Electrification of transport and smart energy systems

Prof.dr.sc. Neven Duić

Power Engineering and Energy Management Chair
Department of Energy, Power and Environmental Engineering
Faculty of Mechanical Engineering and Naval Architecture
University of Zagreb, Croatia

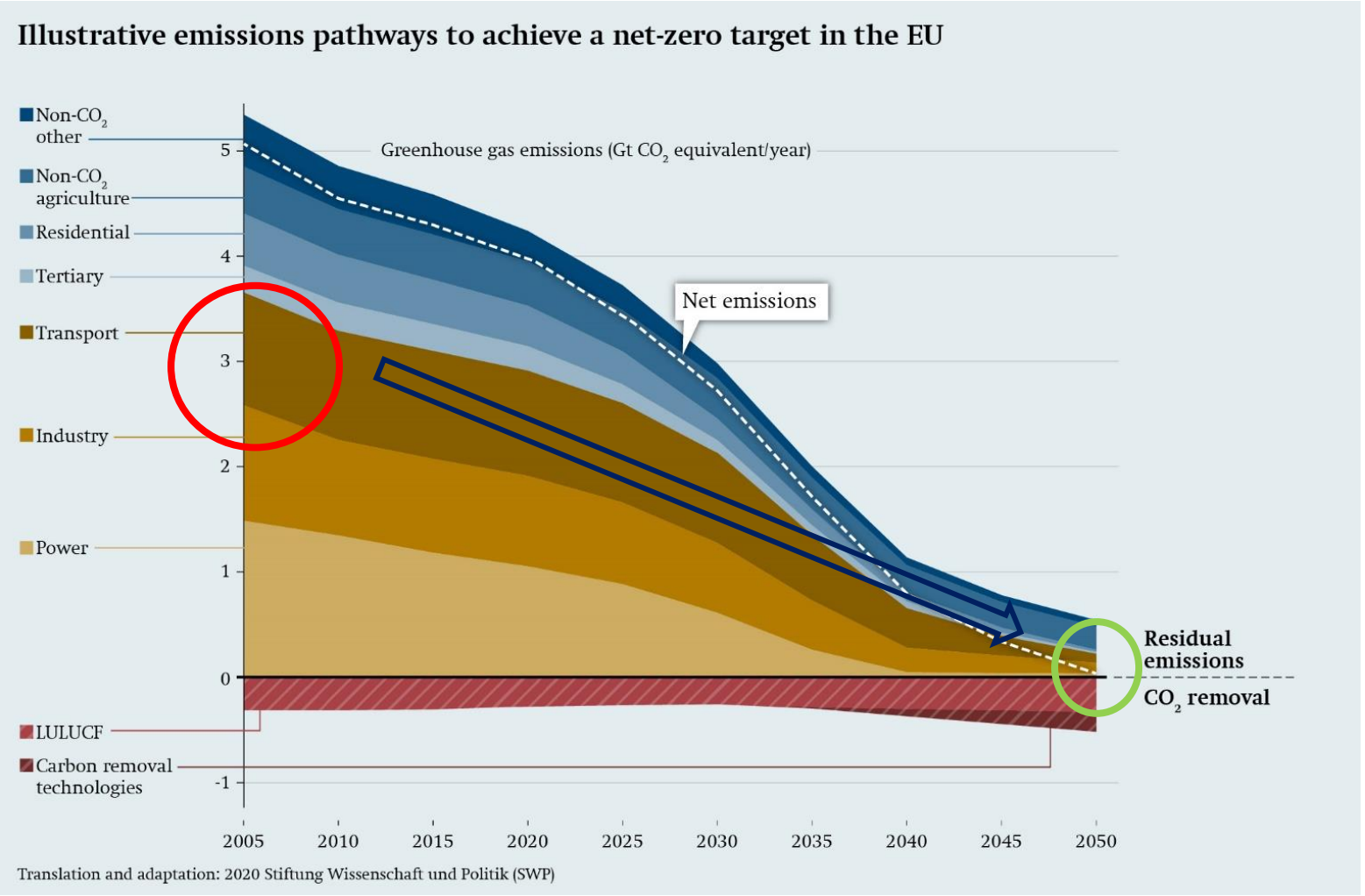
EiC JSDEWES, Editor ECM, Subject Editor Energy
IC SDEWES President

