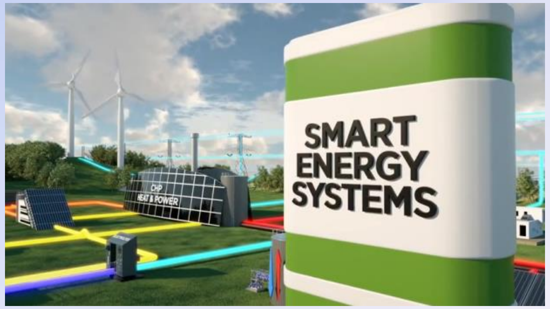
14th CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS



Perspectives on 100% Renewable Energy Systems around the World

Panel discussion, Wednesday 2 October

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Publications on 100% Renewable Energy

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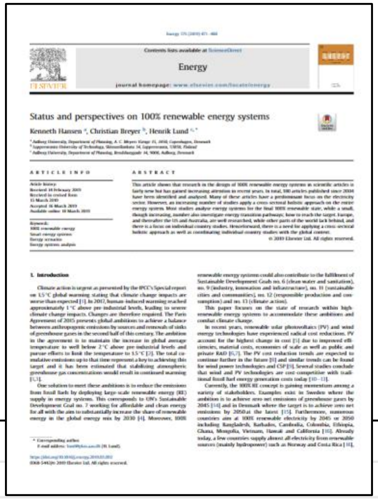
Energy
Status and perspectives on 100% renewable energy systems
Kenneth Hansen, Christian Breyer, Henrik Lund

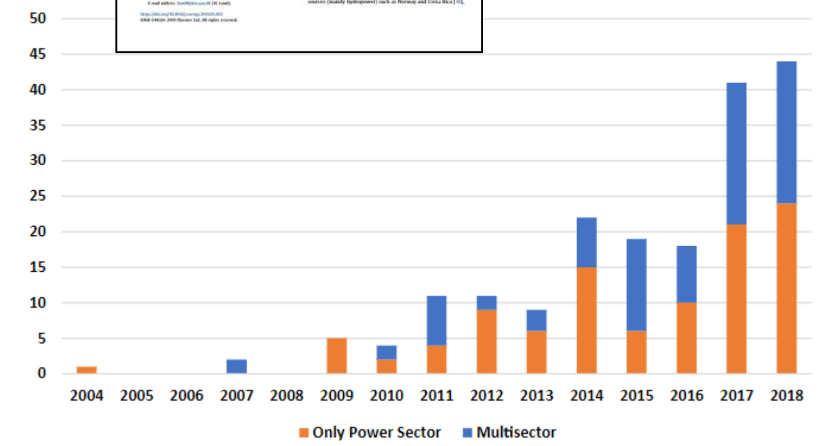

Fig. 1. Number of 100% RE studies for countries, regions and globally according to their publication year.

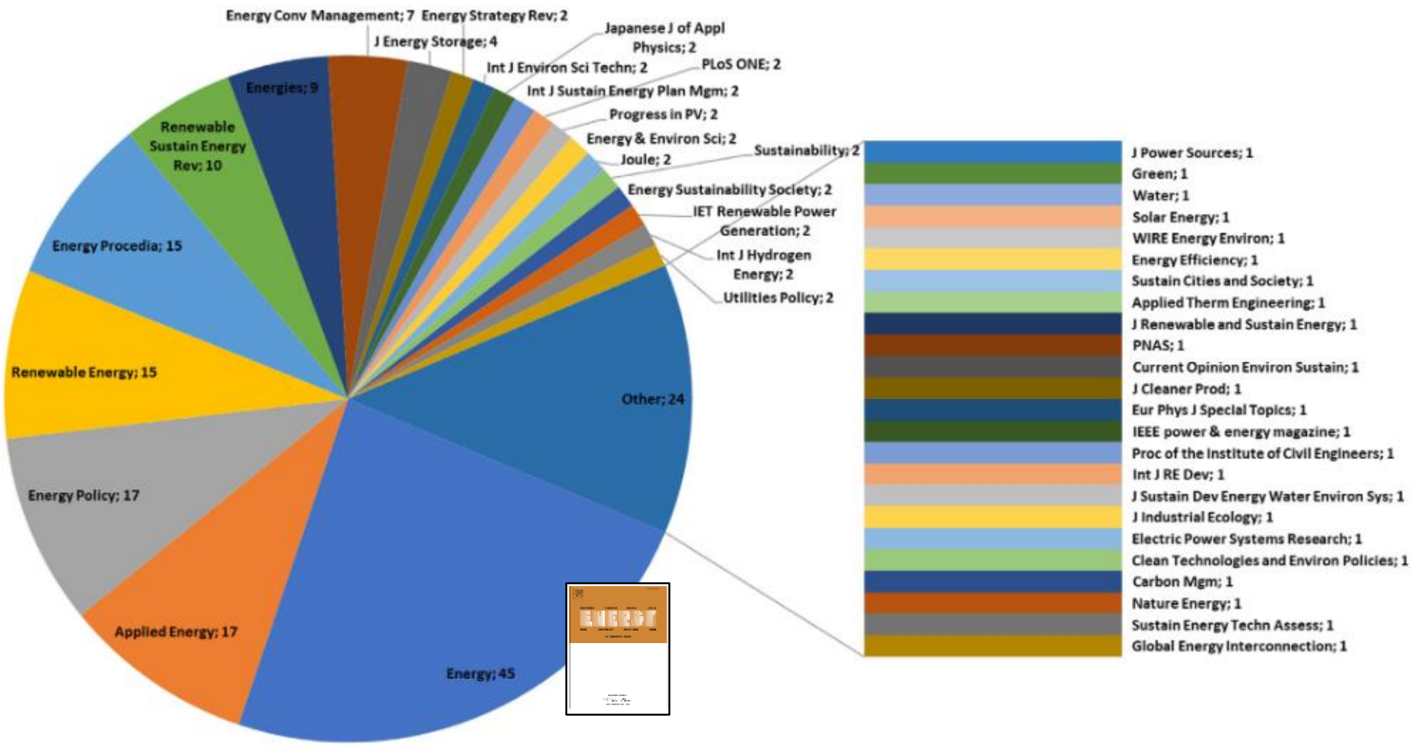

Fig. 3. Number of 100% RE studies for countries, regions and globally according to the publishing journal.

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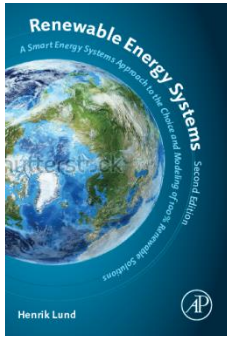
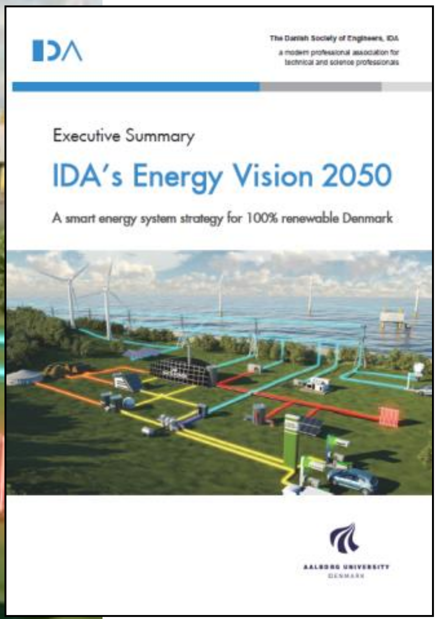
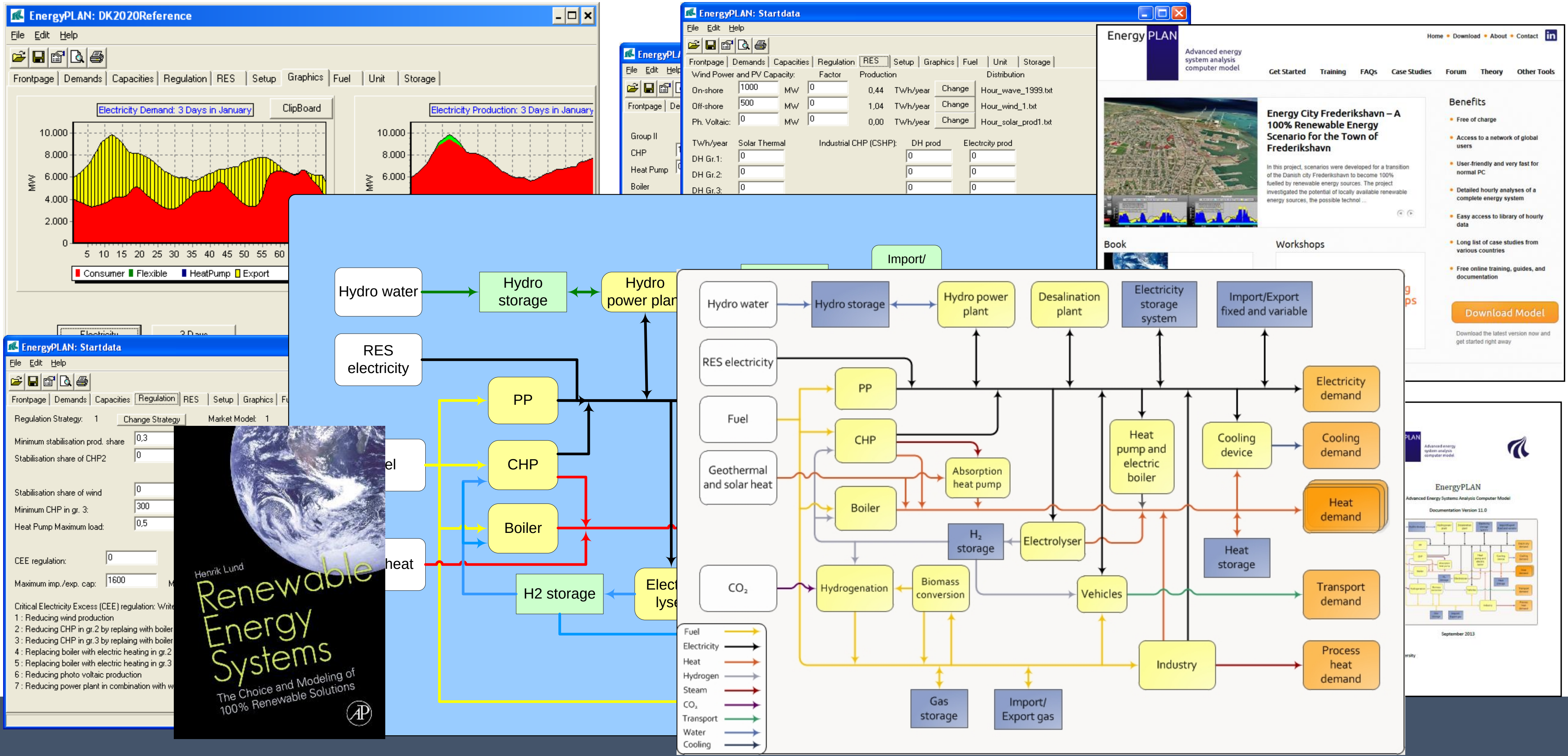
The Design of Renewable Energy Systems

