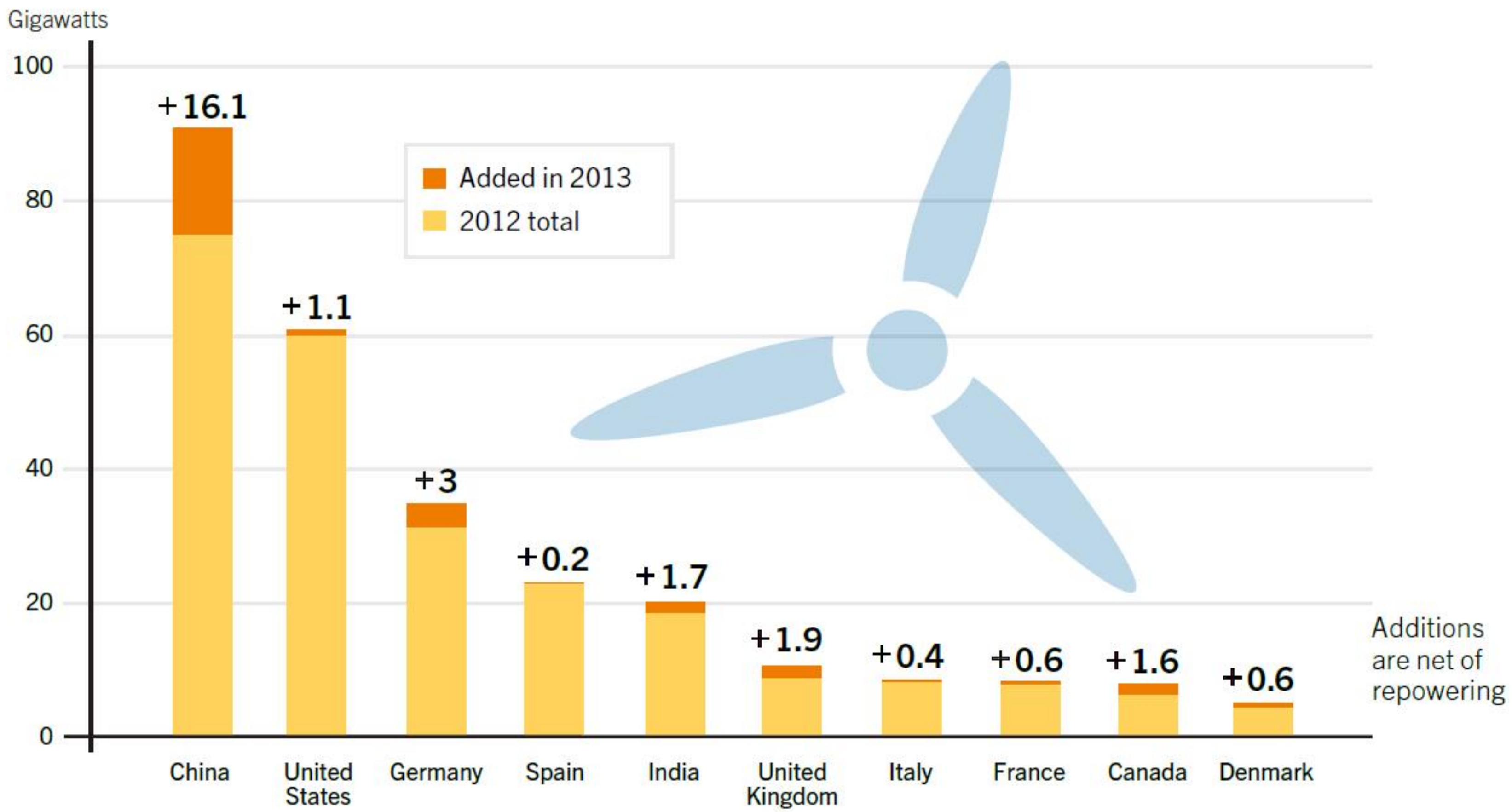


Source: REN 21, Renewables 2014 Global Status Report

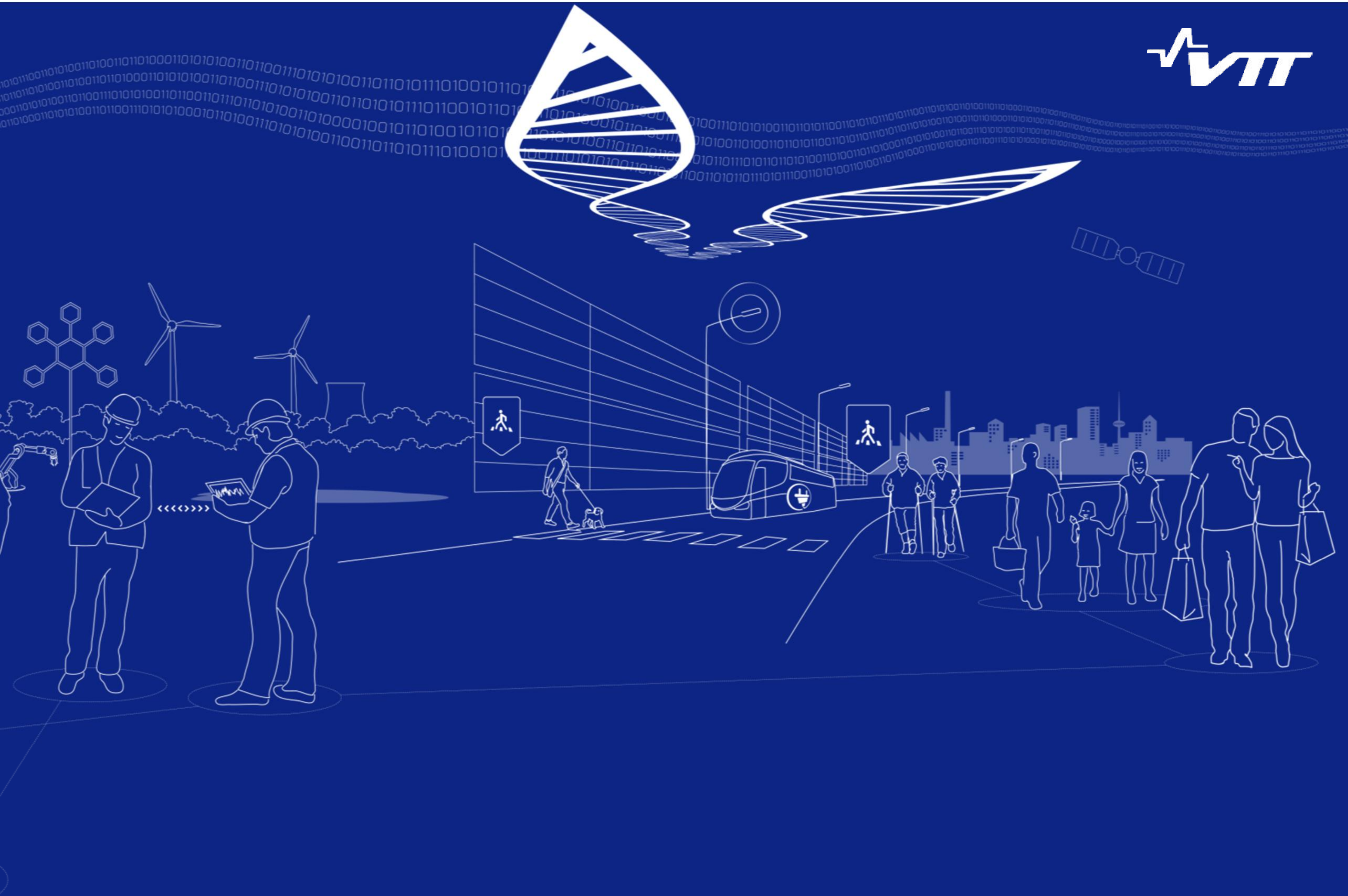


Source: REN 21, Renewables 2014 Global Status Report

Wind Power Capacity and Additions, Top 10 Countries, 2013

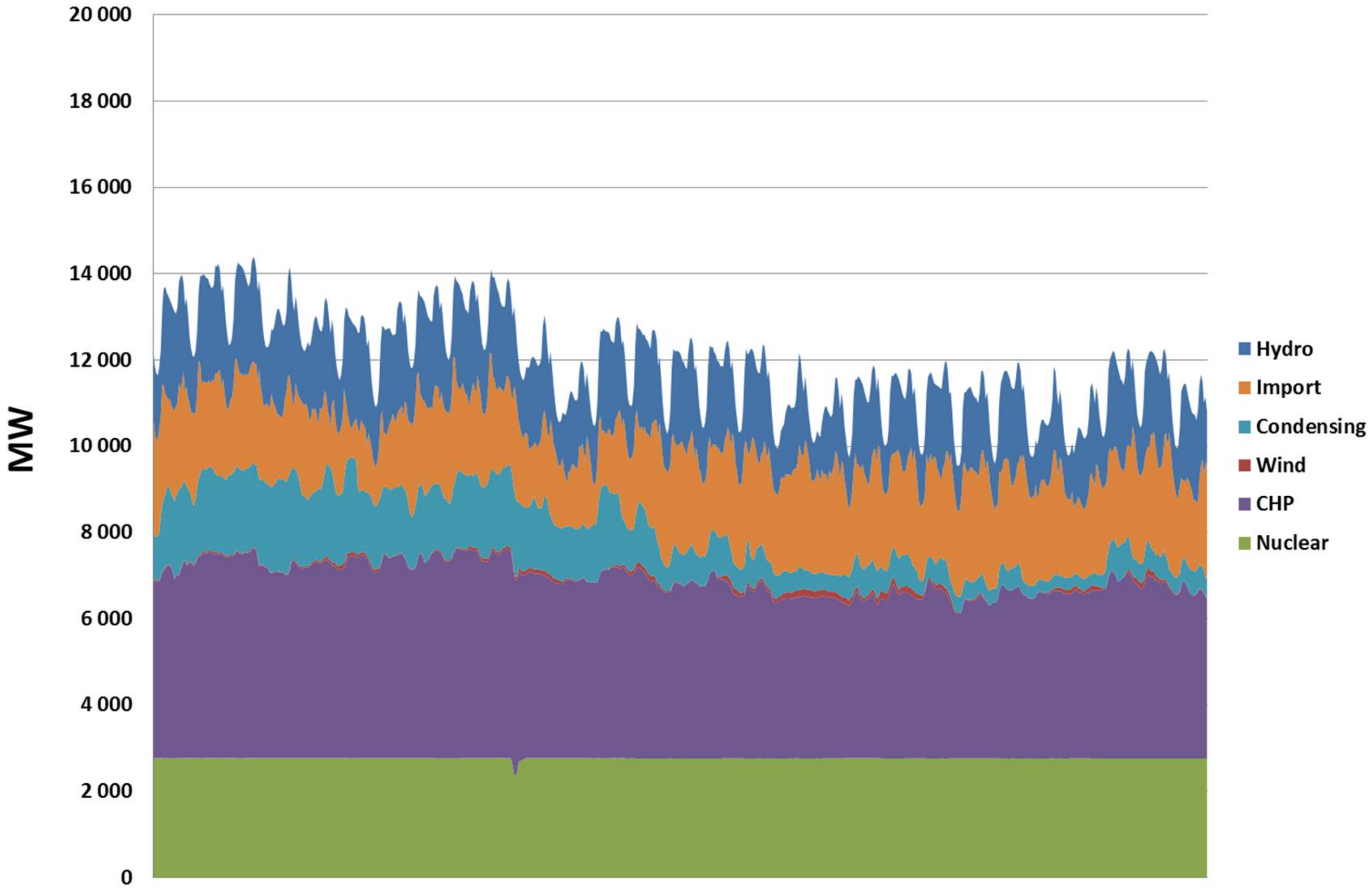


Source: REN 21, Renewables 2014 Global Status Report



A theoretical example of intermittency:

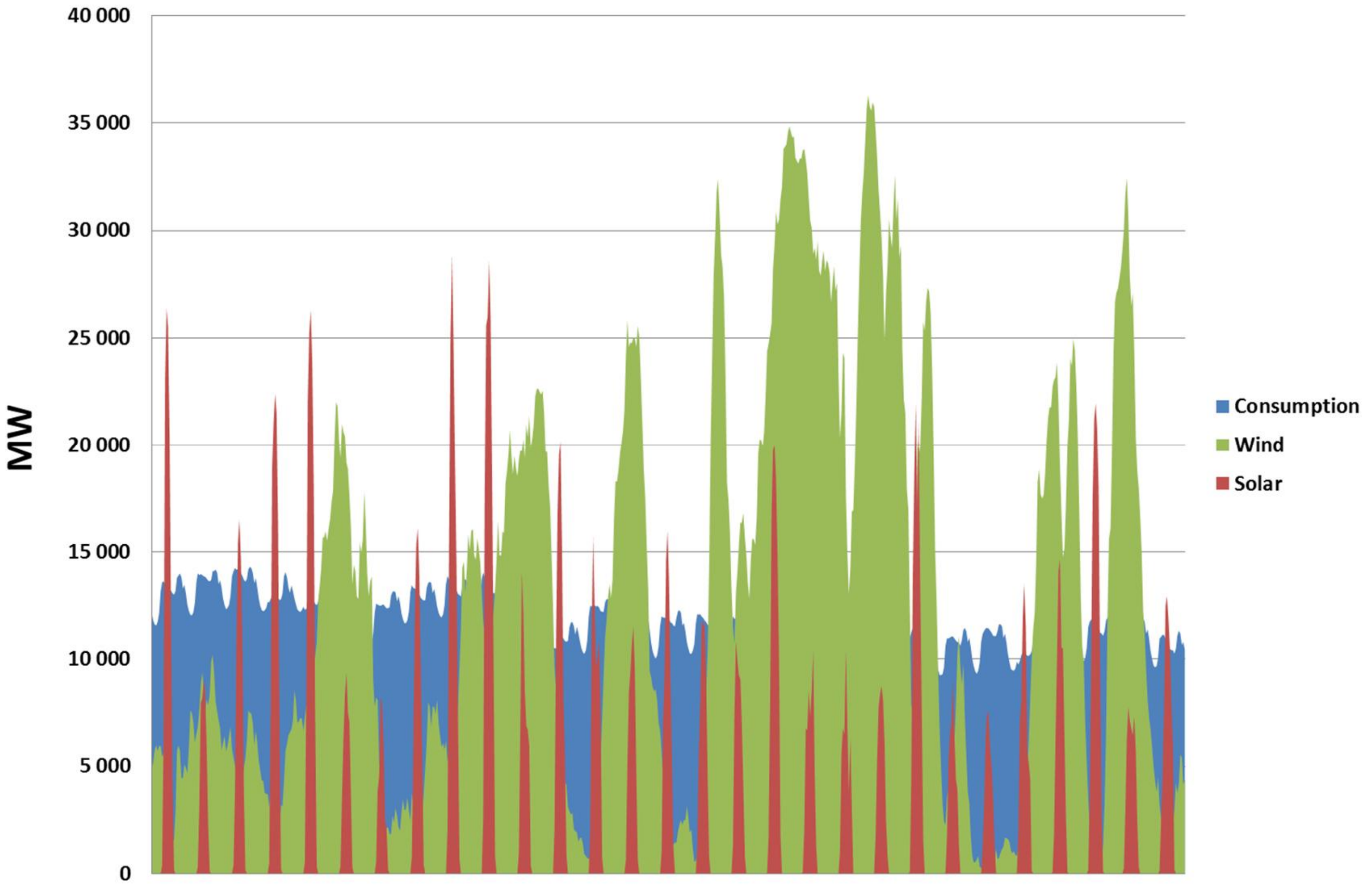
This is how electricity production followed consumption every second in February 2012 (Finland)



Source: **Nordpool, 2012**

How do the production and consumption curves match if you want to produce everything from wind and solar?

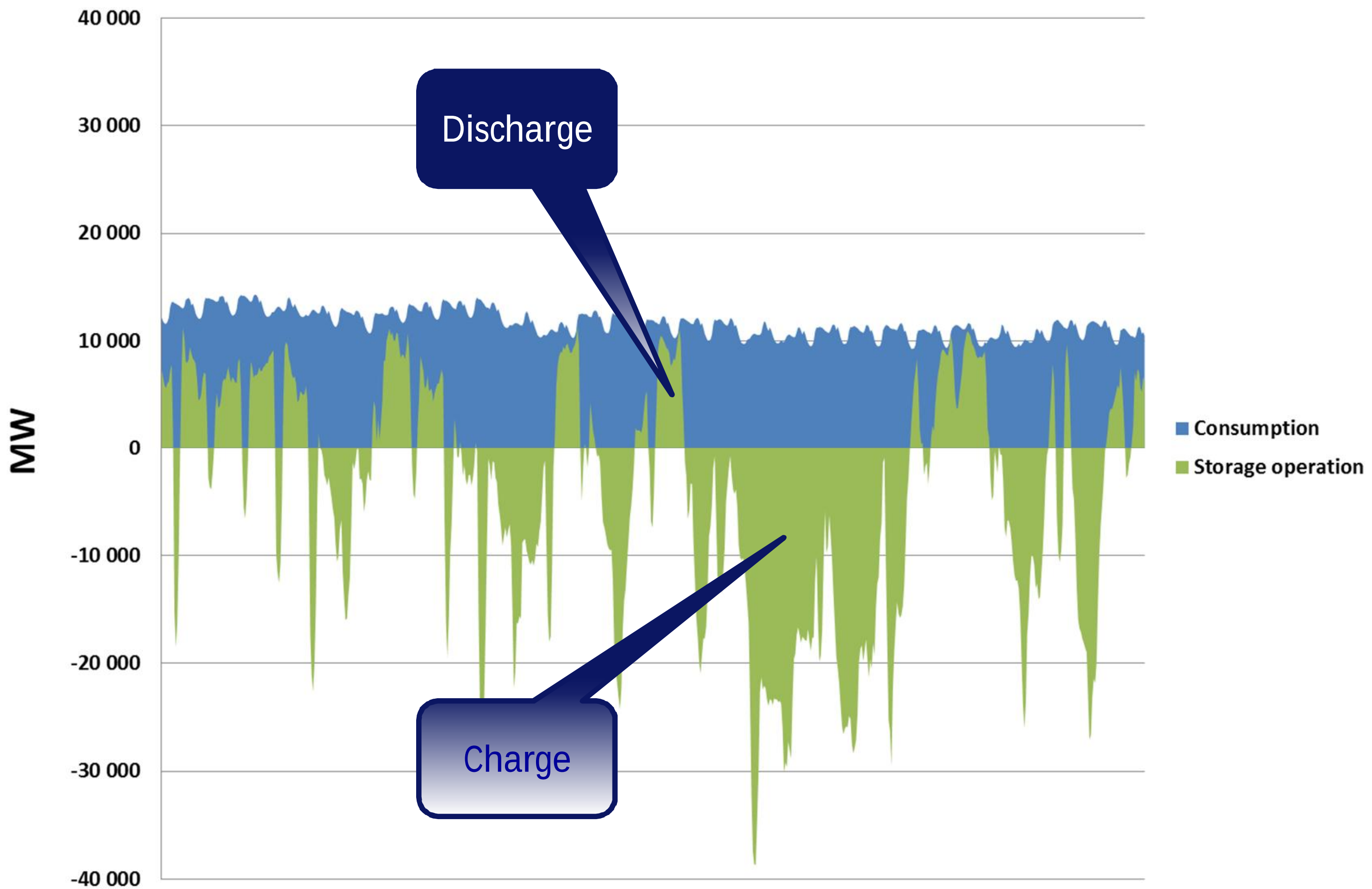
They do not. At all.



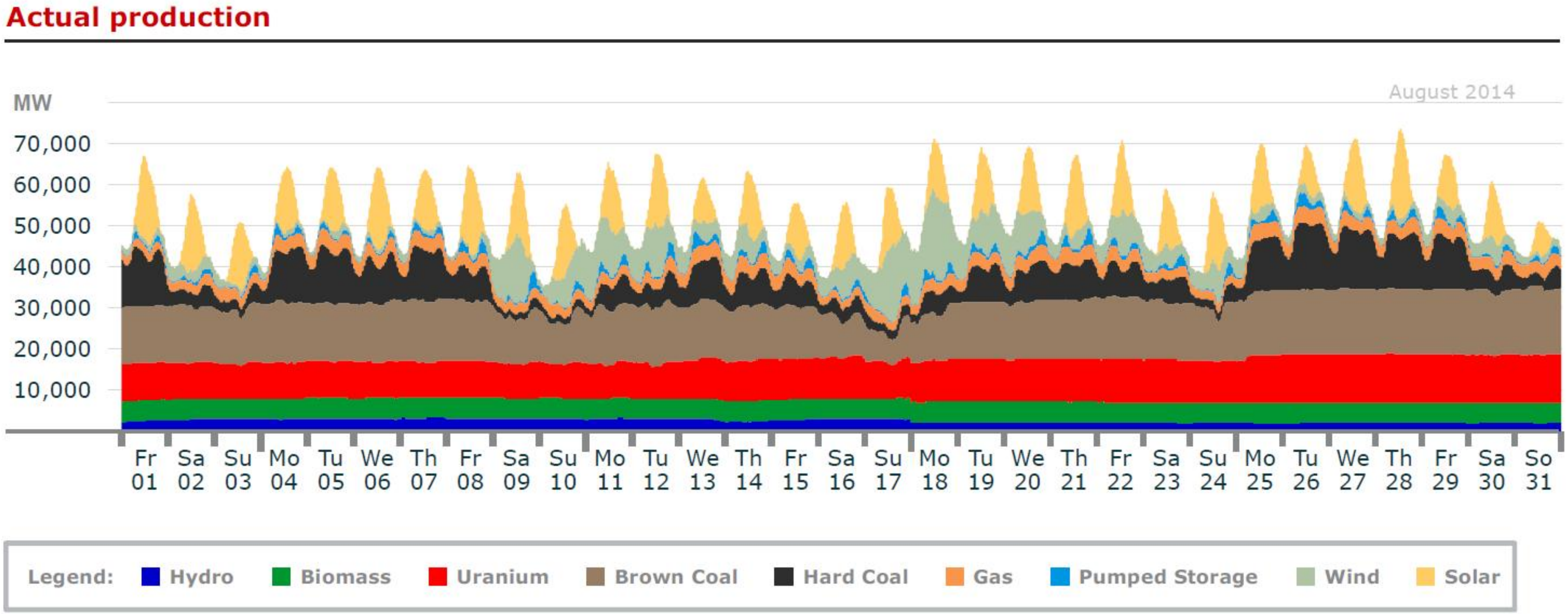
Modelled based on data from: **Nordpool, 2012**
Finnish Meteorological Institute, 2012

So, what do you do?

You design a storage system that can charge and discharge like this:

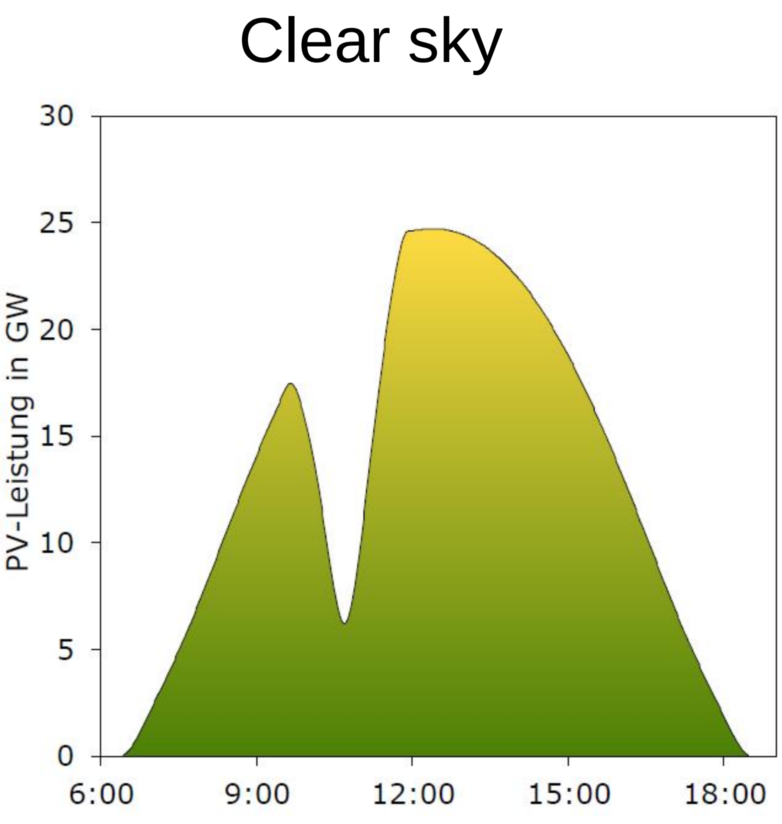


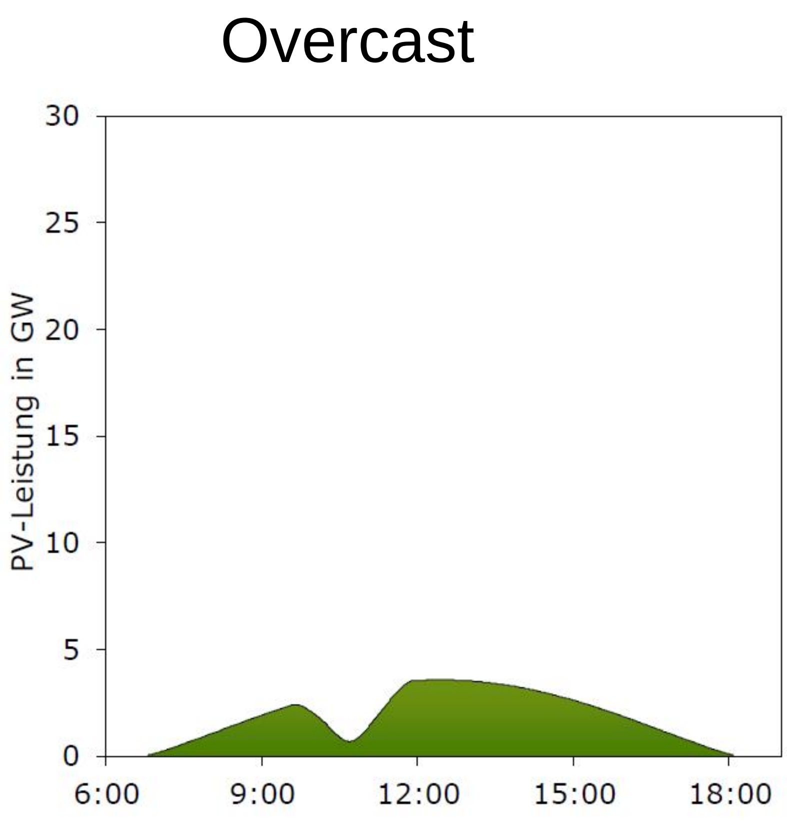
Germany, August 2014

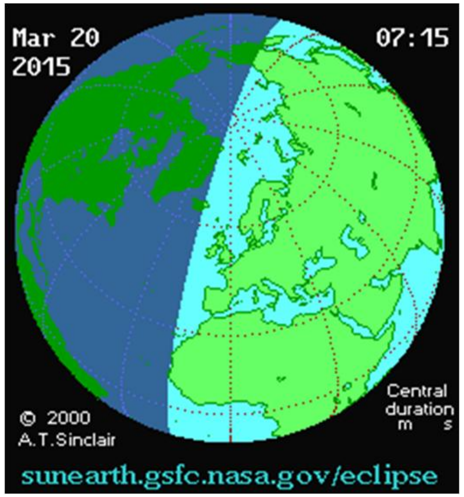


Source: Fraunhover ISE

Solar eclipse 20.3.2015, effects on PV production in Germany

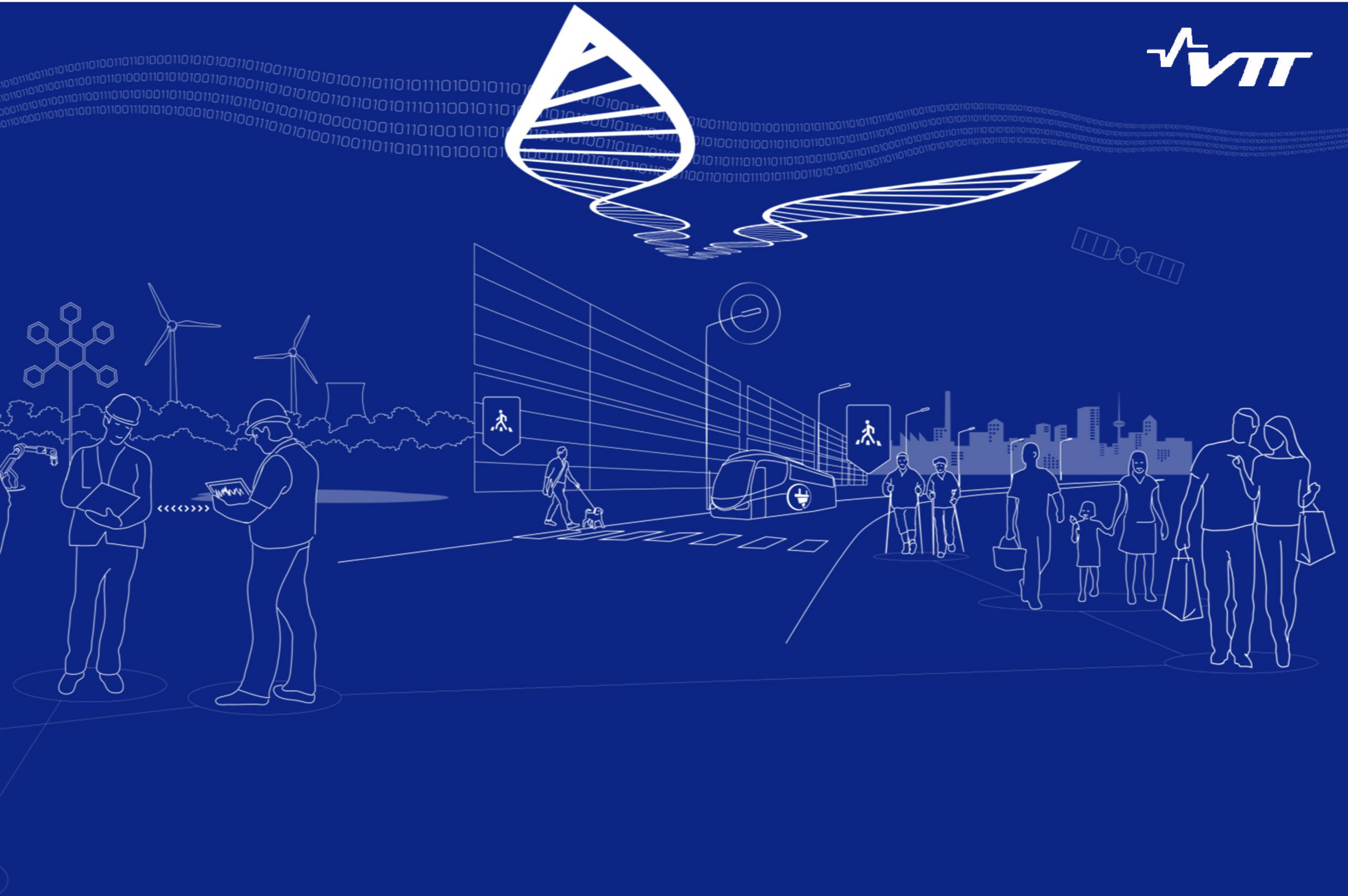




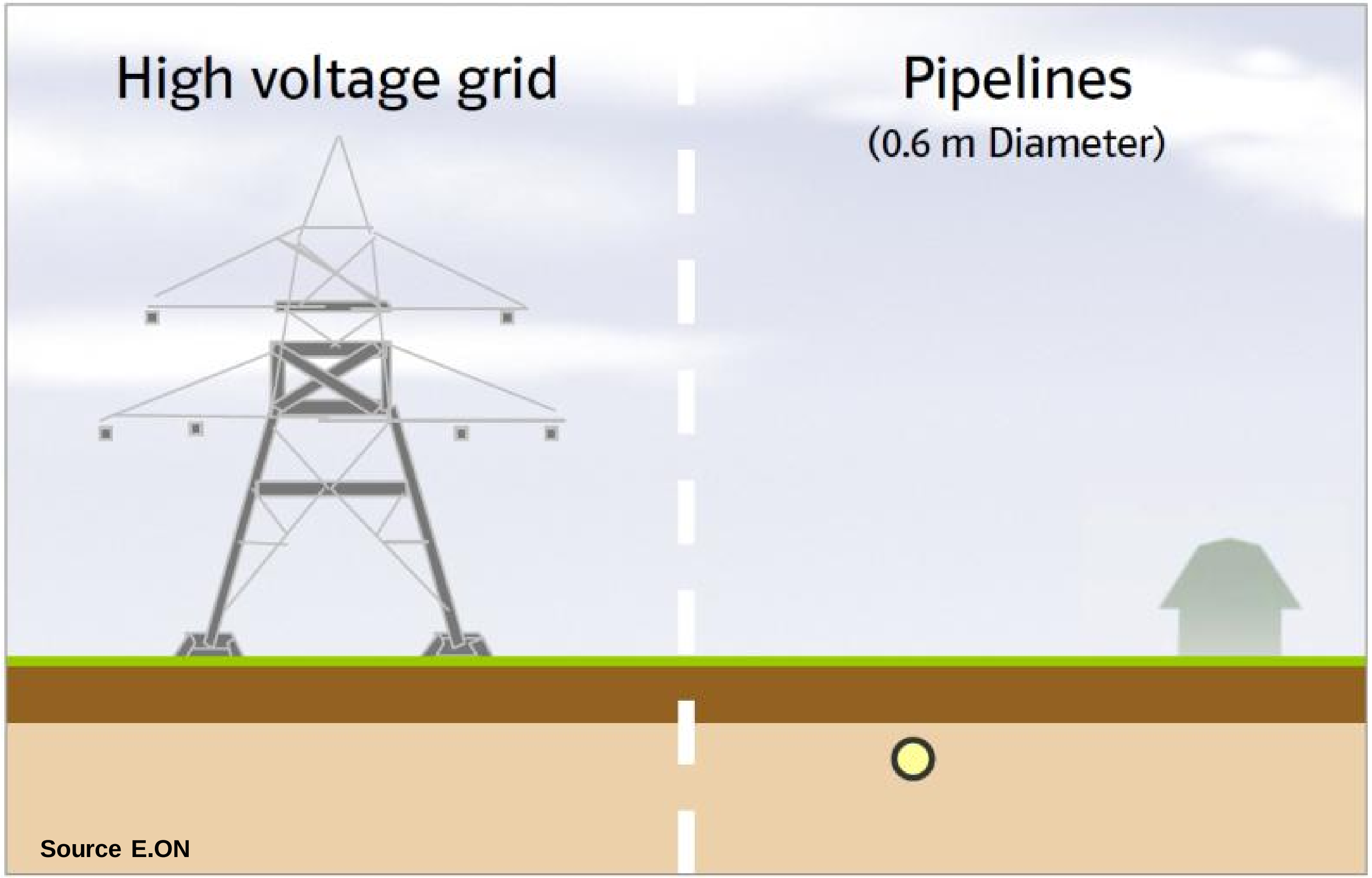


Source: Einfluss der Sonnenfinsternis im März 2015 auf die Solarstromerzeugung in Deutschland

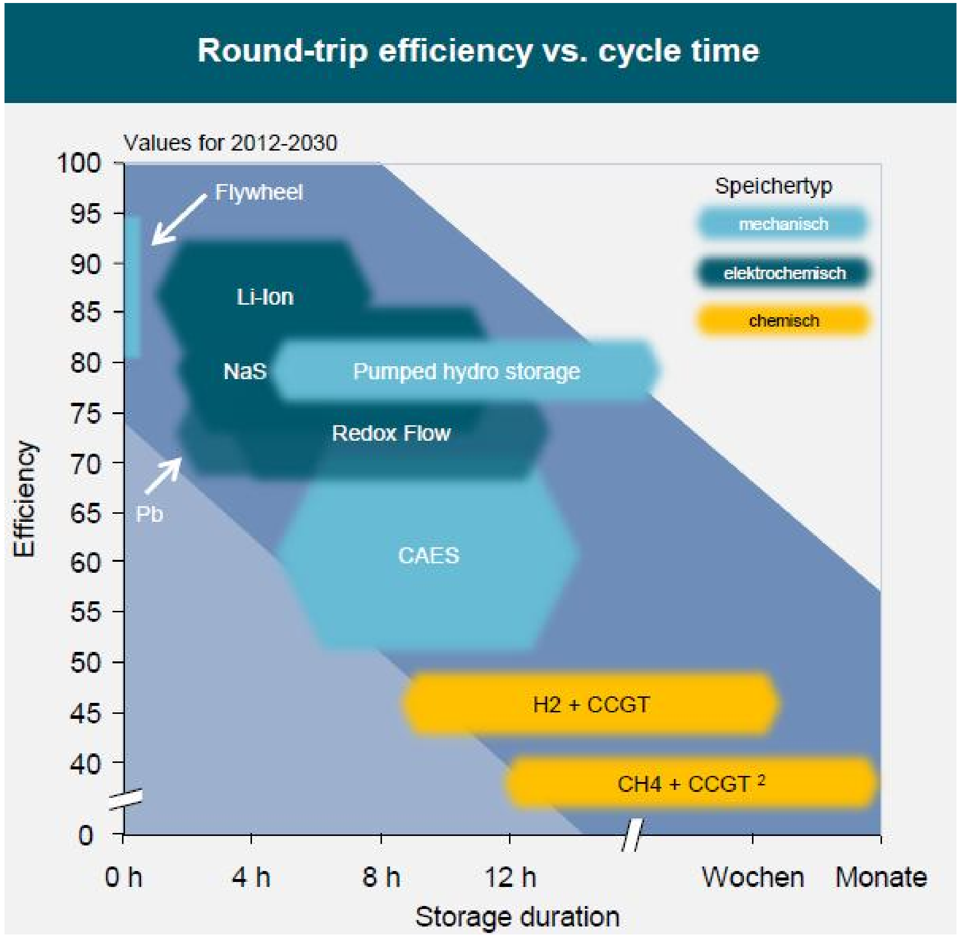
Hochschule für Technik
und Wirtschaft Berlin
University of Applied Sciences