INTRODUCTION to AaCTA

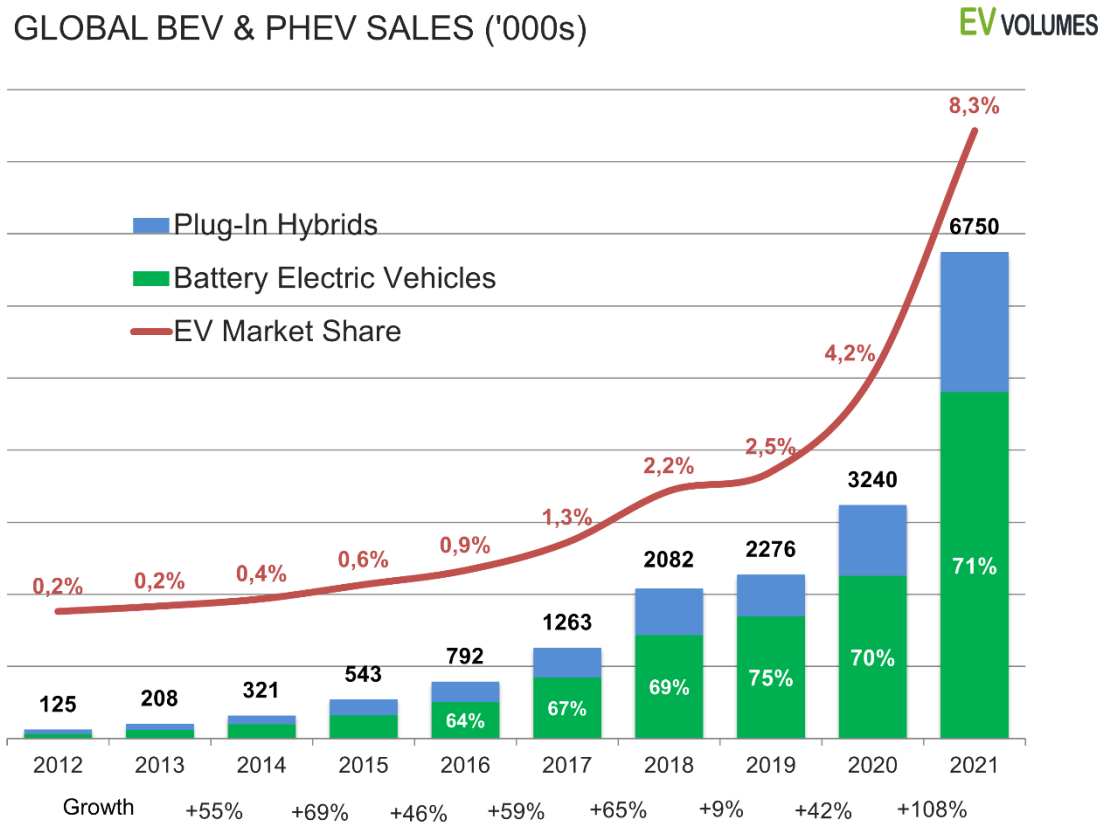
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
European Climate Initiative EUKI

➢ Energy transition and transport?

- Global warming due to anthropogenic CO_2
- Challenging energy transition requires integrated energy systems
- Synergies are necessary
- Fit for 55



Transport electrification has started



Global light vehicles sales in 2021

- 6.7 mln EV
- 81 mln total
- 8.3% global sales
- 108% EV sales growth
- 6% cars sales growth