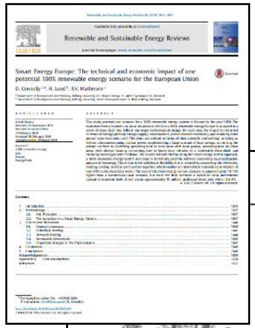


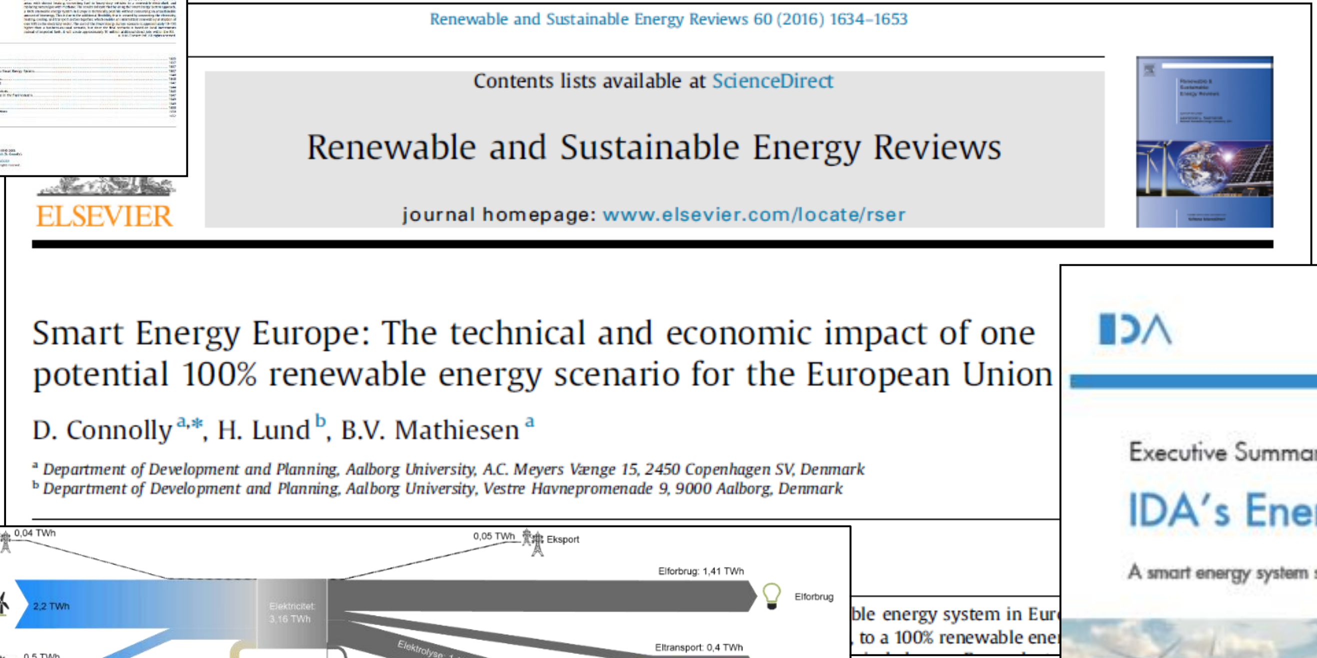


Energy System Analysis and Modelling



Local, National and Regional and Global Studies




Renewable and Sustainable Energy Reviews 60 (2016) 1634–1653
Contents lists available at ScienceDirect
Renewable and Sustainable Energy Reviews
journal homepage: www.elsevier.com/locate/rser
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Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union

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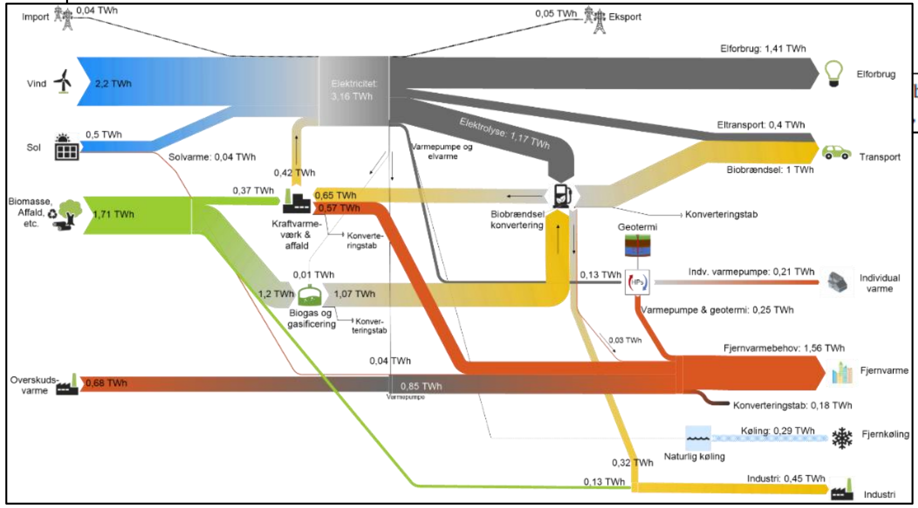