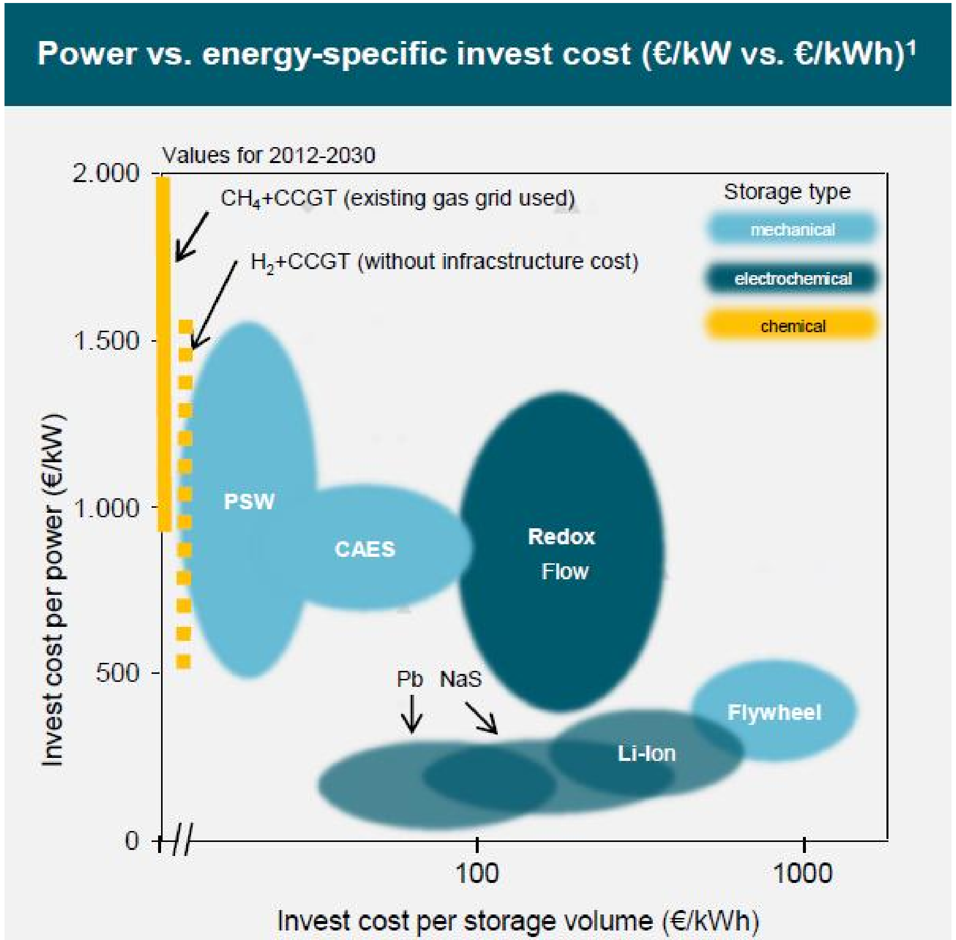


Transmission of 1 GWe

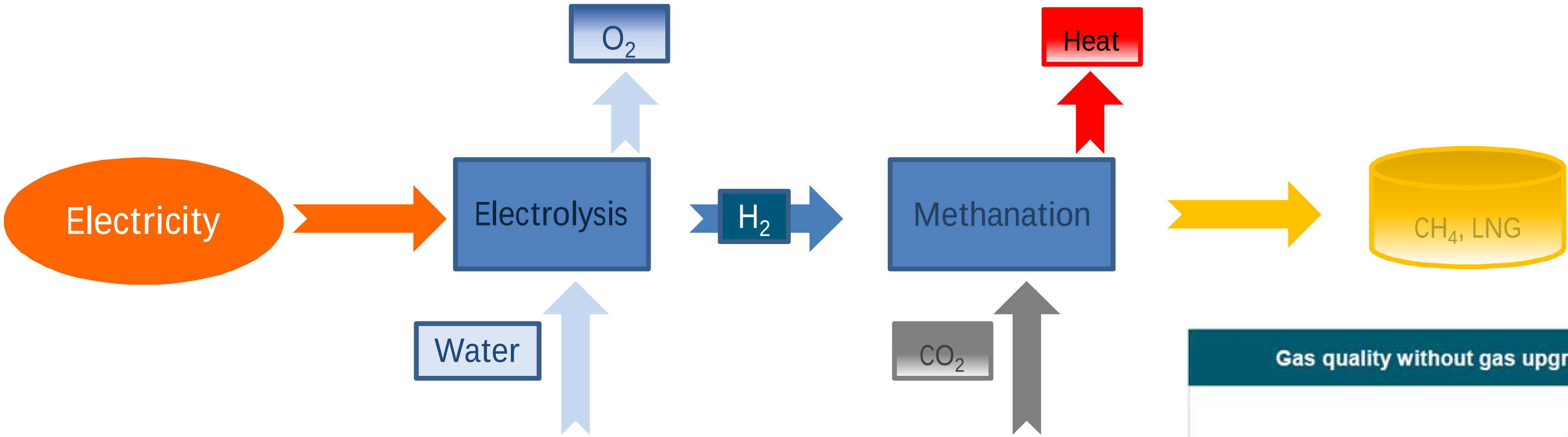


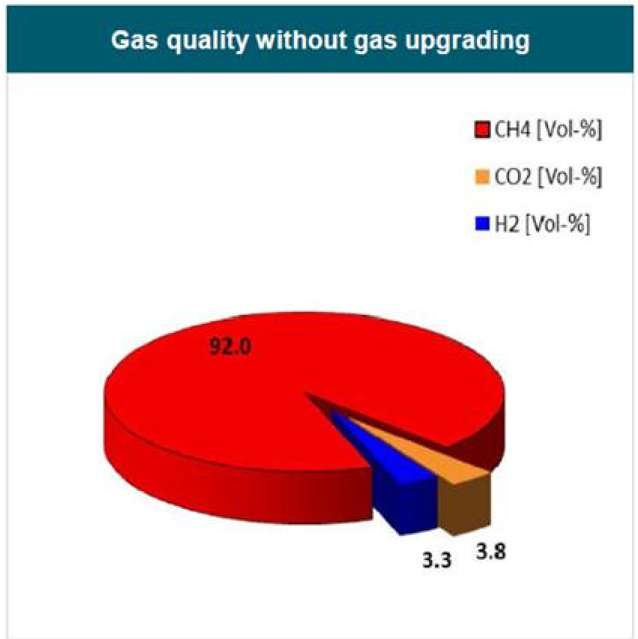
Storage options: Do not mix oranges and apples





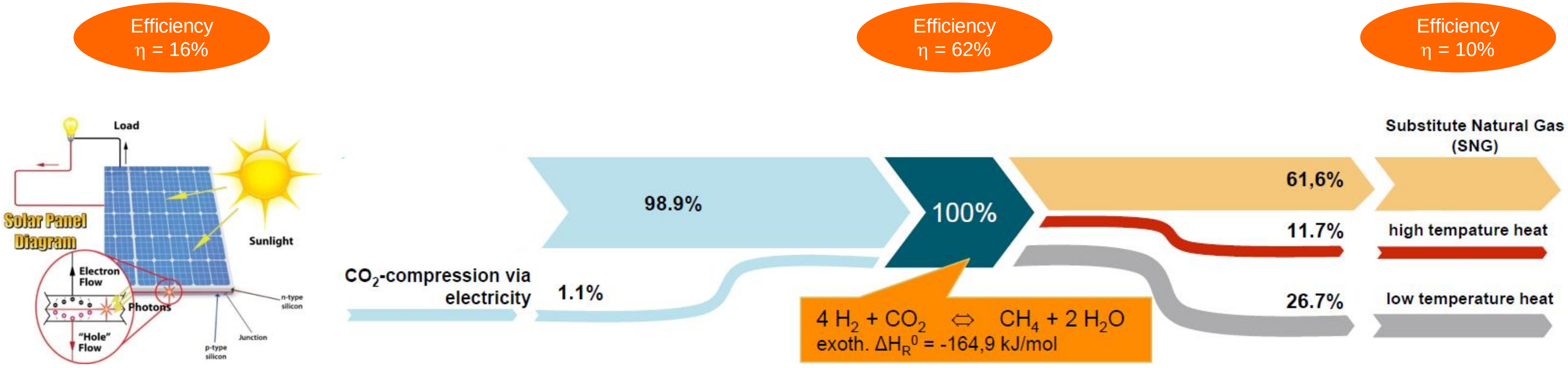
Power-to-gas





Source: ZSW / ETOGAS

Efficiency



η = 55% LHV

Source: ETOGAS

State-of-the-art

α Alpha 25 kW_{el} Pilot Technology

2009 – 2012

- Pilot plant: Feasibility demonstration of the "Power-to-Gas" concept

β Beta 6 MW_{el} Proven Technology

2013

- World-wide largest commercial PtG plant built for Audi AG
- in operation since 2013

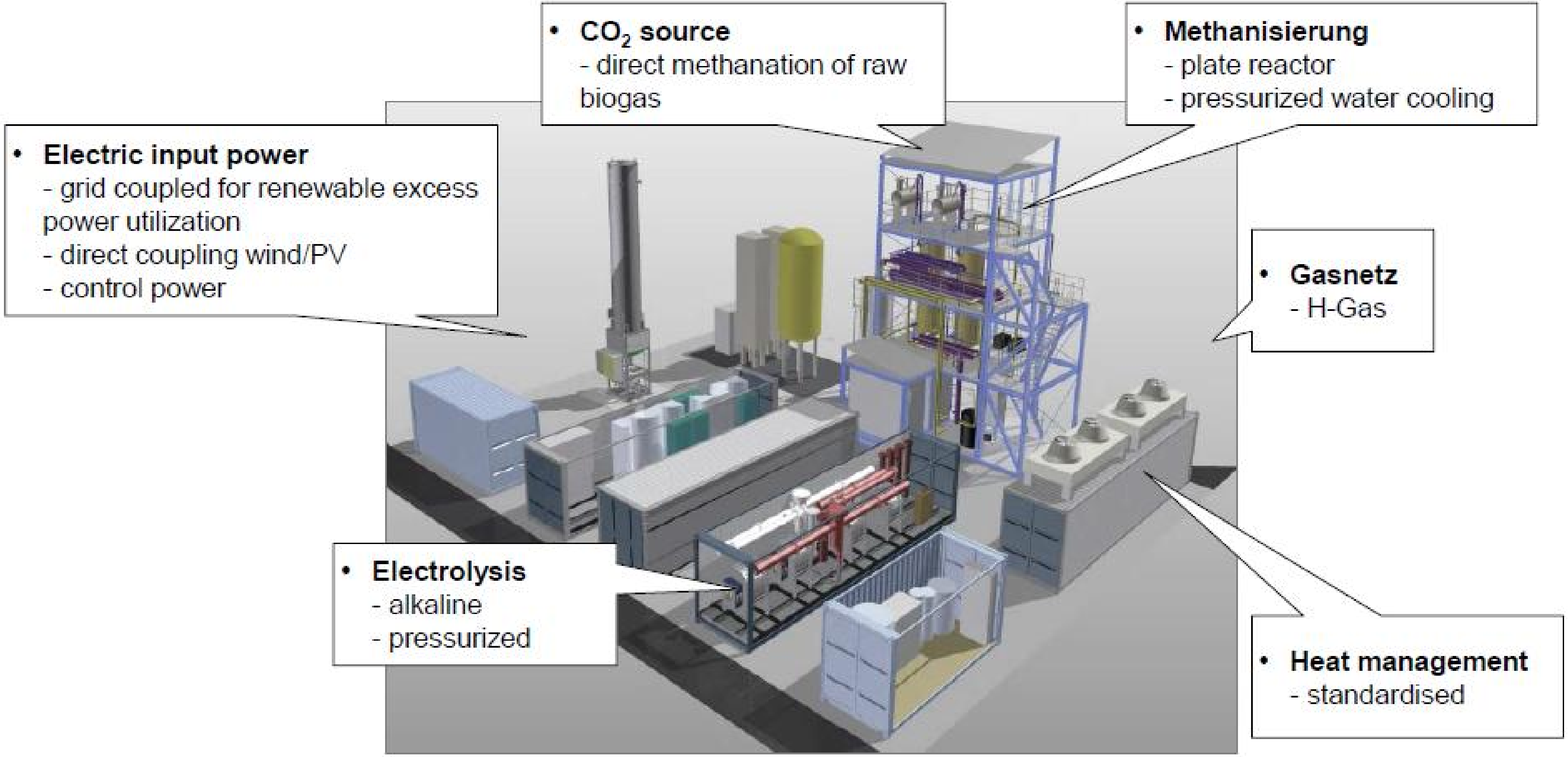
γ Gamma 1,2…10…20 MW_{el} Advanced Technology

- **2012** Methanation pilot 250 kW_{el} Tests successfully finished
- **2014** Electrolysis pilot (short stack)
- **2015** Turn-key plant 1,2 MW_{el}