EU: 19% EV

HR: 3% EV

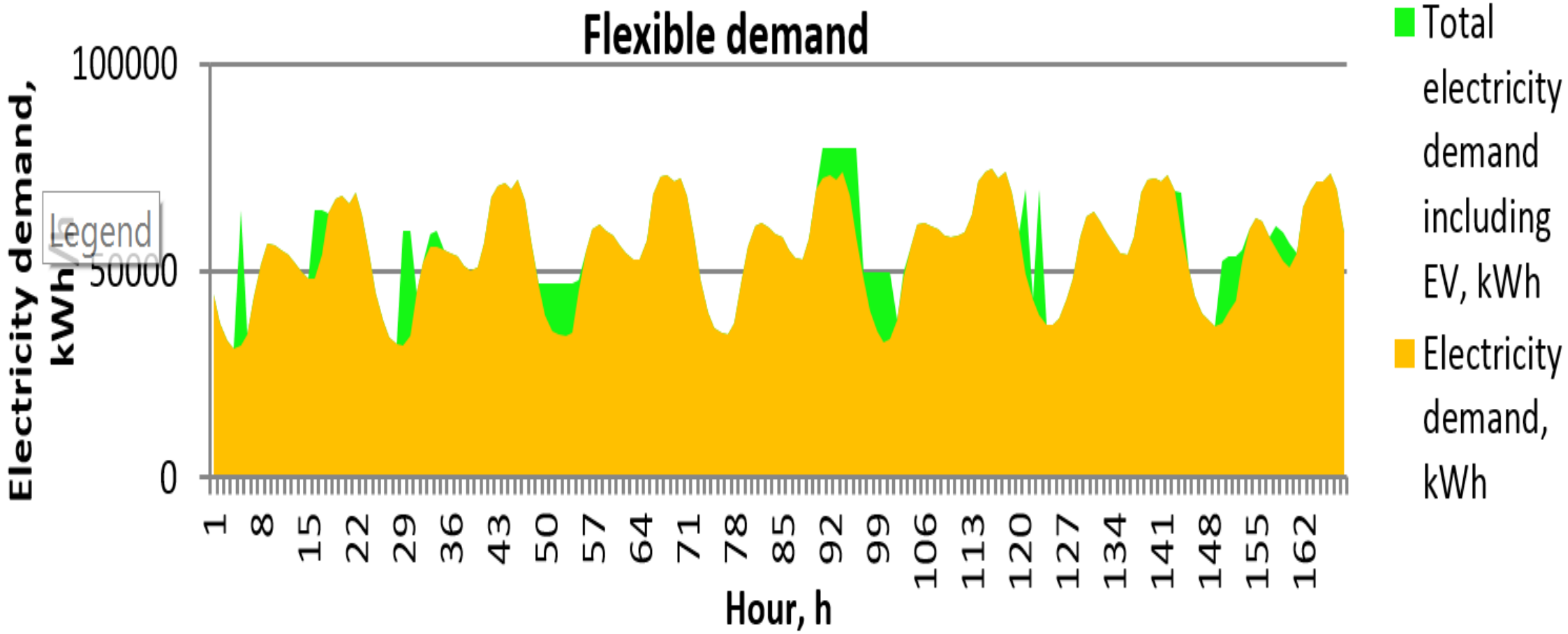
Demand response – power-to-transport

- Electromobility
  - Only personal cars and short distance utility vehicles, 6.7 mln PHEV and BEV sold in 2021
  - Fast charging 70 kW – huge problem if left uncontrolled, ex AT, 4 mln cars arrives home, plugs in – 280 GW (14 GW installed cap)
  - Smart charging – market based, smoothing the demand