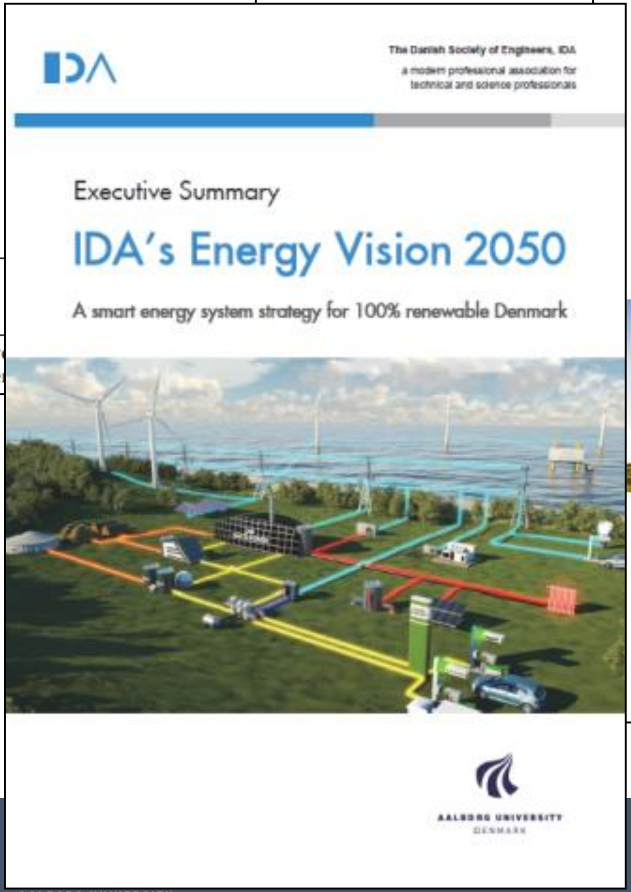

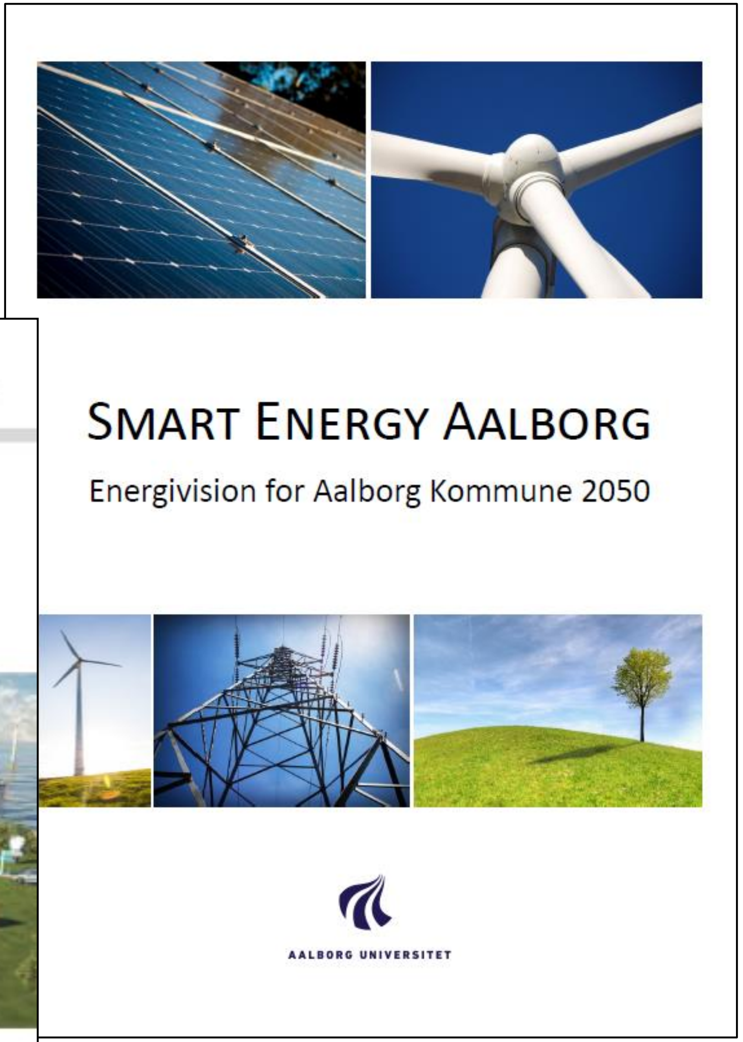

Panel members

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Prof. Christian Breyer
LUT University, Lappeenranta, Finland

Gaps in 100% renewable energy research

Prof. Neven Duić
University of Zagreb, Zagreb, Croatia

100% RES energy systems – electrification, hydrogen or e-fuels?

Prof. Mark Z. Jacobson
Stanford University, Stanford, United States

Prof. Natasa Markovska
Research Center for Energy and Sustainable Development Skopje, North Macedonia

The views from the IPCC SR1.5

Prof. Xiliang Zhang
Tsinghua University, Beijing, China

Decarbonization of China's Electricity Sector for the 2 Degree Targat

Zhang Xiliang
Institute of Energy, Environment and Economy
Tsinghua University

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International pledges & national legally binding targets

- NDC under the Paris Agreement
  - To achieve the peaking of carbon dioxide emissions *around 2030 and making best efforts to peak early*;
  - To lower carbon dioxide emissions per unit of GD**P** by 60-65% by 2030 from the 2005 level; and
  - To increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030.
- National targets for the 13th Five-Year-Plan (2016-2020)
  - Energy intensity target: reduce 15% relative to 2015
  - Carbon intensity target: reduce 18% relative to 2015
  - Non-fossil energy target: 15% of non-fossil fuels in primary energy supply by 2020

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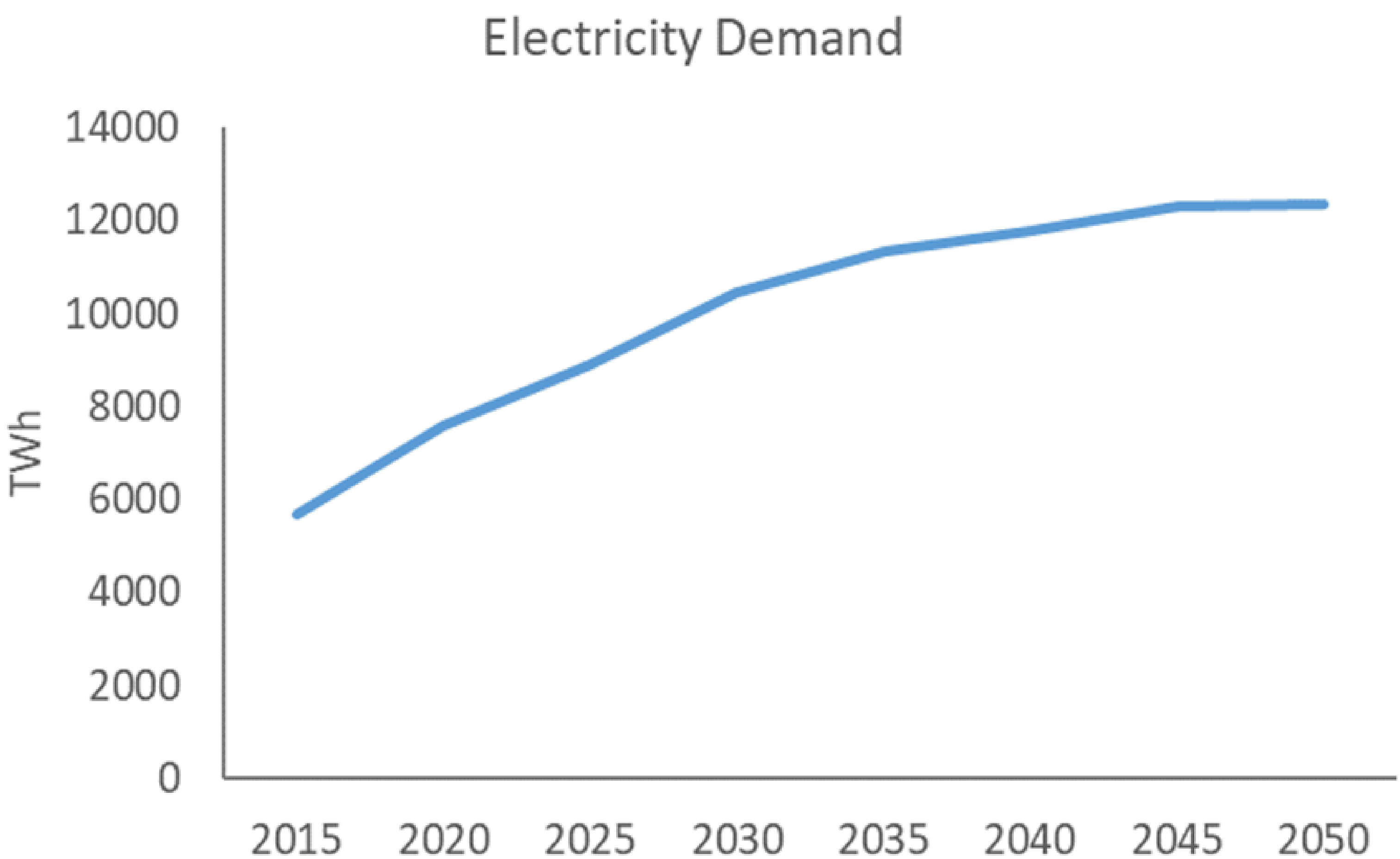
China's Electricity Consumption Growth