2009 - 2012 | **2013** | **2014 / 2015+**

Source: ETOGAS

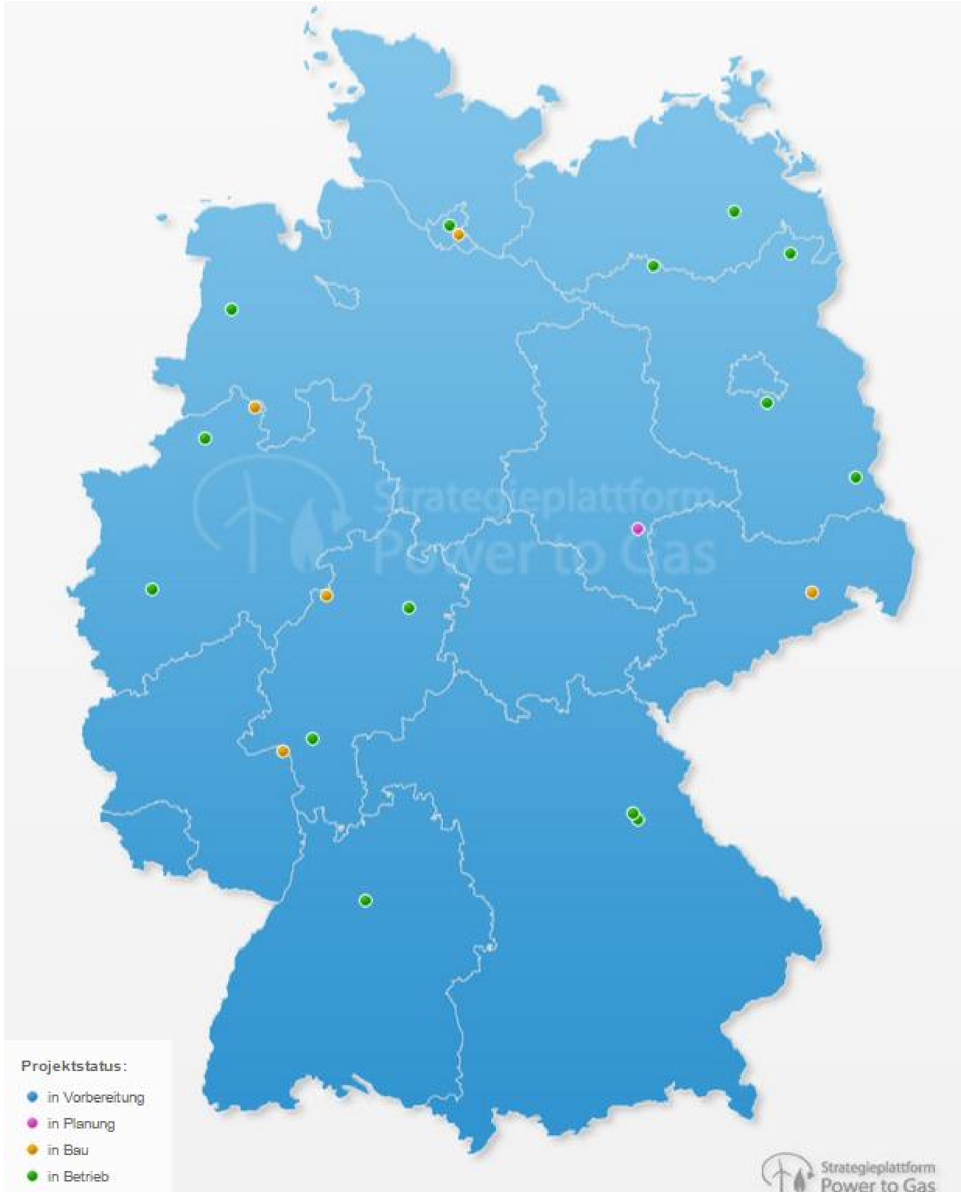
State of the art
1.2 MWe standard unit with modular setup



Source: ETOGAS

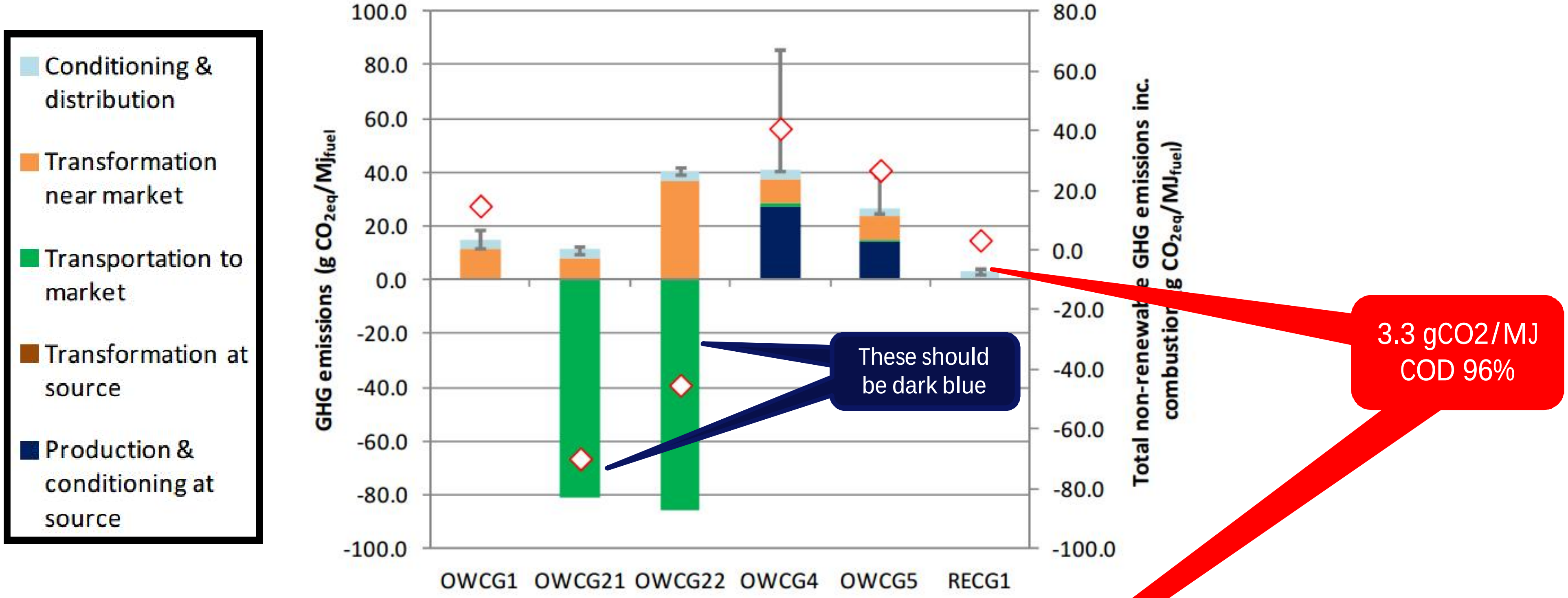
Aprox. 20 P2G demonstration projects in the Europe

- Majority of projects in Germany
- Mostly handful of kWe
- ~ 1/4 with methanation
- A couple of units MW scale
- Alkaline and PEM electrolysers, SOEC in lab



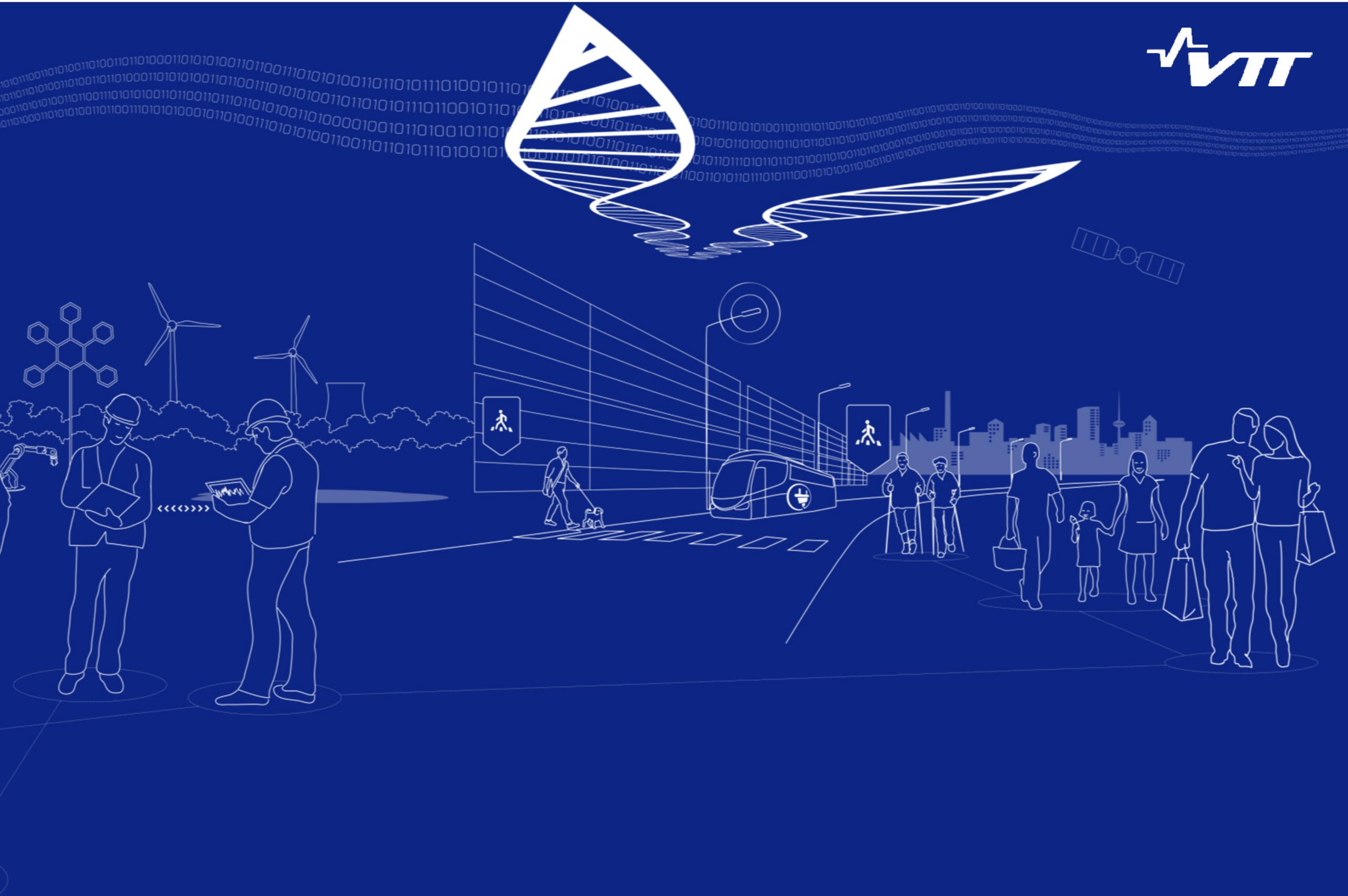
www.powertogas.info

WTT GHG balance for compressed biogas (CBG) pathways

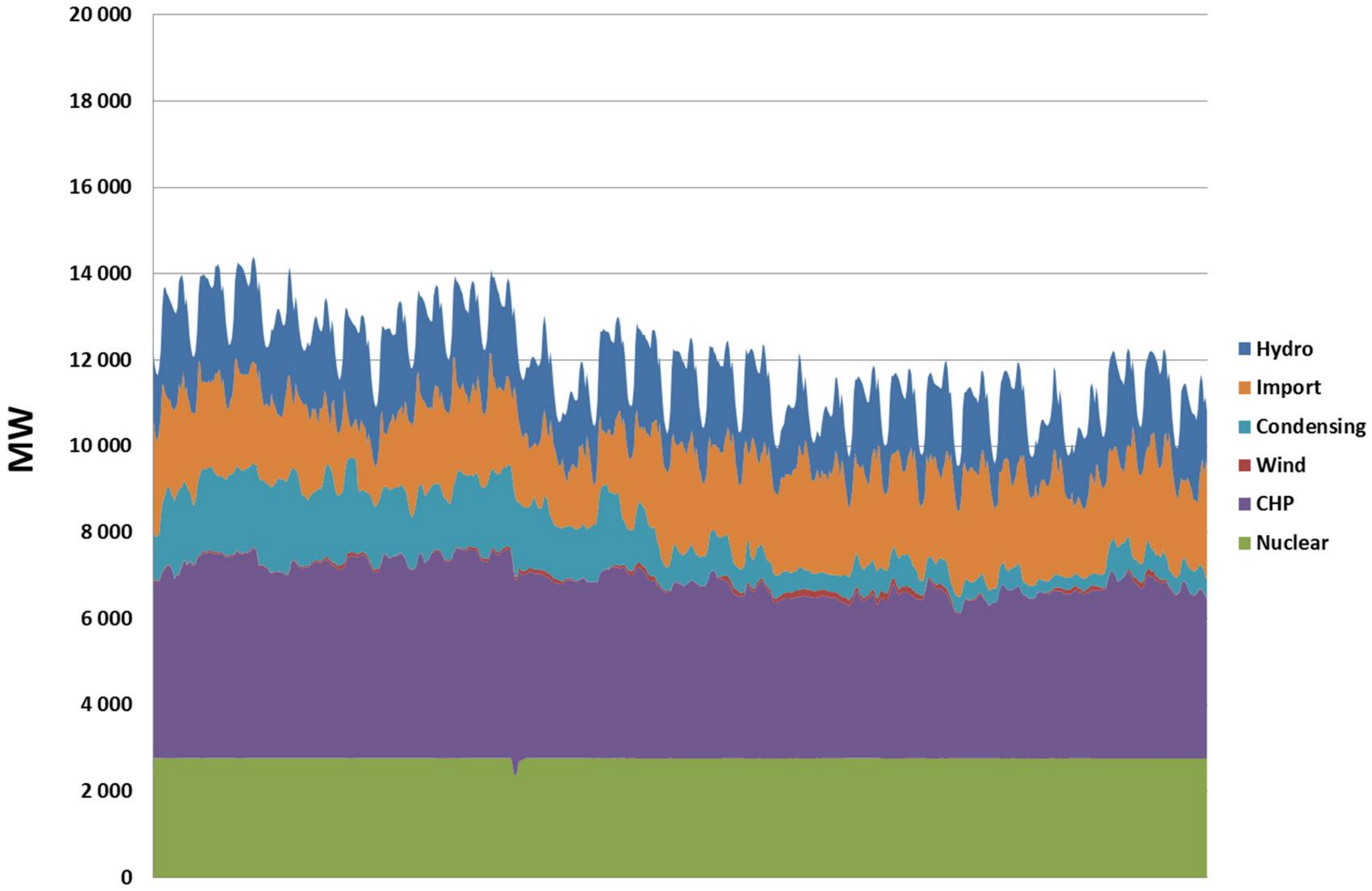


CBG	
OWCG1	Municipal waste
OWCG21	Liquid manure (closed storage)
OWCG22	Liquid manure (open storage)
OWCG4	Maize (whole plant)
OWCG5	Barley/maize (double cropping) whole plant
RECG1	Synthetic methane