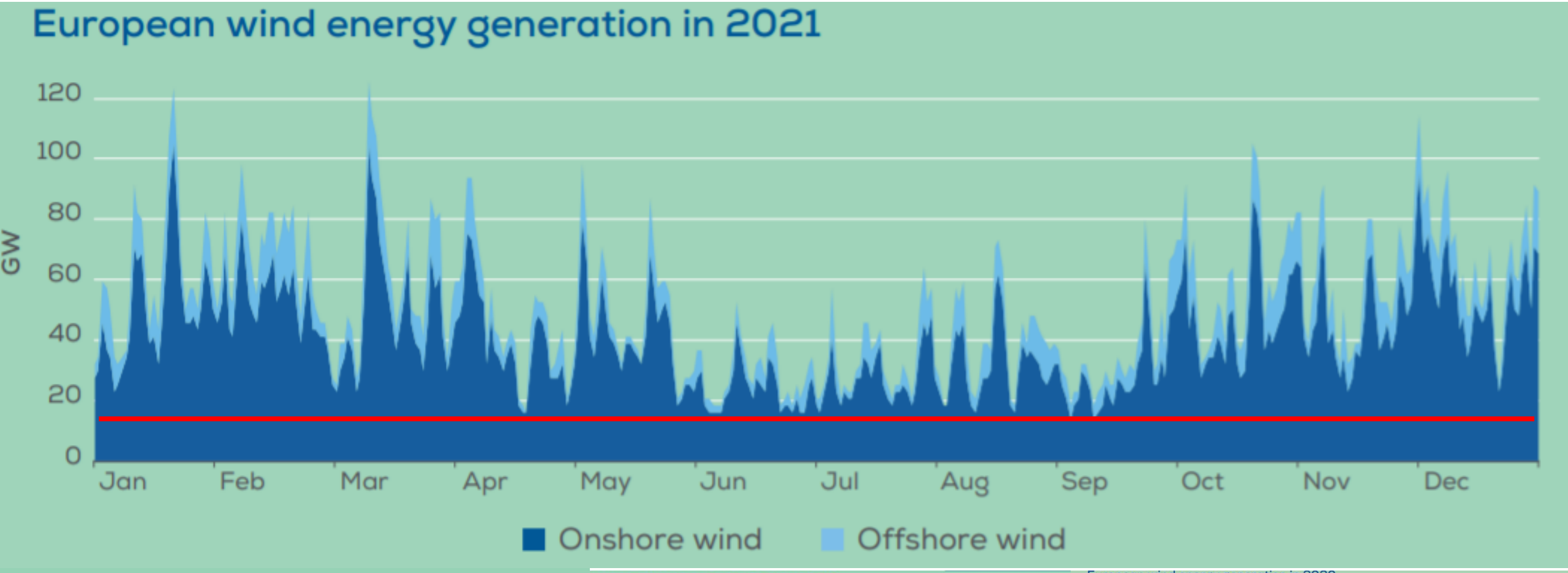
Charging EV

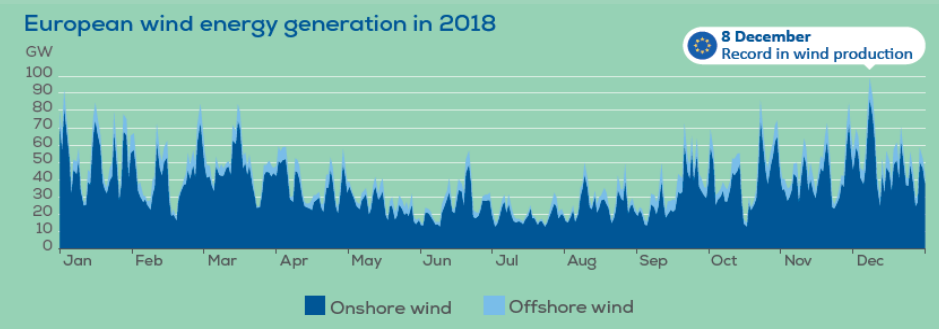
- Fast chargers on highways
- Slow but smart chargers at each parking place