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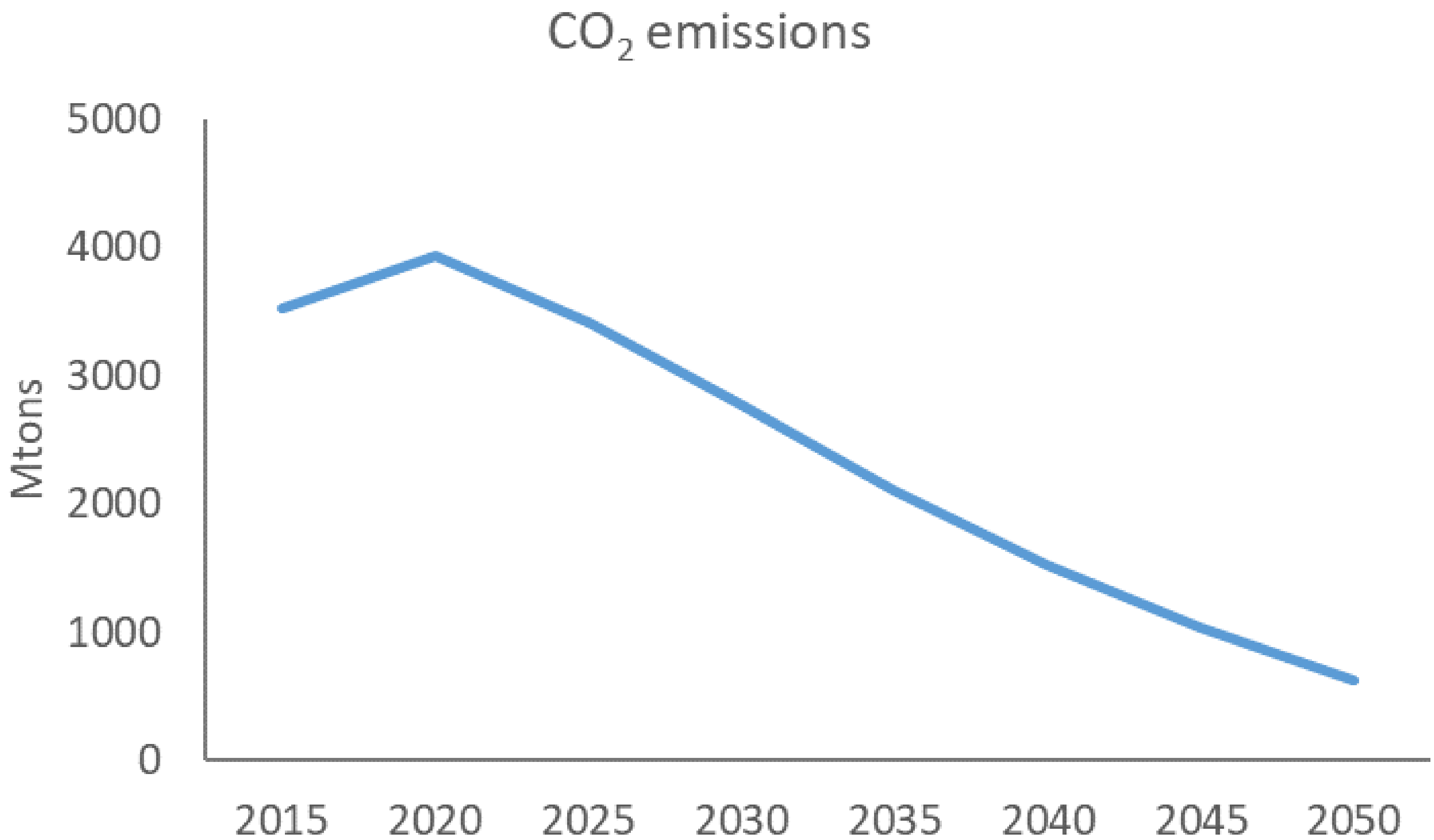
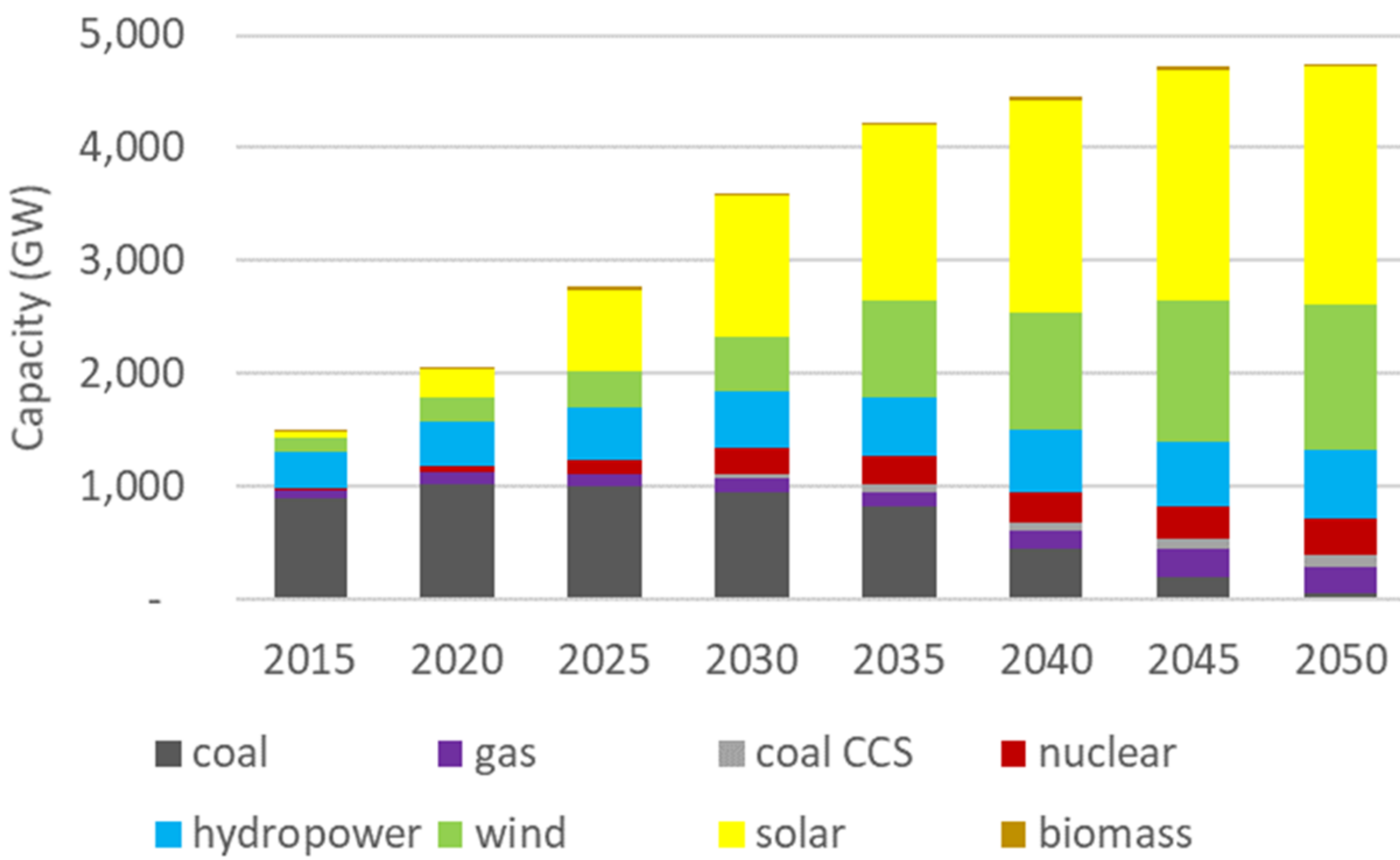
CO2 Emissions of the Electricity Sector for the 2 Degree Target