Source: JEC Well-To-Wheels Analysis, Report EUR 26237 EN - 2014



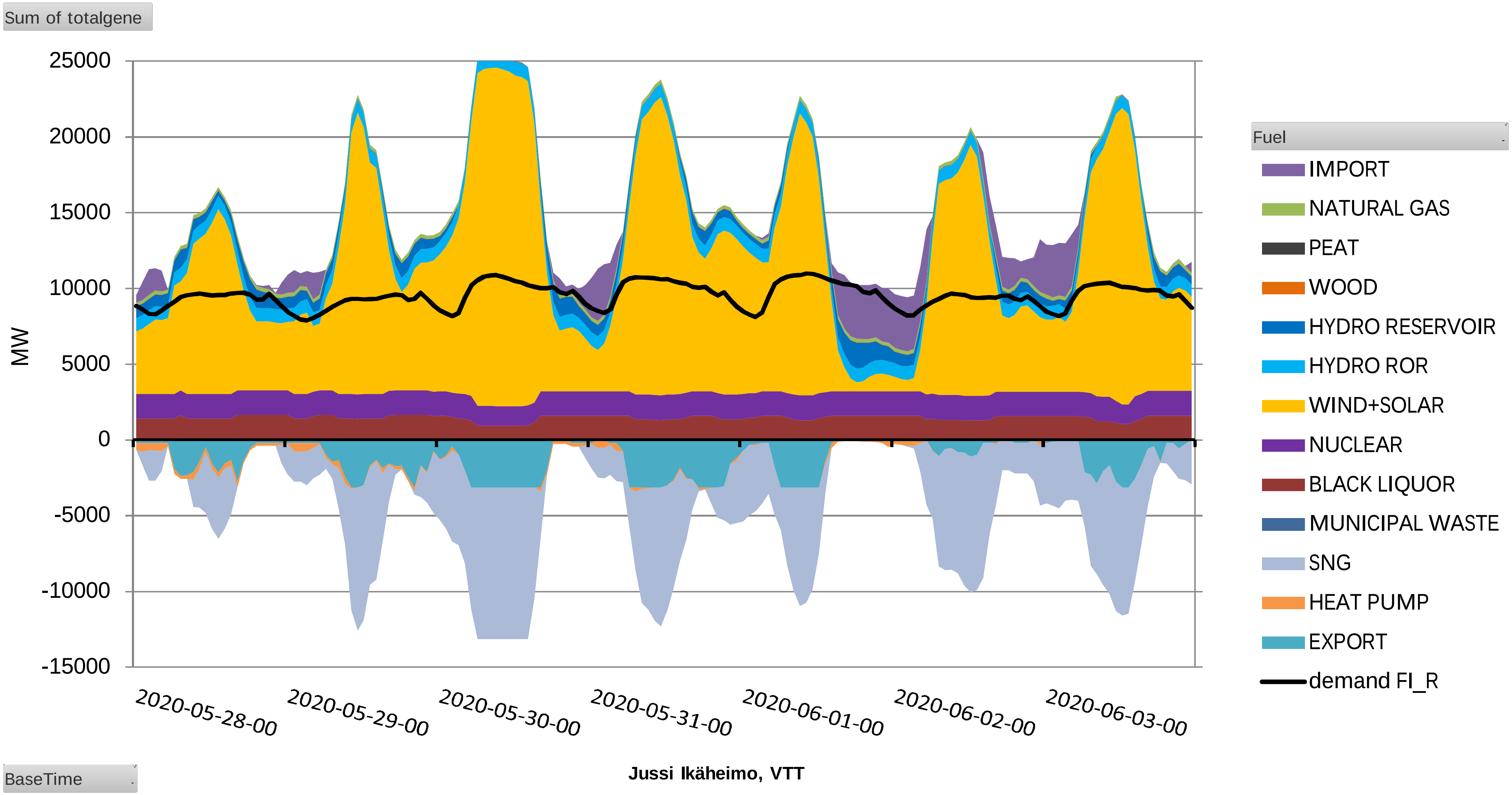
Electricity system now



Source: Nordpool, 2012

Finnish electricity system – example high solar

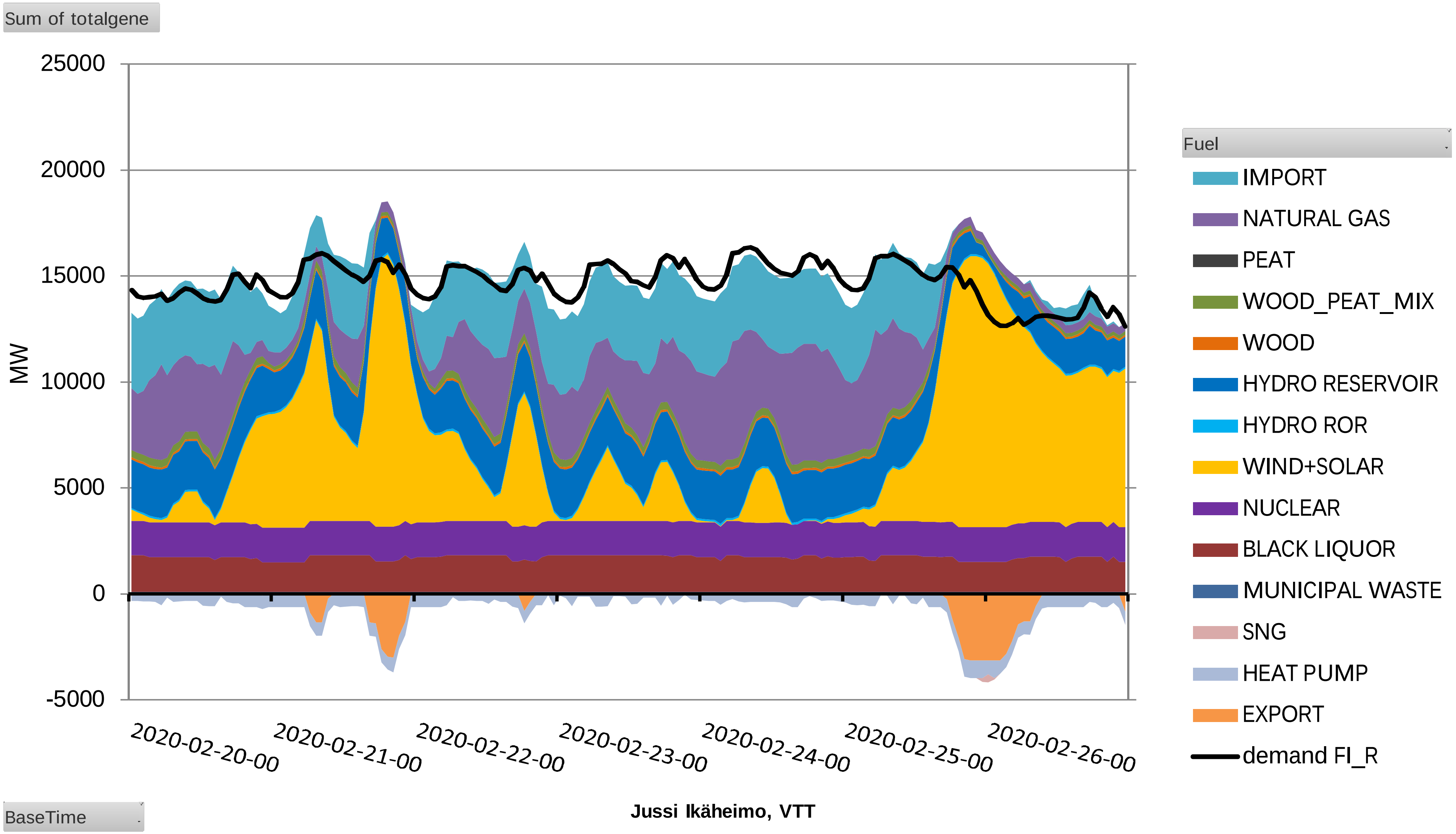
first results - shown for indicative purposes only



Jussi Ikäheimo, VTT

Finnish electricity system – example high demand

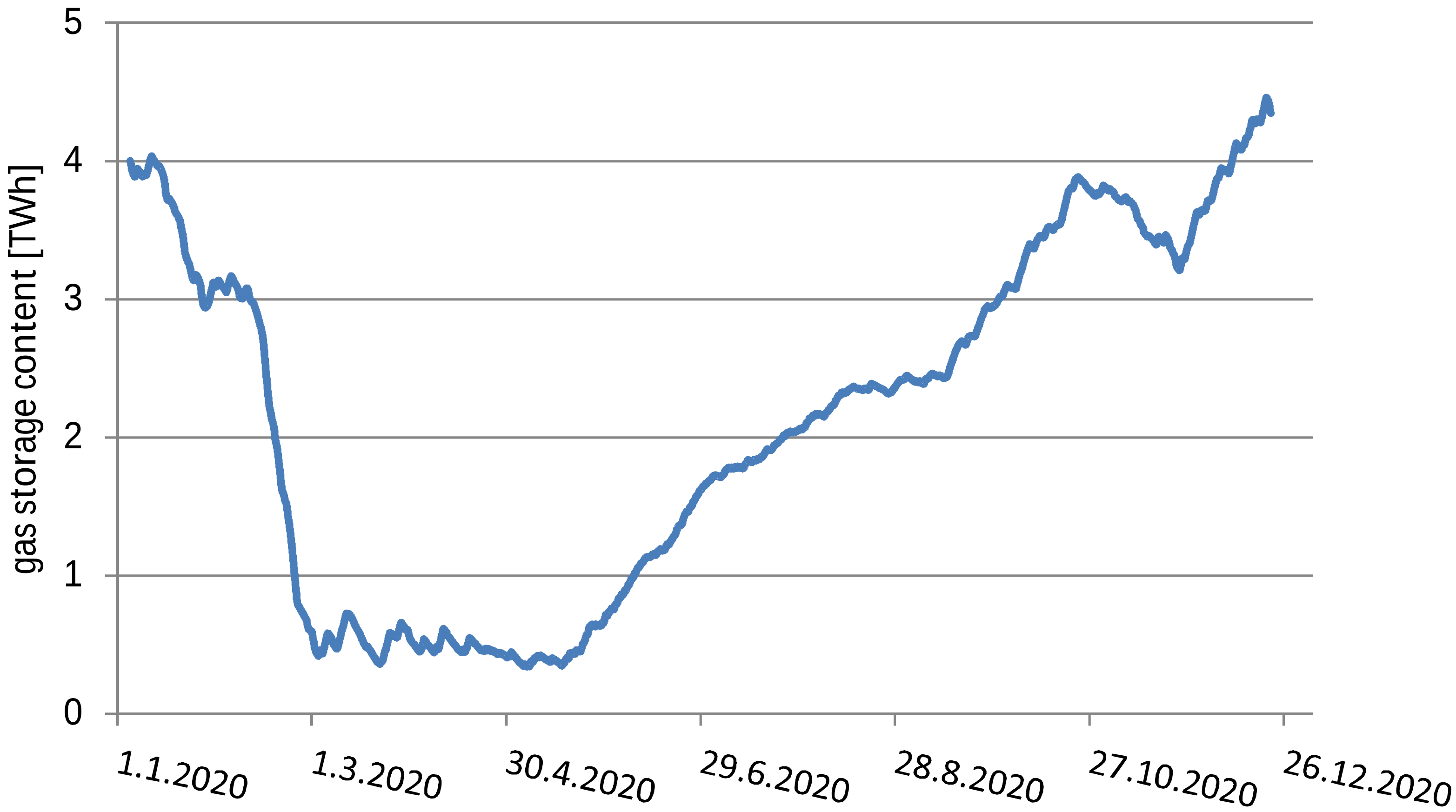
first results - shown for indicative purposes only