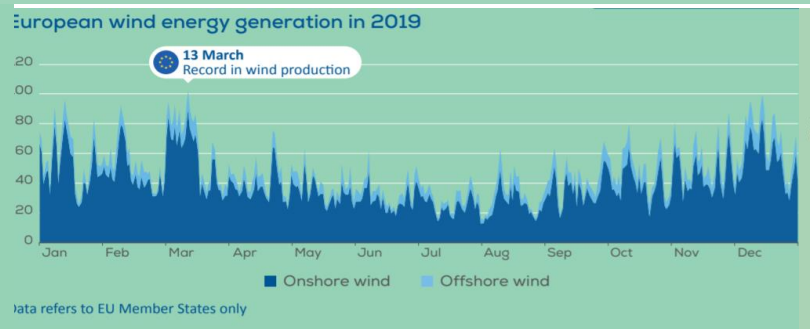
Smart charging

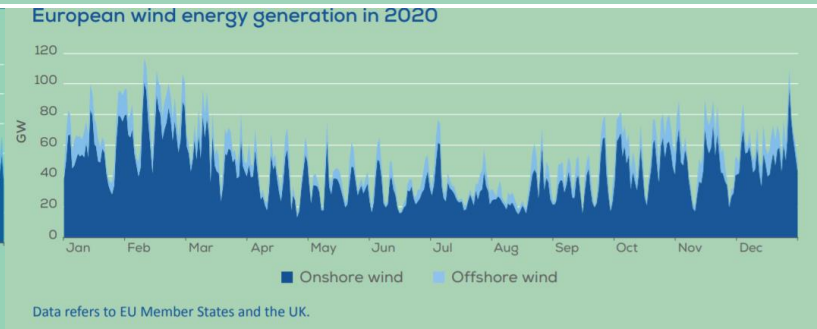


Wind is actually baseload with excess









Demand response – power-to-X

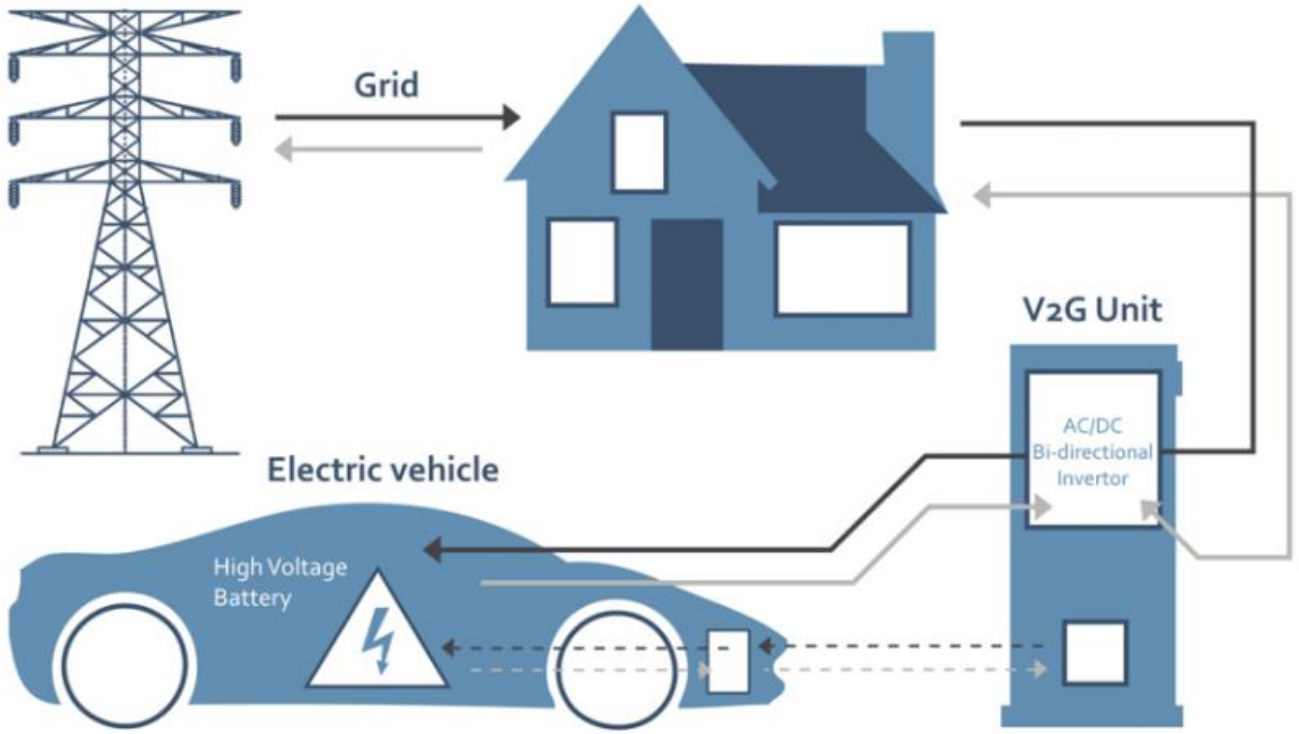
- 20th century energy systems: supply follows demand
- 21st century energy systems: demand follows supply -> smart energy systems