Installed Capacity of Electricity Generation



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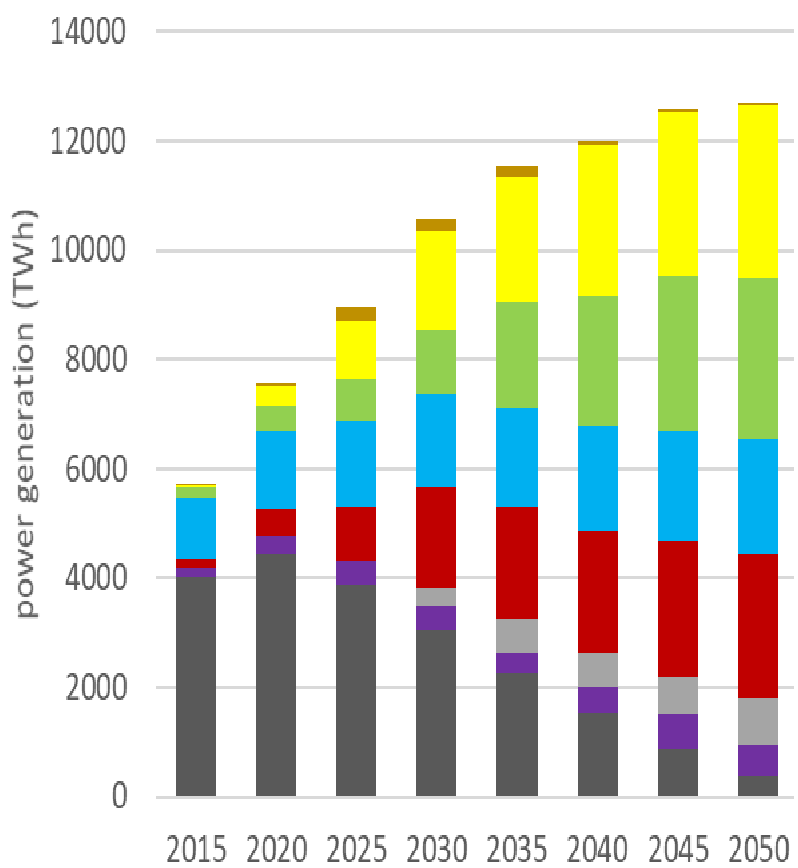
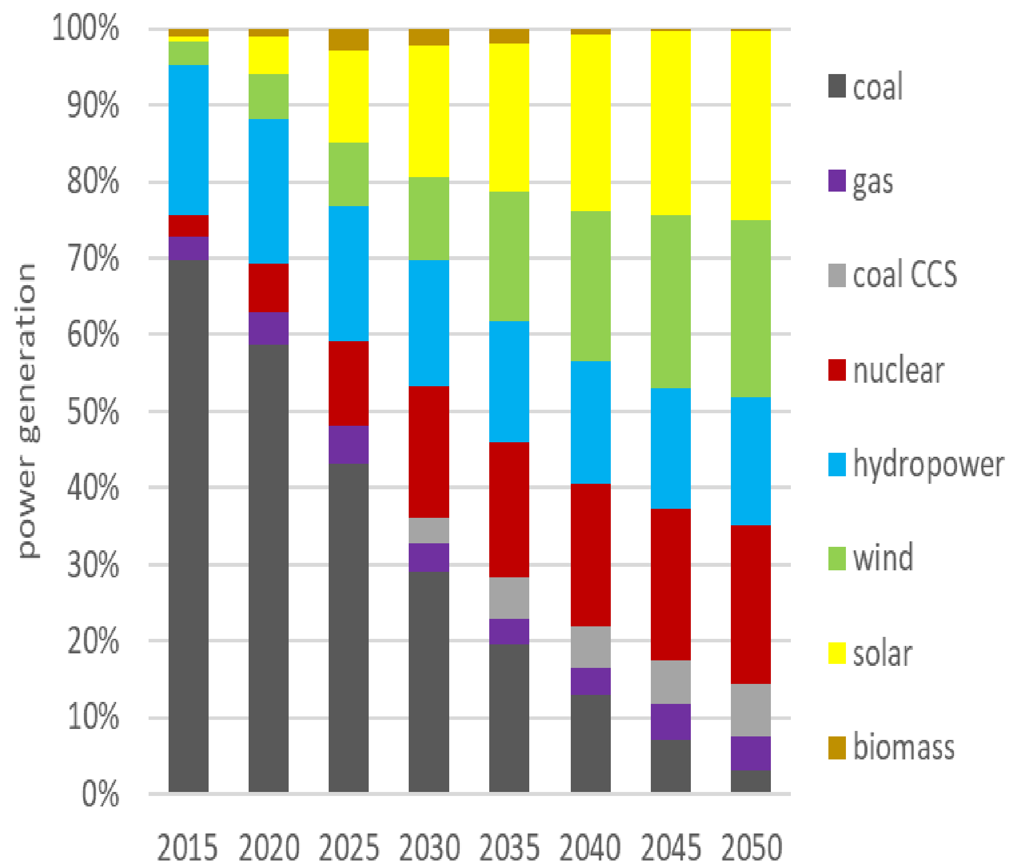
Mix of Electricity Generation





Key Technological and Policy Measures

- System flexibility
  - Improve the flexibility of coal-fired power plants
  - Encourage the development of flexible power plants and storage
  - Enhance the interconnection of power grids
  - Encourage the development of demand response
- System reliability and frequency management
  - Renewable power forecasting
  - Integration with other energy systems
  - Storage and back-up units
  - Frequency management
  - Ancillary service
- Policy and institutional reform
  - Complete electricity market
  - Renewable portfolio standard
  - Carbon emissions trading system

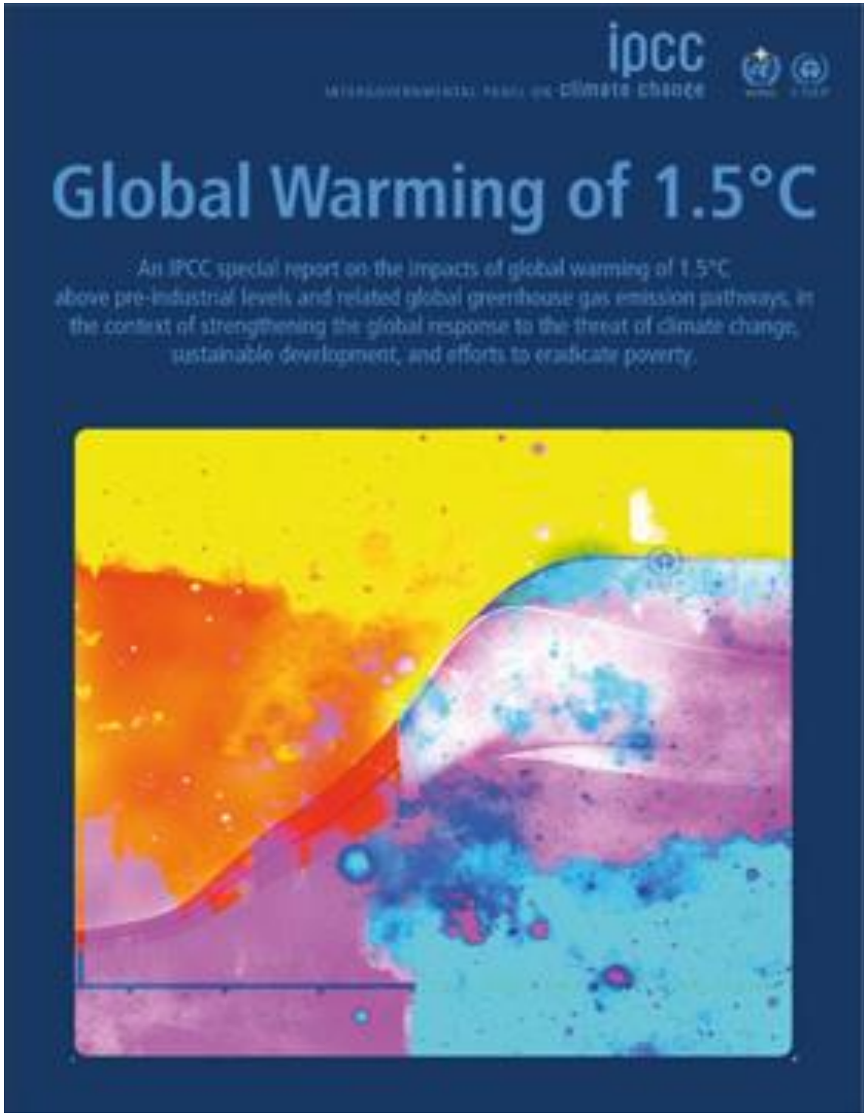
Thank you for your attention.

Zhang_xl@Tsinghua.edu.cn

Panel: **Perspectives on 100% Renewable Energy Systems around the World**

The views from the IPCC SR1.5

IPCC SR1.5



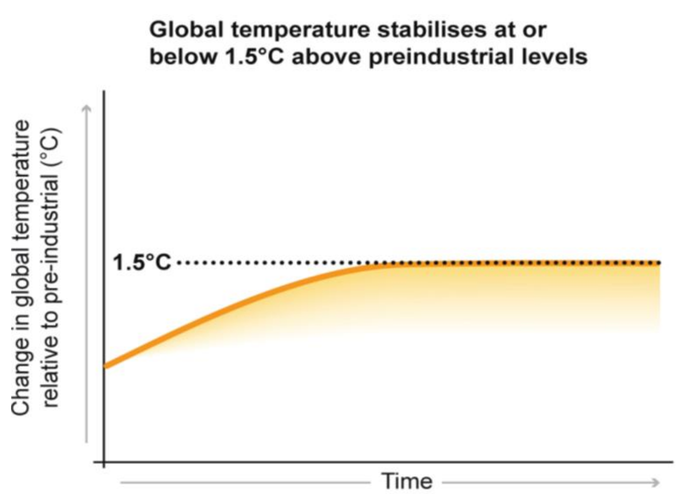
Numbers behind the science:

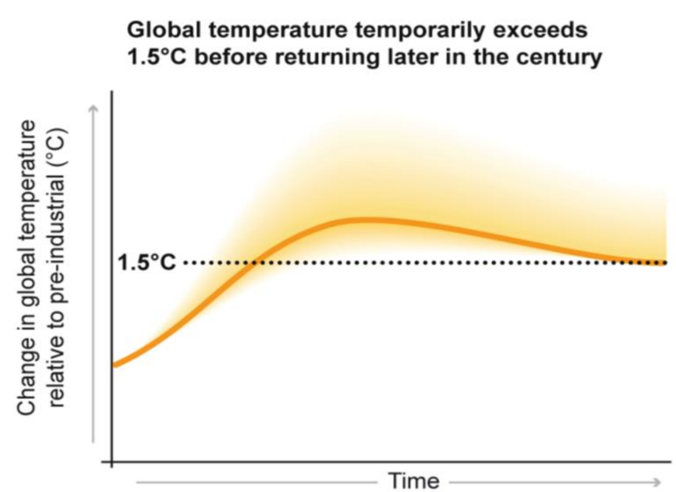
- More than 6000 research papers assessed
- 91 authors and editors from 40 countries
  - 9% Africa, 20% Asia, 37% Europe, 11% South America, 4% North America, 9% Oceania
  - 32% women
- More than 42 000 comments received in three reviews

SR1.5 Assessments

What a 1.5°C warmer world would look like?