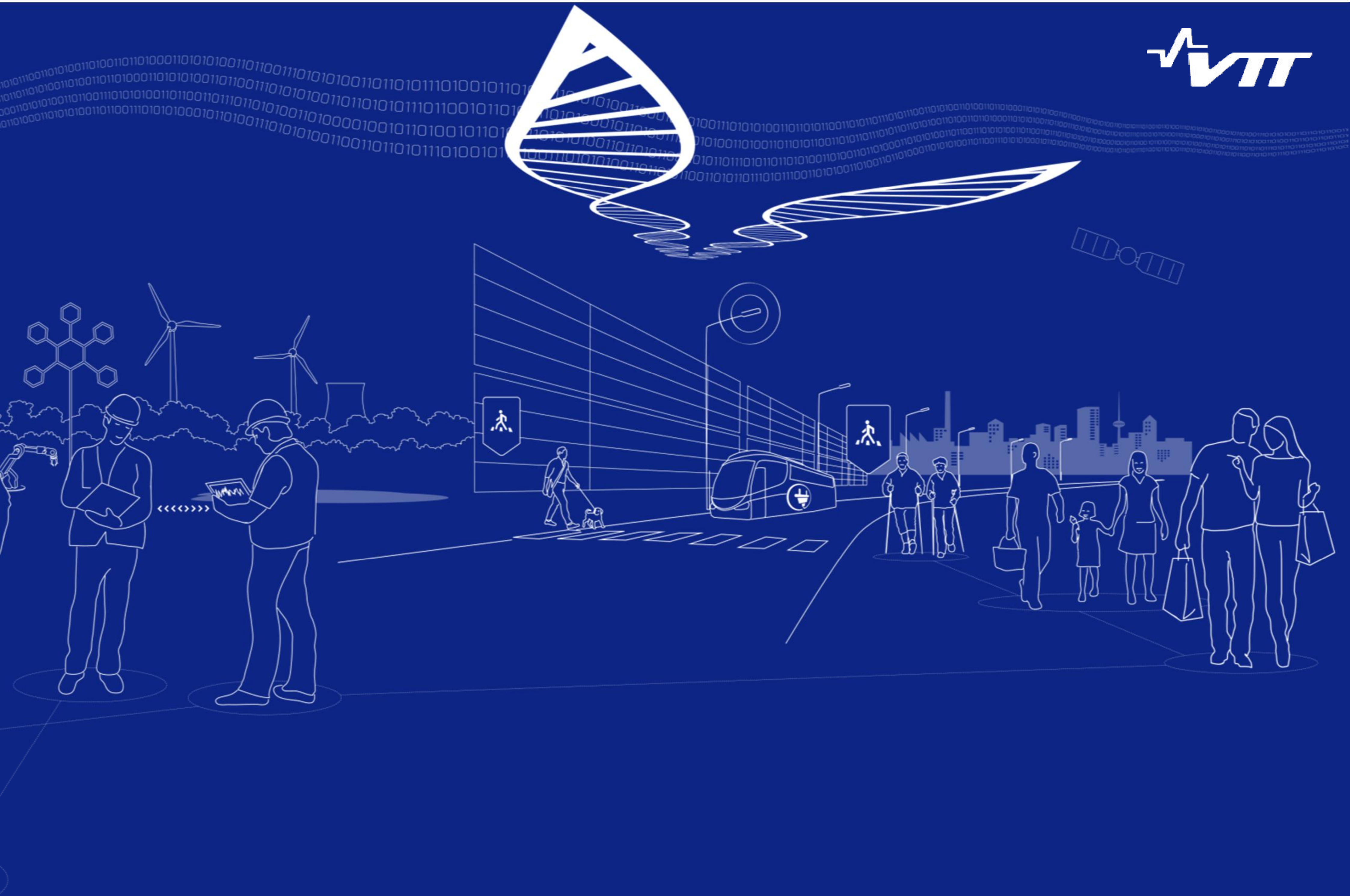


Jussi Ikäheimo, VTT

Finnish electricity system – gas storage status

first results - shown for indicative purposes only





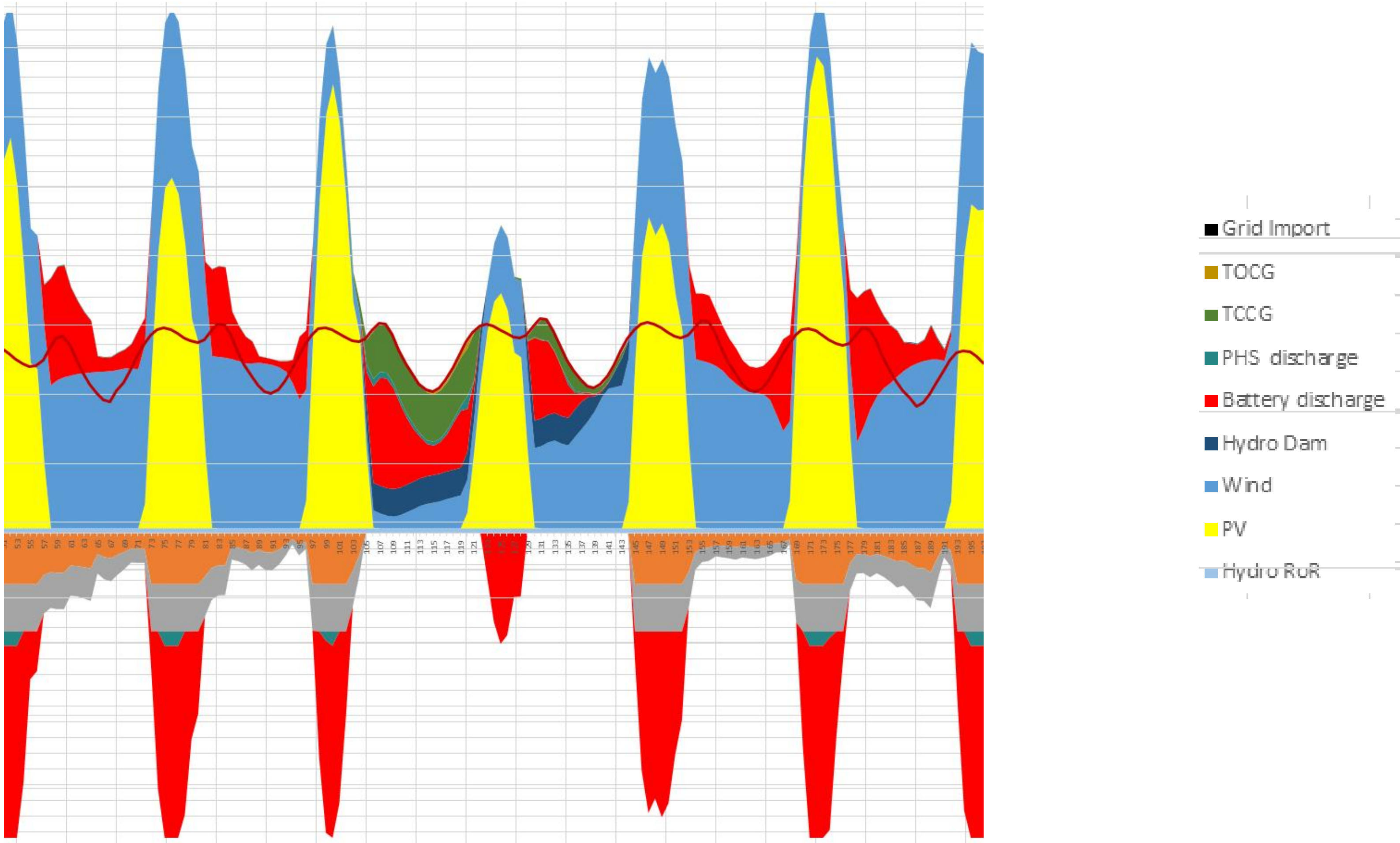
Including batteries, cost optimised

Annual demand: 6030 TWh
Max. load: 985 GW

Region names and transmission line lengths

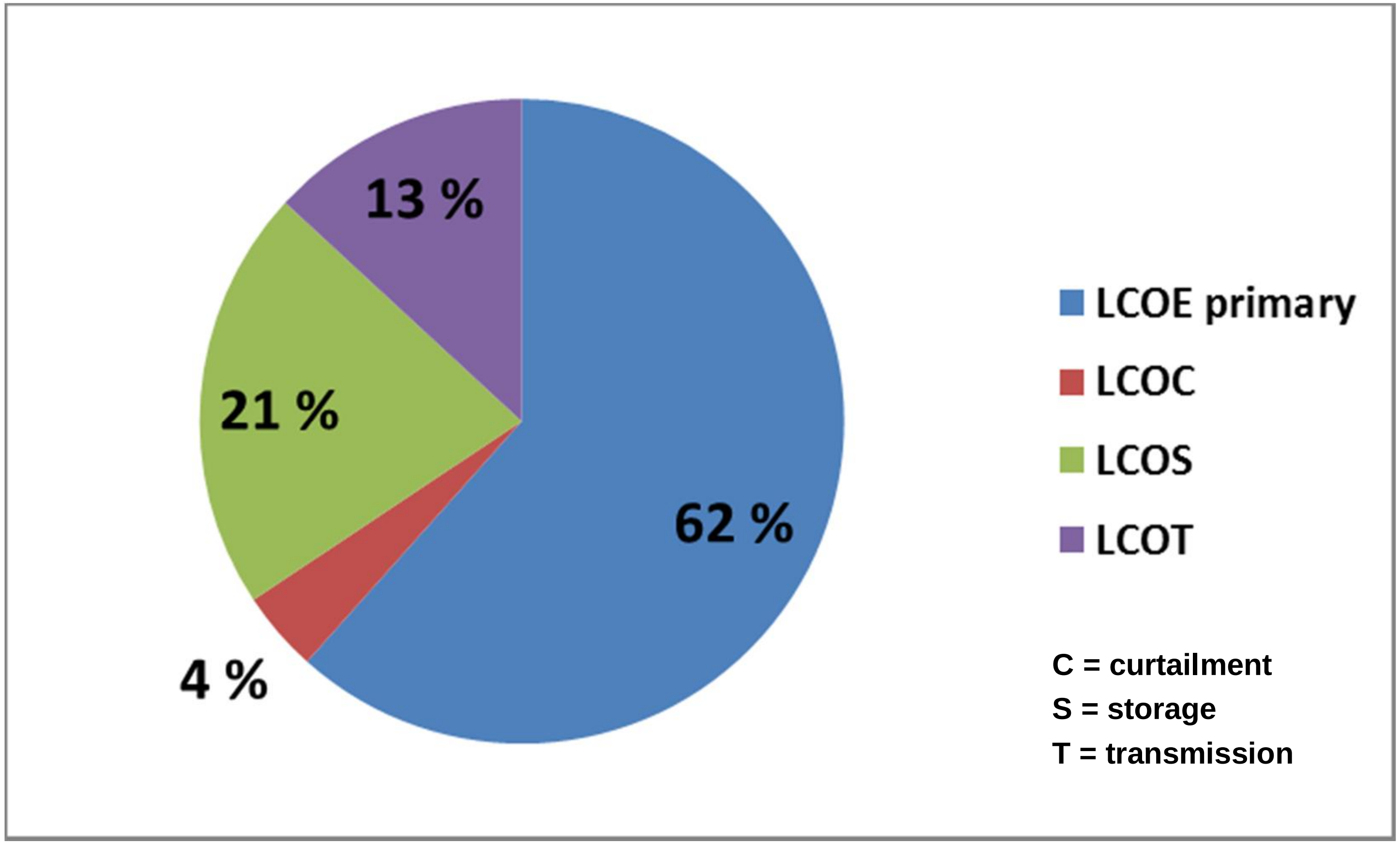
Source: **Breyer Ch. and Bogdanov D. et al., 2014. North-East Asian Super Grid: Renewable Energy Mix and Economics, WCPEC-6, Kyoto, November 23-27, to be published**

Including batteries, cost optimised
West Japan



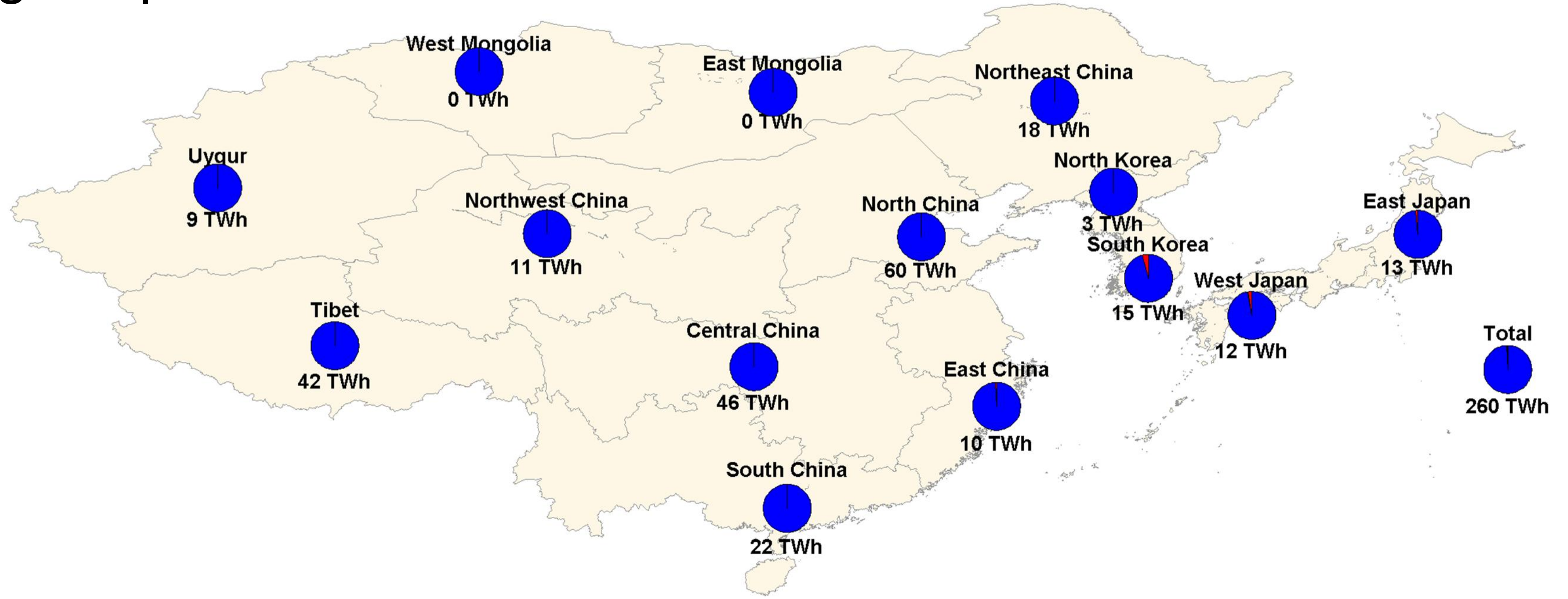
Source: **Breyer Ch. and Bogdanov D. et al., 2014. North-East Asian Super Grid: Renewable Energy Mix and Economics, WCPEC-6, Kyoto, November 23-27, to be published**