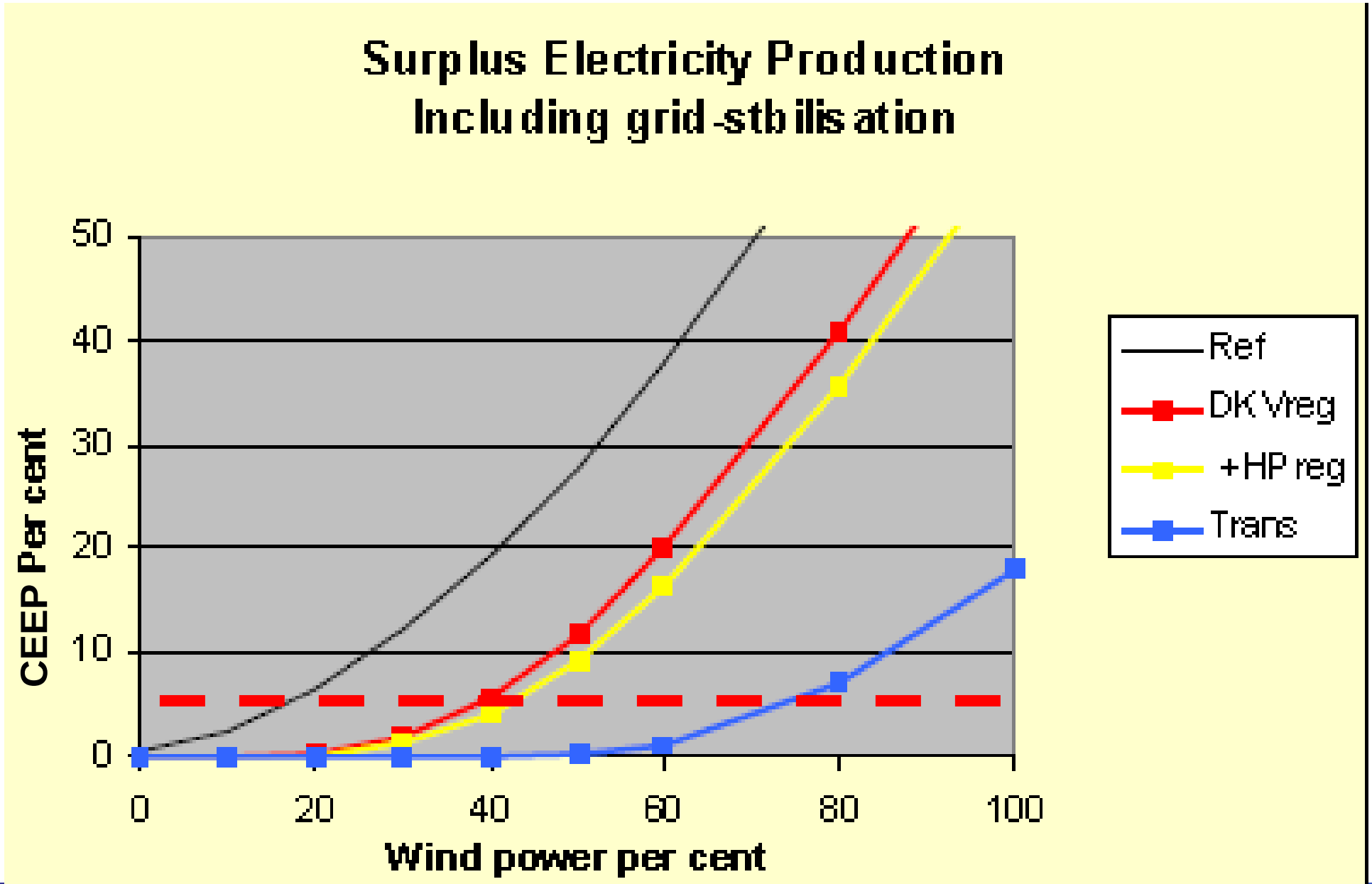
INTRODUCTION to AaCTA

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
European Climate Initiative EUKI

Demand response technology and a balancing technology to support the power system

- New markets are being developed
- Smart charging
- Vehicle-to-grid

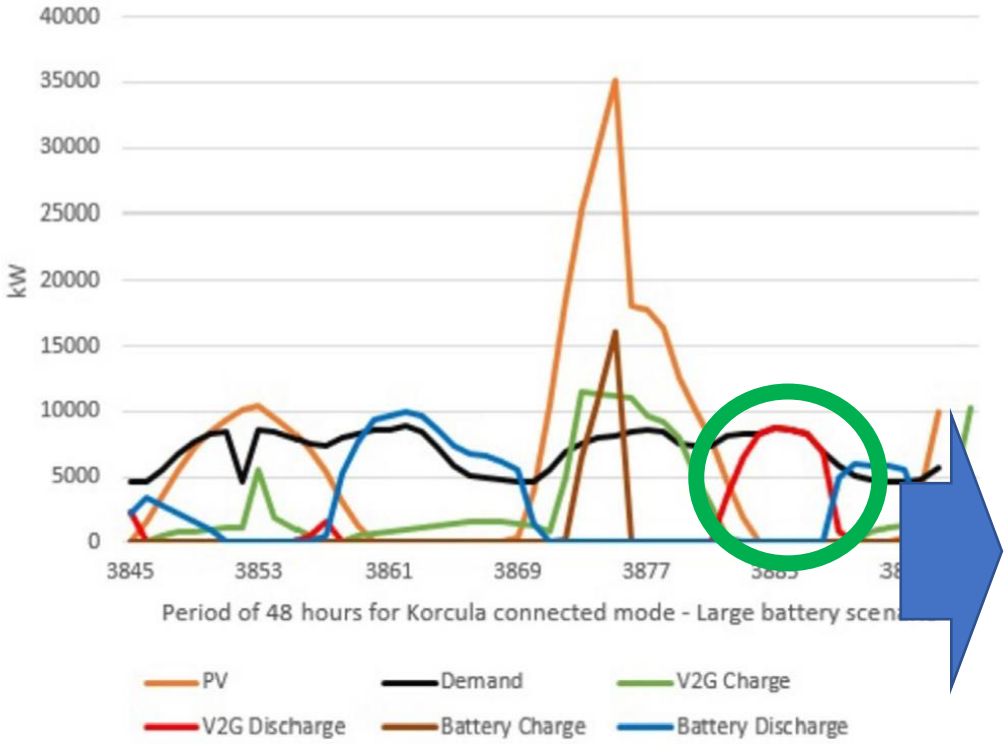



Surplus Electricity Production
Including grid-stbilisation
CEEP Per cent
50
40
30
20
10
0
0
20
40
60
80
100
Wind power per cent
Ref
DK Vreg
+HP reg
Trans

INTRODUCTION to AaCTA

Electrification of transport and its interaction with the power sector is a hot topic

Dorotić, Hrvoje; Doračić, Borna; Dobravec, Viktorija; Pukšec, Tomislav; Krajačić, Goran; Duić, Neven, Integration of transport and energy sectors in island communities with 100% intermittent renewable energy sources // *Renewable & sustainable energy reviews* **99**, 109-124 (2018)