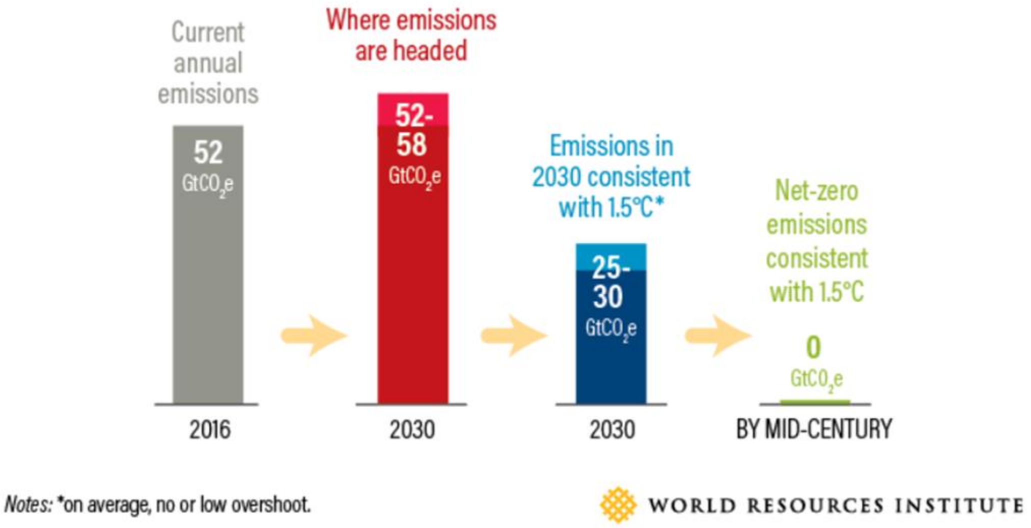
Pathways that limit global worming to 1.5°C





Common features of 1.5°C pathways

By 2030, halving the emissions, and by mid-century, CO2 emissions falling to net-zero



- Renewables supplying 70 percent to 85 percent of electricity and unabated coal use being largely phased out
- Use of carbon dioxide removal (CDR) in the order of 100 – 1000 GtCO2 over the 21st century

CDR deployed at such a scale is unproven, and is a major risk to our ability to limit warming to 1.5˚C !!!

100%- renewable energy scenarios

- Acknowledges the growing body of relevant scientific literature which goes beyond the wide range of Integrated Assessment Models (IAM) projections of renewable energy shares in 1.5°C and 2°C pathways.

- Updated representation of renewable energy resource potentials, technology costs and system integration in IAMs since the AR5.

- Higher renewable energy deployments in many cases.

- **None of the IAM projections identify 100% renewable energy solutions for the global energy system as part of cost-effective mitigation pathways**.

100%- renewable energy scenarios

Will the SDEWES science shed a different light?

Gaps in 100% RE research

- all sectors to be included: power, heat, transport, industry, also non-energetic fuel use in industry; new sector CDR/NETs
- industry sector and transport sector beyond road transport to be more investigated
- better reflection of infrastructure, e.g. grids (power, heat, gas, etc.), and implications on system change with and without stranded assets
- overnight scenarios are helpful, but transitions scenario are more helpful to describe investment lock-ins, or at least risk for stranded assets
- better geographic coverage in high resolution.
    - Europe is understood best in most energy sectors
    - US/ Australia is understood well, but often only for the power sector
    - Africa, Latin America, Africa, Middle East, South Asia, East Asia lack research
- investigation of key cost assumptions, in particular for PV, batteries, electrolysers
- flexibility is key, thus all forms of flexibility have to be studied (supply response, demand response, grids, sector coupling, storage)
- sector coupling to be better understood, e.g. in flexibility, efficiency, cost, etc.

Gaps in 100% RE research

- international power-to-X (fuels, chemicals, material refining) trading to be studied
- material resource availability research requires much more emphasis
- net energy/ EROI analyses are helpful for understanding overvall system efficiency
- Energy System Models have to cover all energy sectors and fuels use plus CO_2 management and CO_2 carbon removal/ negative CO_2 emission technologies
- global 100% renewables sceanarios are needed for the entire 21st century, this allows to compare to the energy sector scenarios of Integrated Assessment Models
- cominbed use of highly resolved Energy System Models and the valuable system interaction modelling of Integrated Assessment Models may create new insights
- IEA, IPCC and others have an institutional bias against 100% - why?
- How to incorporate societal aspects of all kinds in models? Where is the limit of constraints?
- How to project discount factors/ cost of capital/ WACC for an energy transition?
- more review articles in the field of 100% RE are needed

100% RES energy systems – electrification, hydrogen or e-fuels

A view from Europe

Neven Duić

University of Zagreb, Croatia

SDEWES 2019, 100% RES Panel, October 2, 2019

EU climate energy policy

- GHG reduction of 20% by 2020
- GHG reduction of 40% by 2030, but 32% RES & 32.5% EE leads to 45% GHG reduction by 2030 – compatible with s 2 °C
- 55-60% by 2030 compatible with 1.5 °C, EC/EP decided for 55%
- EU ETS CO2 ≈ 25 EUR/t, coal phase out by 2030

EU climate energy policy

- GHG reduction of 80% by 2050 – compatible with 2 °C
- Climate neutral EU by 2050 – GHG reduction by 95% – compatible with 1.5 °C, EC proposal

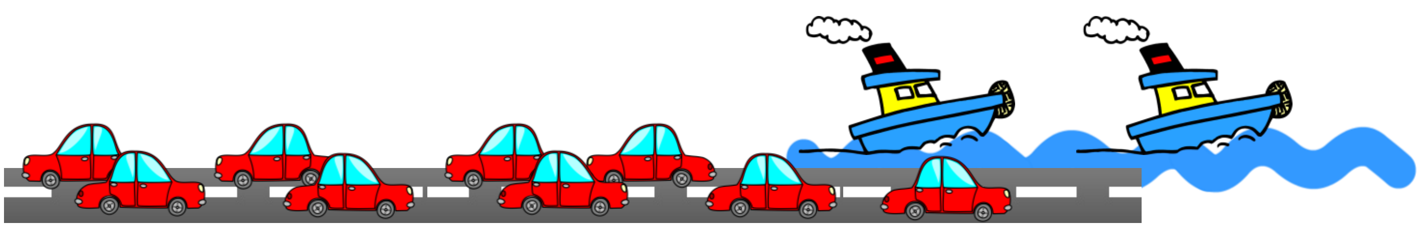
How to avoid stranded costs?

- 2050 – no fossil fuels used
- Gas boilers and ICE cars have lifetime of 20 years
- So, selling them should stop at latest by 2030, sooner the better
- NL banned new gas boilers in 2018, UK after 2025
- NO bans sales of ICE cars after 2025, more countries by 2030

Which way to go?