Levelised Cost of Electricity structure – example

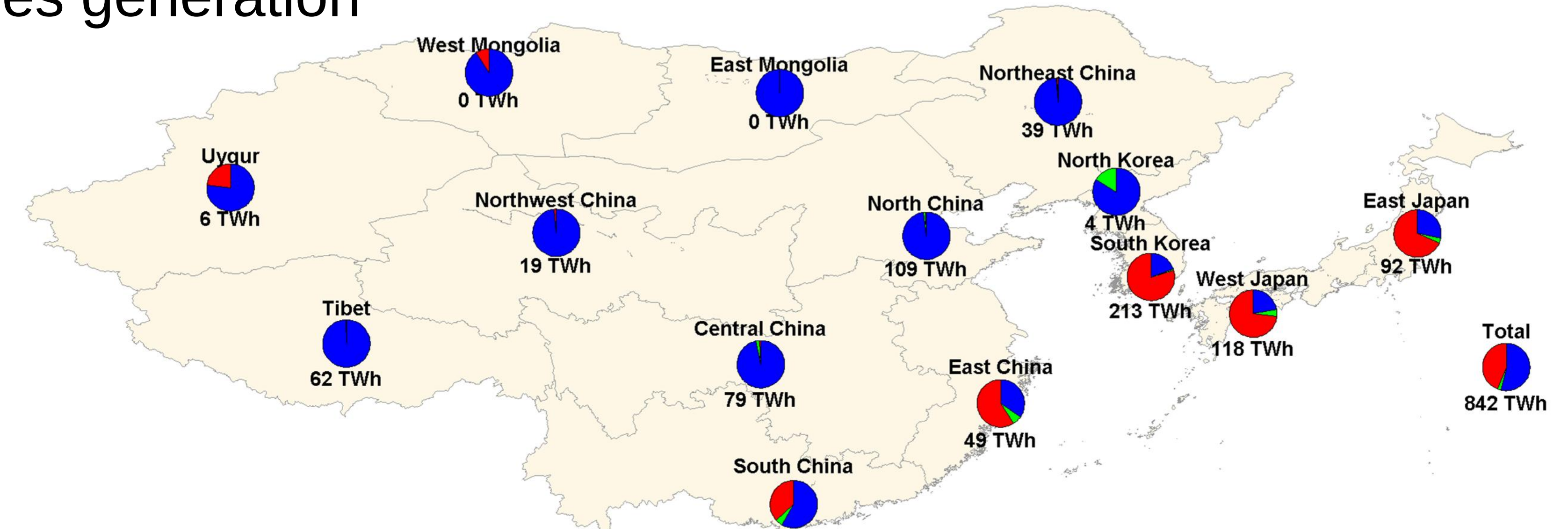


Source: Breyer Ch. and Bogdanov D. et al., 2014. North-East Asian Super Grid: Renewable Energy Mix and Economics, WCPEC-6, Kyoto, November 23-27, to be published

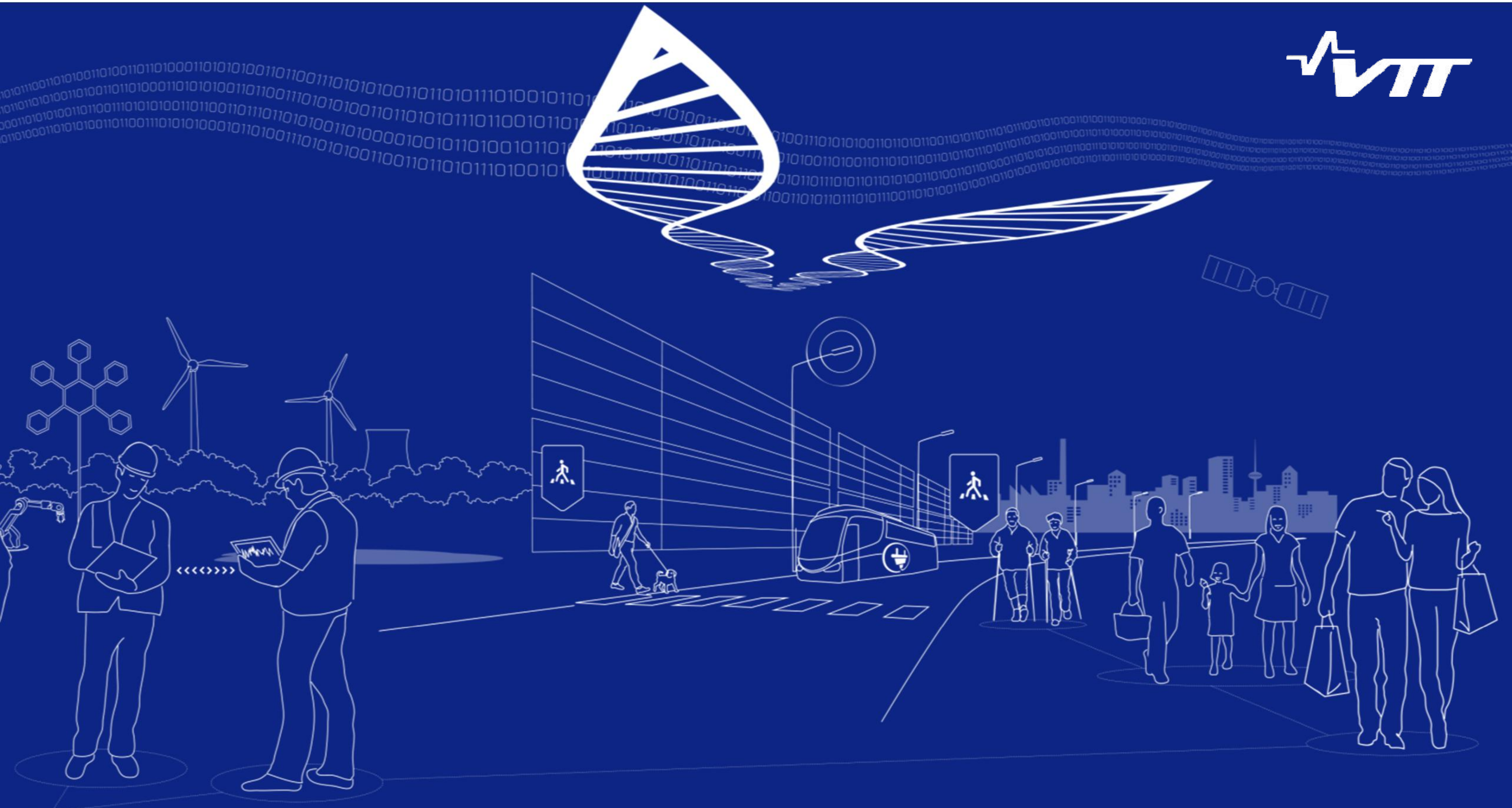
▪ Storage capacities



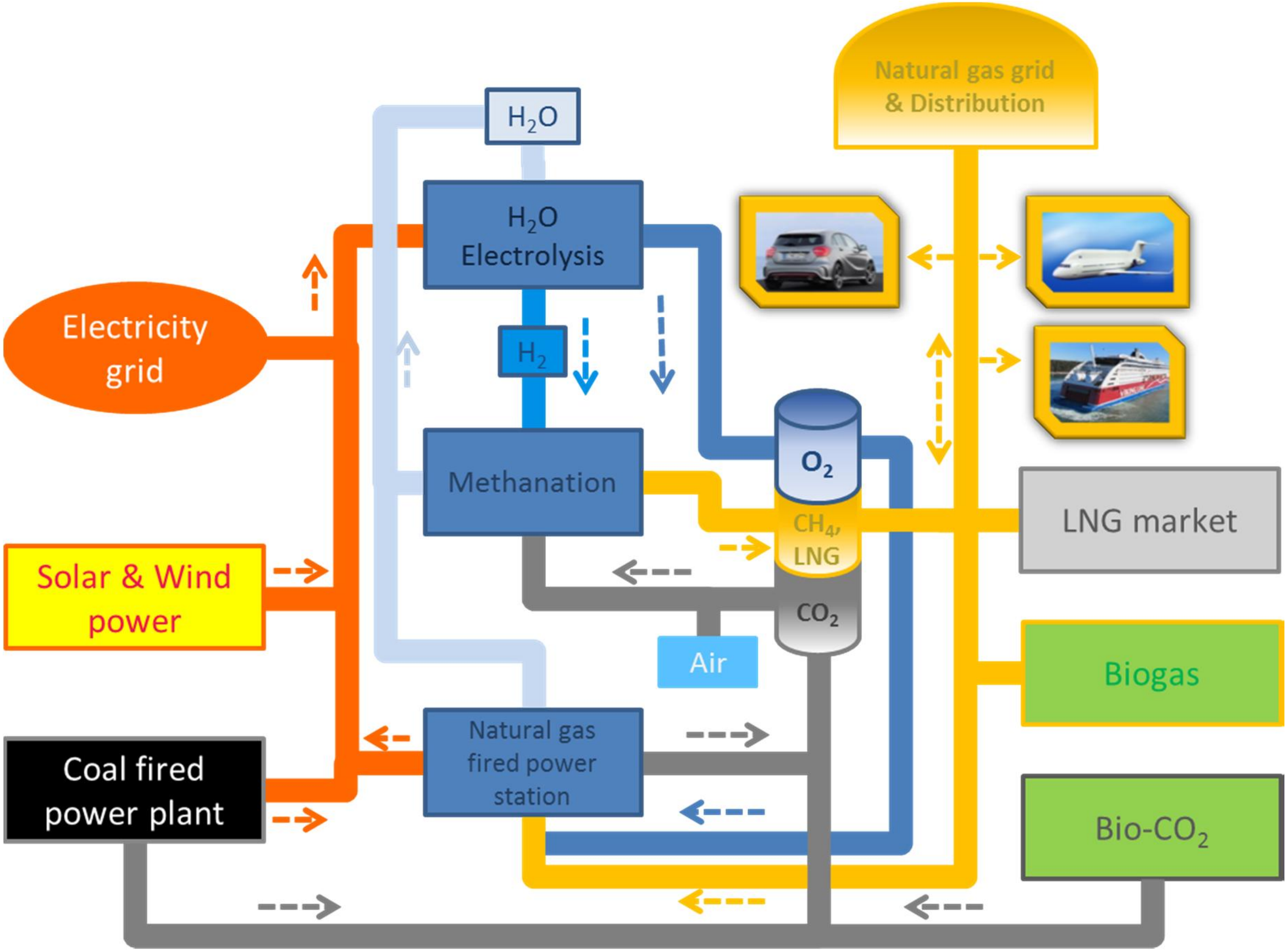
▪ Storages generation



Source: Breyer Ch. and Bogdanov D. et al., 2014. North-East Asian Super Grid: Renewable Energy Mix and Economics, WCPEC-6, Kyoto, November 23-27, to be published



System level view



NEO-CARBON ENERGY

We want to make a zero emission energy system with significant proportion from renewables cost efficient and technically feasible by 2020 by providing solutions for peer-to-peer energy trading, energy storage and electricity grid stability in order to balance intermittent solar and wind production.

Key data

- **5** years 1.7.2014-30.6.2019
- **14.2** M€
- **3** National research partners
- **15** industrial partners
- **3** NGOs
- **5** International partners
- **VTT** as the co-ordinator / DSc Pasi Vainikka

- The NEO-CARBON ENERGY project's results provide **foundations for designing** such energy system through:
  - **Principles** of future energy system through futures research.
  - Energy **system design** through system modelling with variable production and energy storages in place.
  - Design and testing **new technologies** for large-scale energy storage and power for mobility. Including process modelling.
  - Suggestions for **market and legislative** frameworks.
  - Initiation of first business cases as **pilot plants** in Finland.
  - Turning the challenges of the new energy system - i.e. integrated smart energy grid management and storage technologies - to an export **opportunity for Finnish industry**.

VTT

LUT Lappeenranta University of Technology

FINLAND FUTURES RESEARCH CENTRE

Turun yliopisto University of Turku

NEO-CARBON ENERGY project is one of the Tekes strategic research openings and the project is carried out in cooperation with VTT, Lappeenranta University of Technology and University of Turku, Finland Futures Research Centre.

Content

- Choices for energy sources
- Status in renewables
- The different types of storages
- The role of energy storages
- State-of-the-art in ‘Power-to-Gas’ and the role of ‘P2G’
- How ‘100% renewable’ electricity system works


VTT
TECHNOLOGY FOR BUSINESS