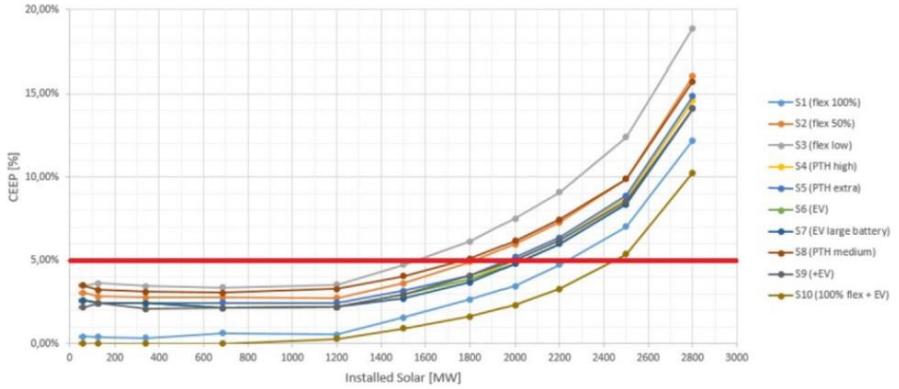


Fig. 3. Results of different scenarios compared to the 5% CEEP limit.

Pfeifer, Antun ; Krajačić, Goran ; Ljubas, Davor ; Duić, Neven, Increasing the integration of solar photovoltaics in energy mix on the road to low emissions energy system – Economic and environmental implications // *Renewable energy*, **143**, 1310-1317 (2019

Table 4
Input data for all scenarios.

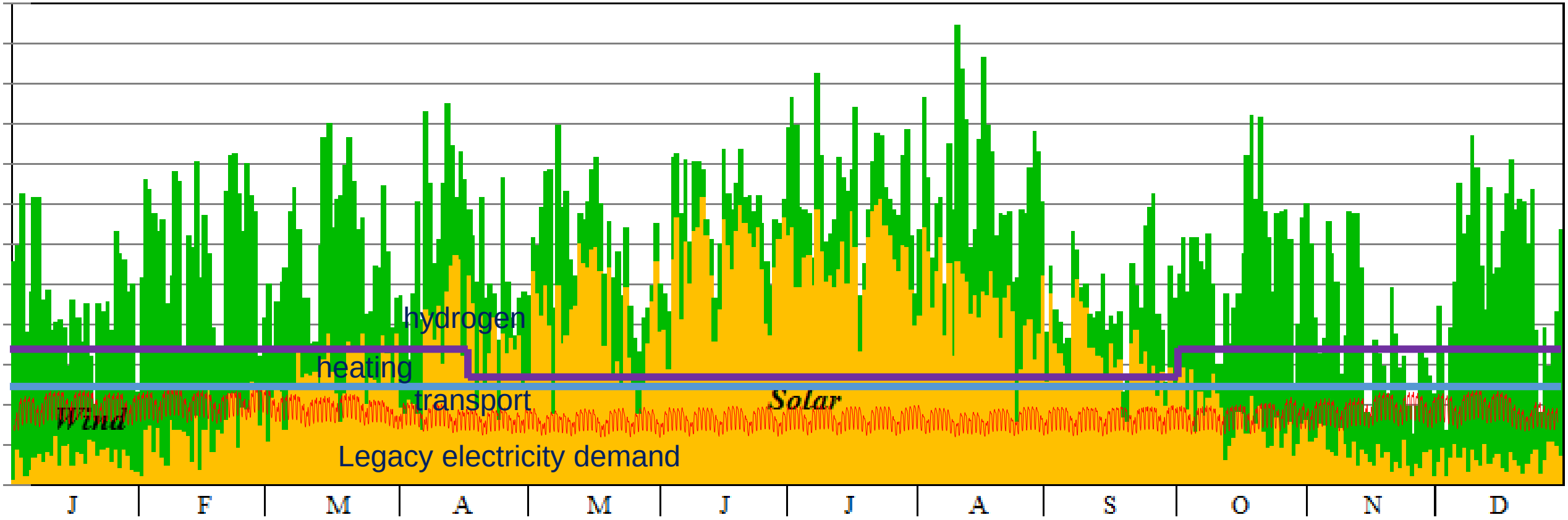
Year 2030	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Minimum CHP [MW]	0	0	150	0	0	0	0	0	0	0
Minimum PP [MW]	0	200	200	200	200	200	200	200	200	0
PTH Storage [GWh]	2.25	2.25	2.25	4.5	10	2.25	2.25	2.25	2.25	10
HP COP	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
HP [MW]	90	90	90	180	180	180	180	100	100	100
EV consumption [TWh]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.72	0.72
EV battery size [kWh]	15	15	15	15	15	15	20	20	20	20