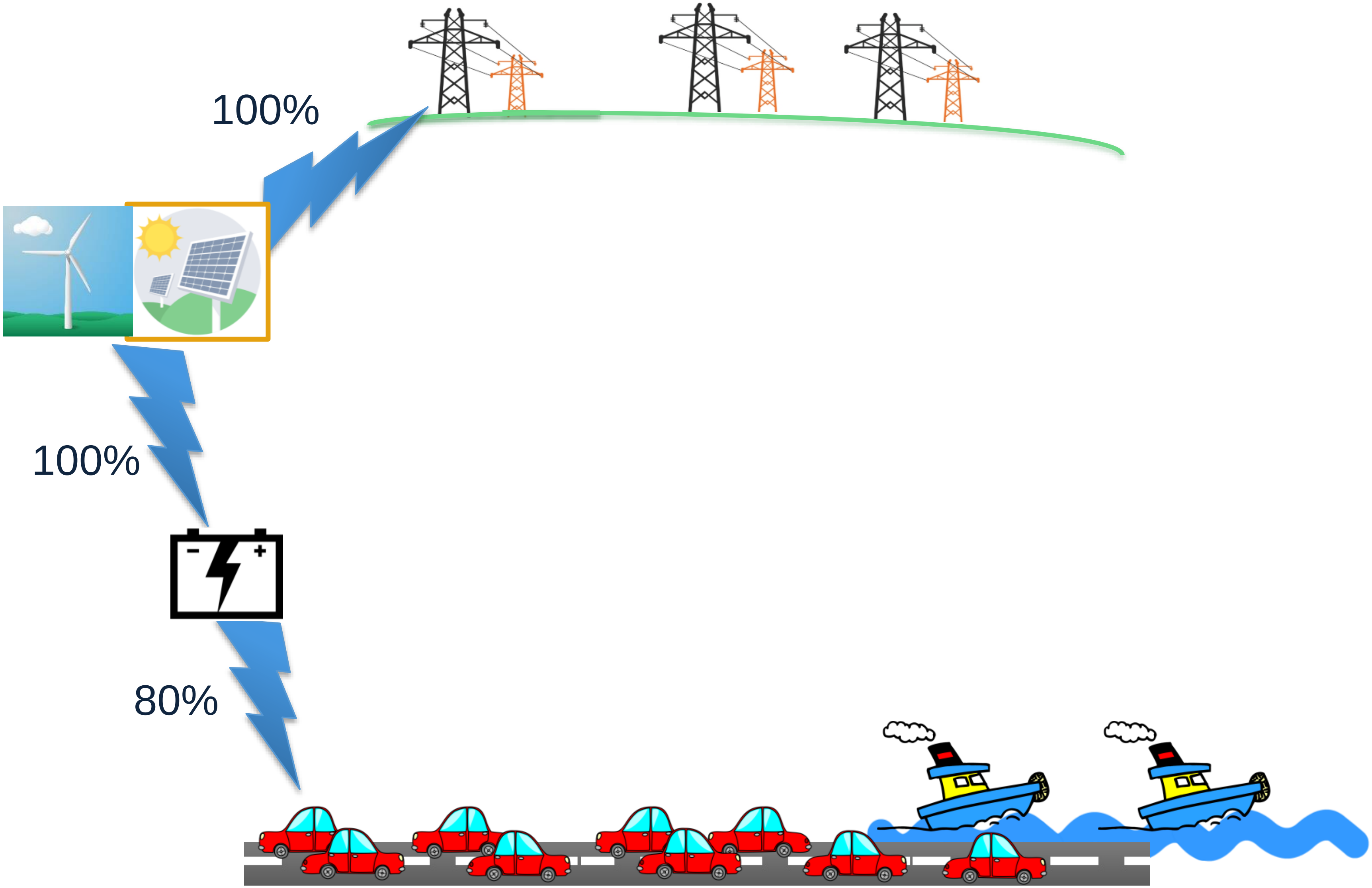
- Heating: which is the best way to decarbonisation?
  - District heating with power to heat plus heat pumps with heat storage or
  - Hydrogen or
  - Renewable gas (bio and e-methane)
- Transport: electricity, hydrogen or e-fuels?

Service delivery



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

Service delivery



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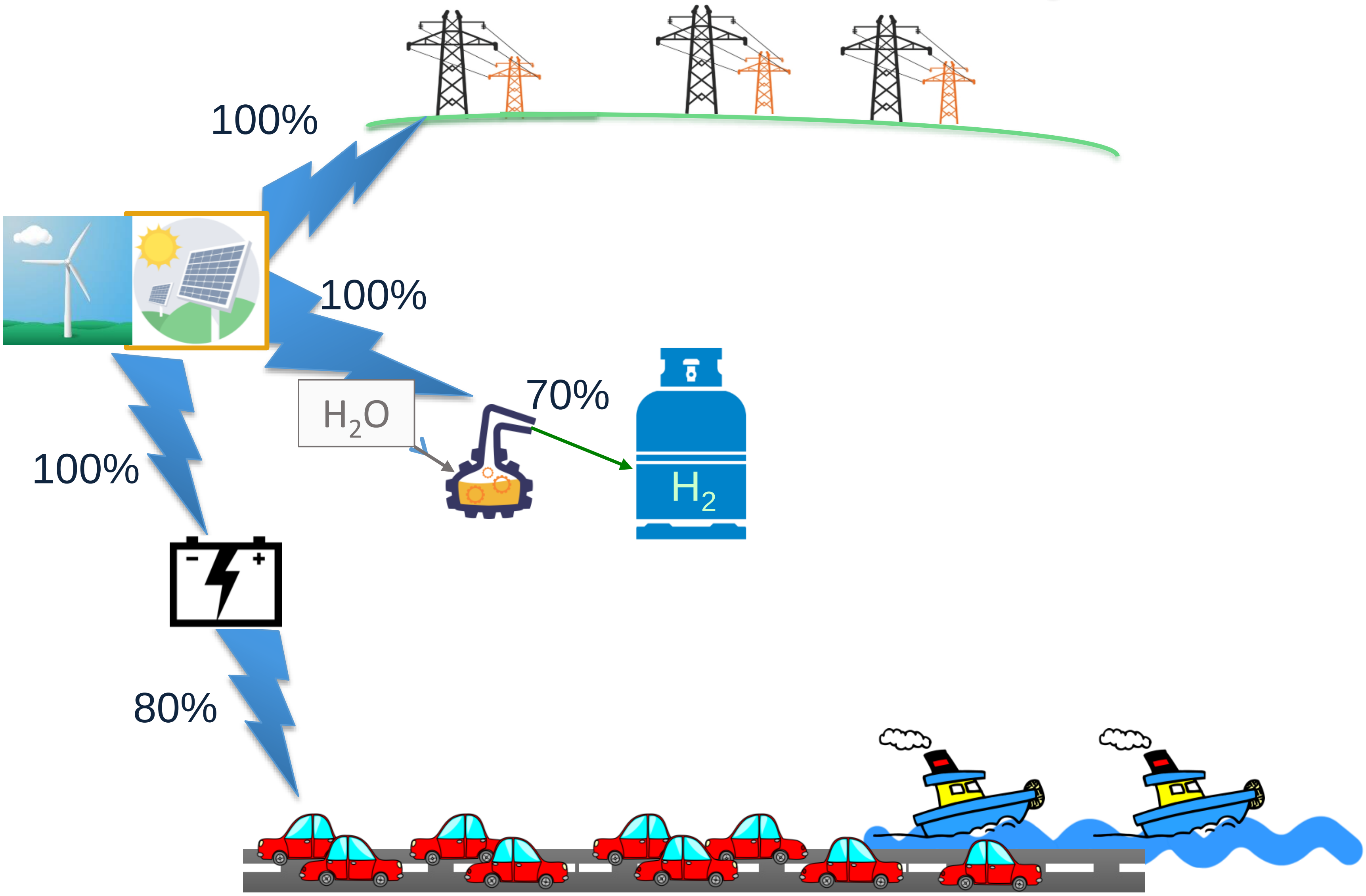
Service delivery



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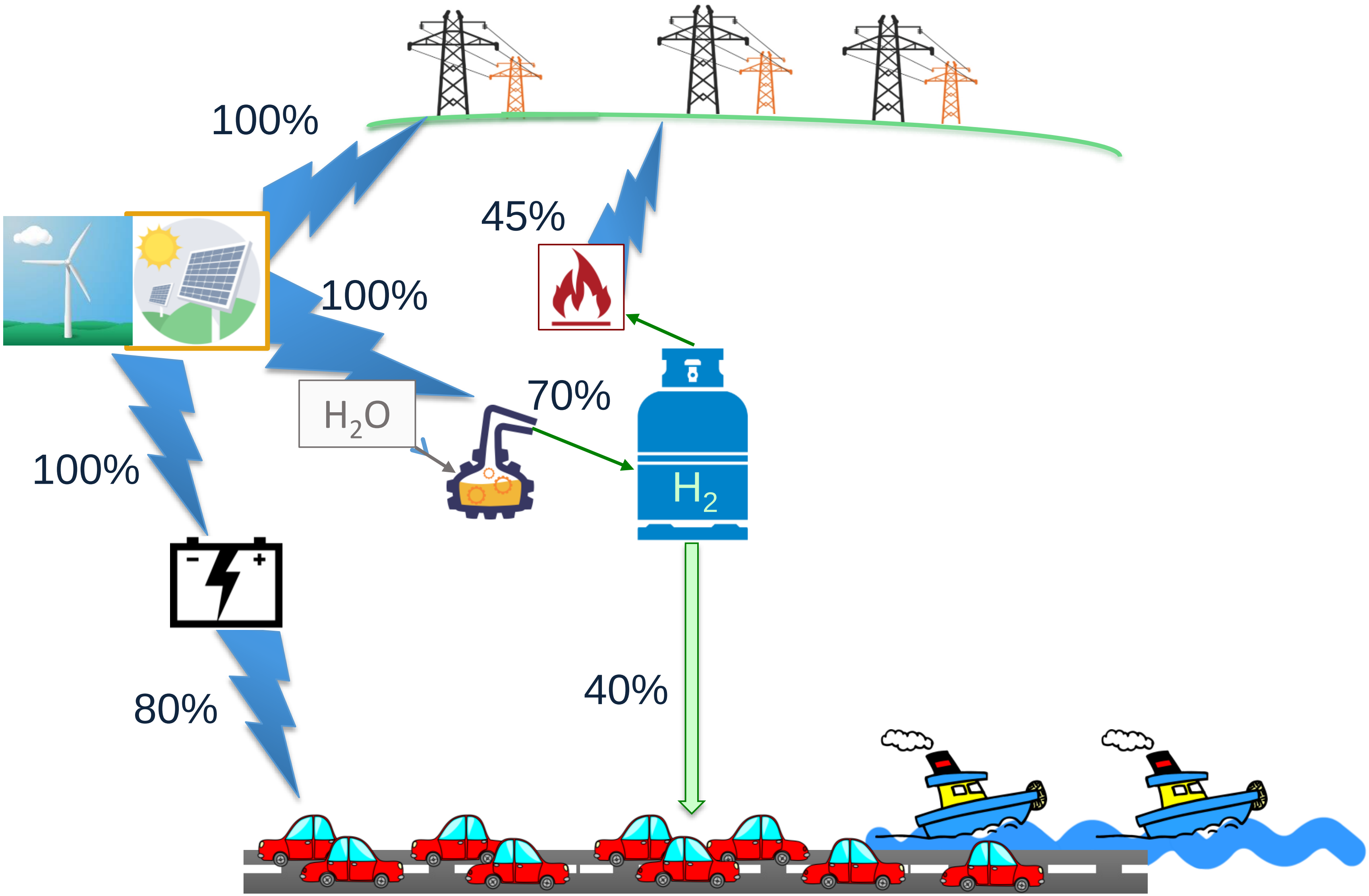

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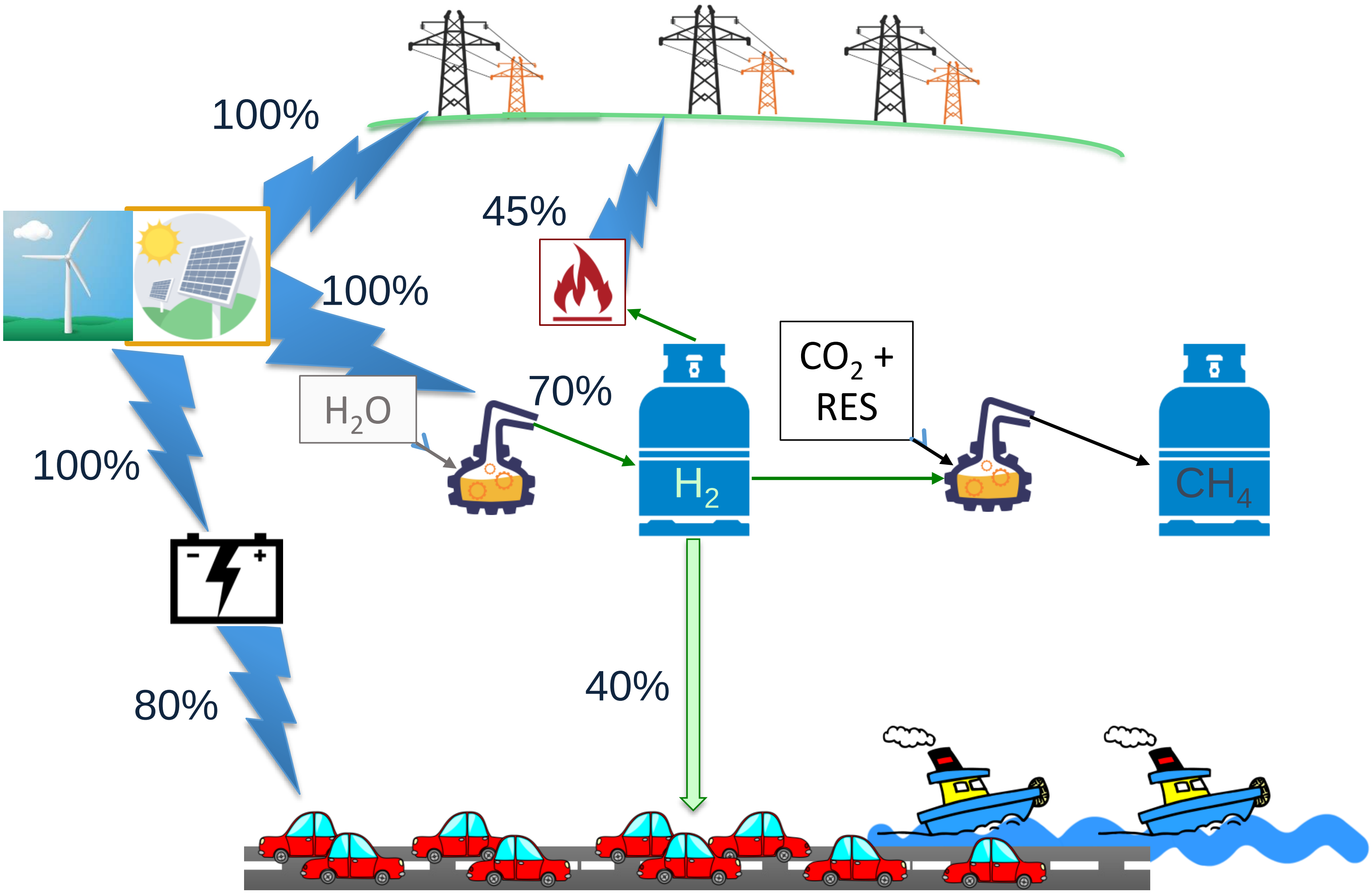

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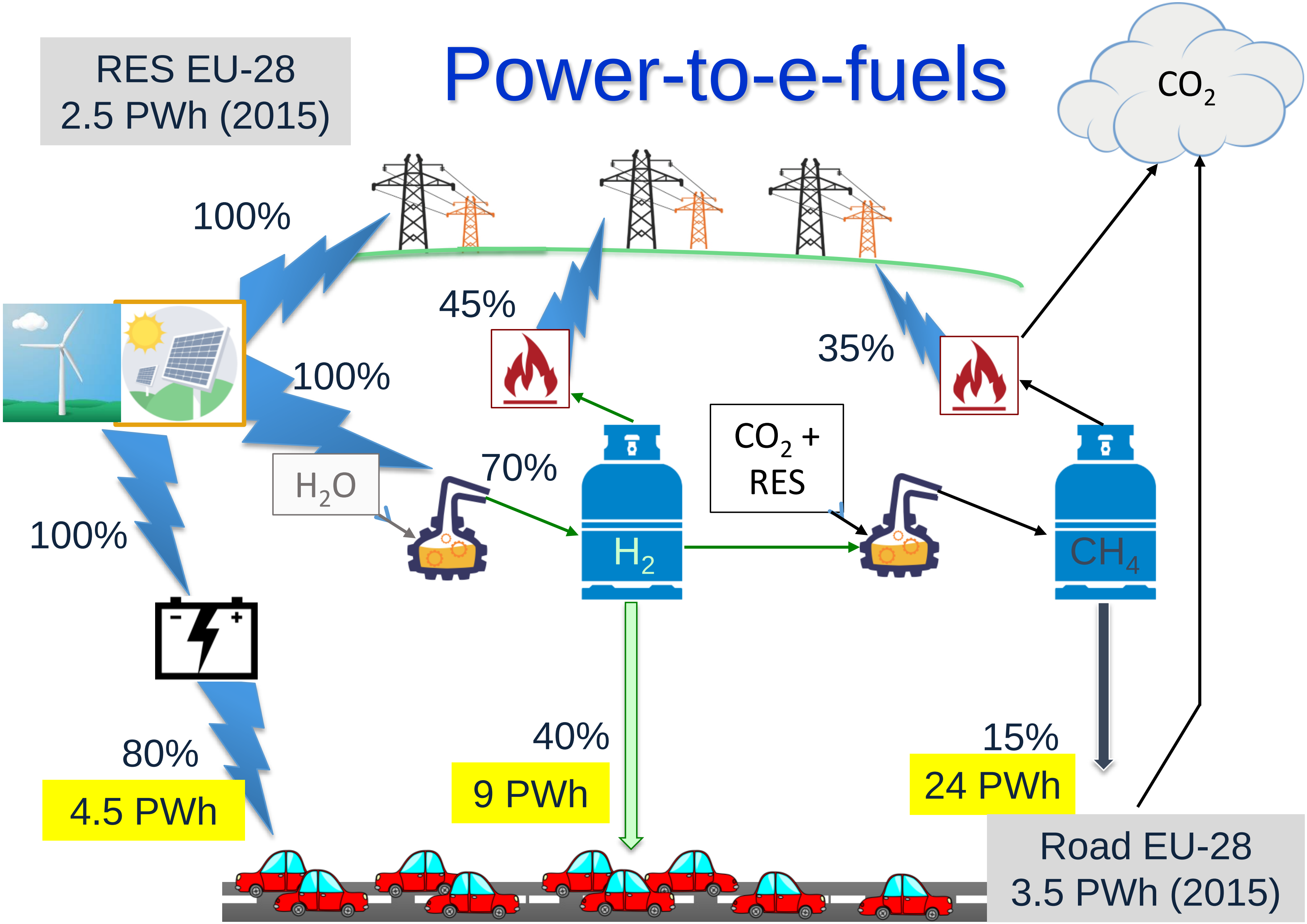
Power-to-e-fuels



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