In combination with other technologies, it provides flexibility for variable generation

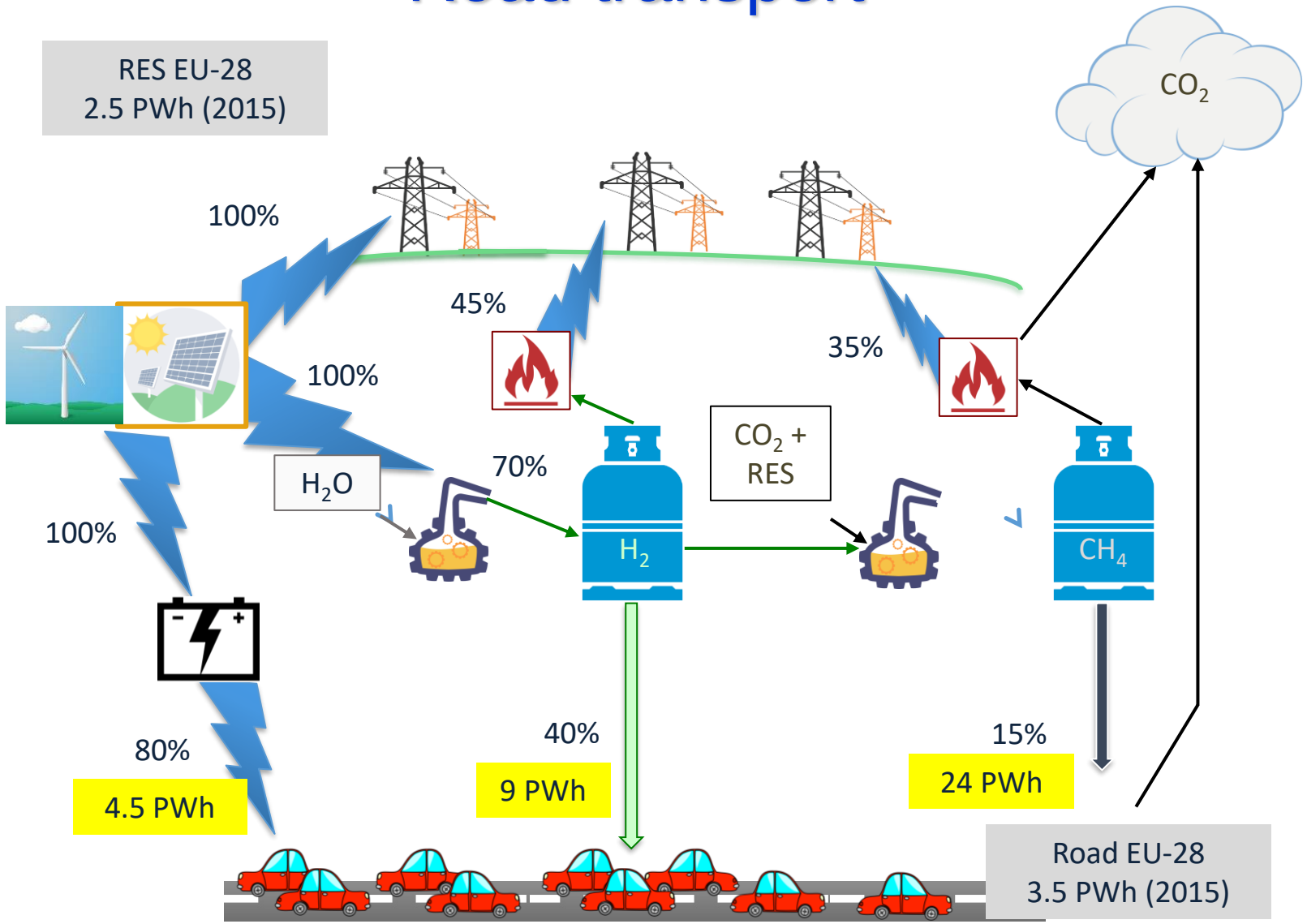
Pfeifer, Antun; Dobravec, Viktorija; Pavlinek, Luka; Krajačić, Goran; Duić, Neven, Integration of renewable energy and demand response technologies in interconnected energy systems // *Energy* **161**, 447-455 (2018)

In insular systems, it can provide complete supply on its own in critical hours

Wind and solar are actually baseload with excess, which we can use for heating, driving and hydrogen for industry



Road transport



Based on slides by Marco Mazzotti, ETH Zurich, presented in Brussels – Feb 20th, 2018