SIMULATING AND MONITORING ENERGY TRANSITION

Experiences from Germany

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www.ise.fraunhofer.de

www.ise-module.de

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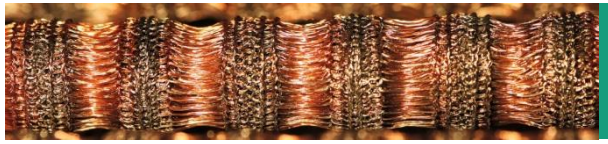
Introduction

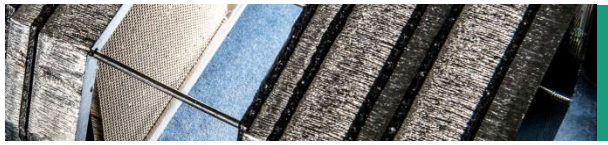
Fraunhofer ISE - Areas of Business

PHOTOVOLTAICS
- Silicon Photovoltaics
- III-V and Concentrator Photovoltaics
- Emerging Photovoltaic Technologies
- Photovoltaic Modules and Power Plants

SOLAR THERMAL TECHNOLOGY



BUILDING ENERGY TECHNOLOGY



HYDROGEN TECHNOLOGIES

ENERGY SYSTEM TECHNOLOGY

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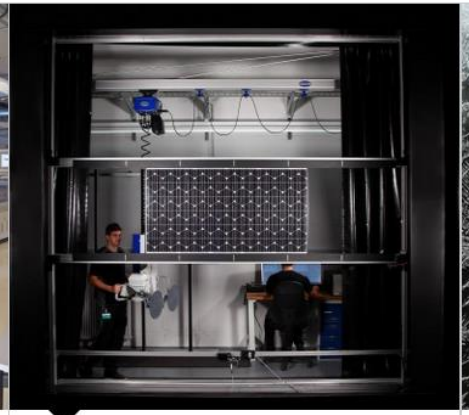
Introduction

PV Modules and Power Plants: Fields of Work

Module Technology



Module Calibration

Module Testing and Degradation Analysis

PV Power Plants

Solar Forecasting

Building Integrated PV

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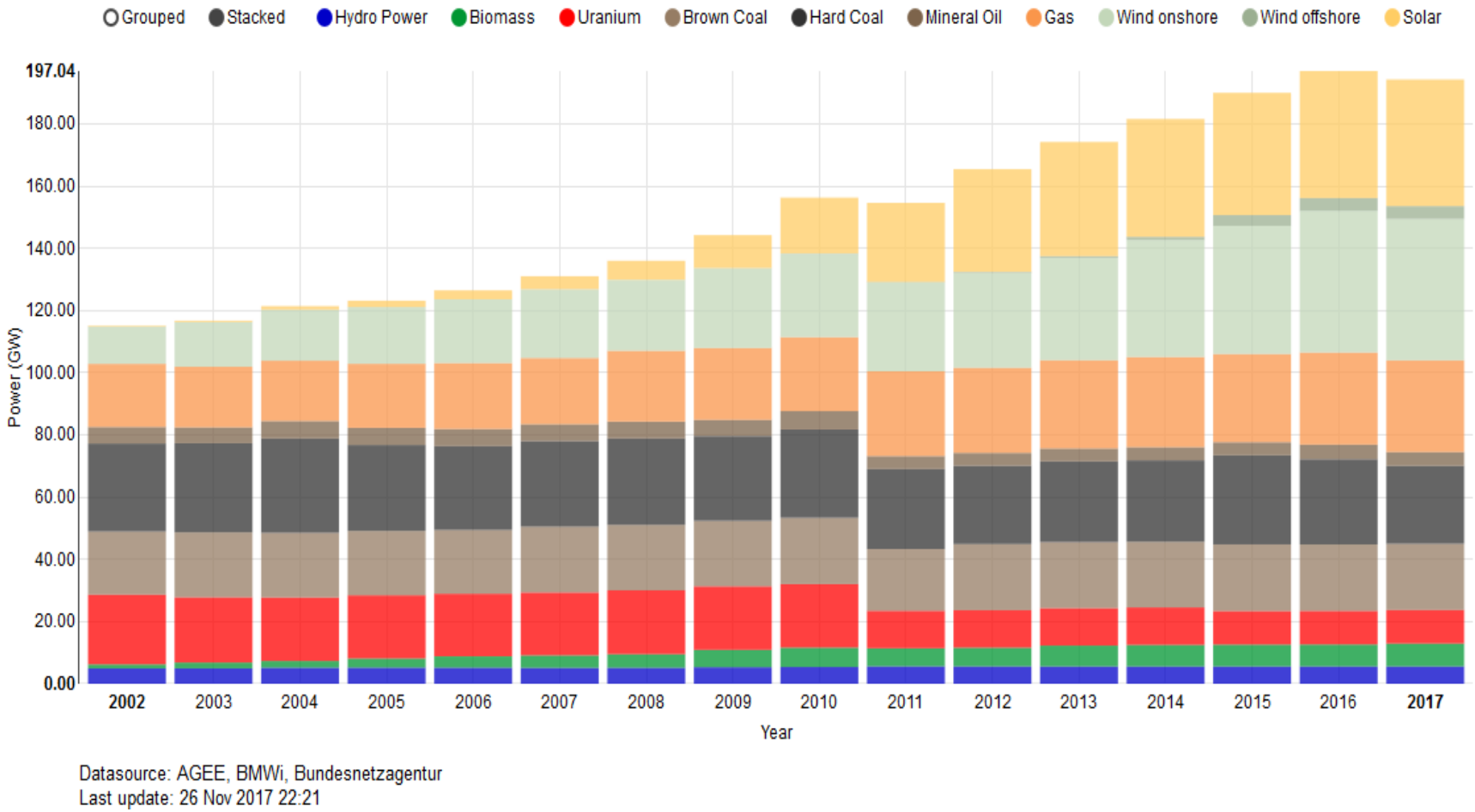
Current Status

Installed generation capacity



https://www.energy-charts.de

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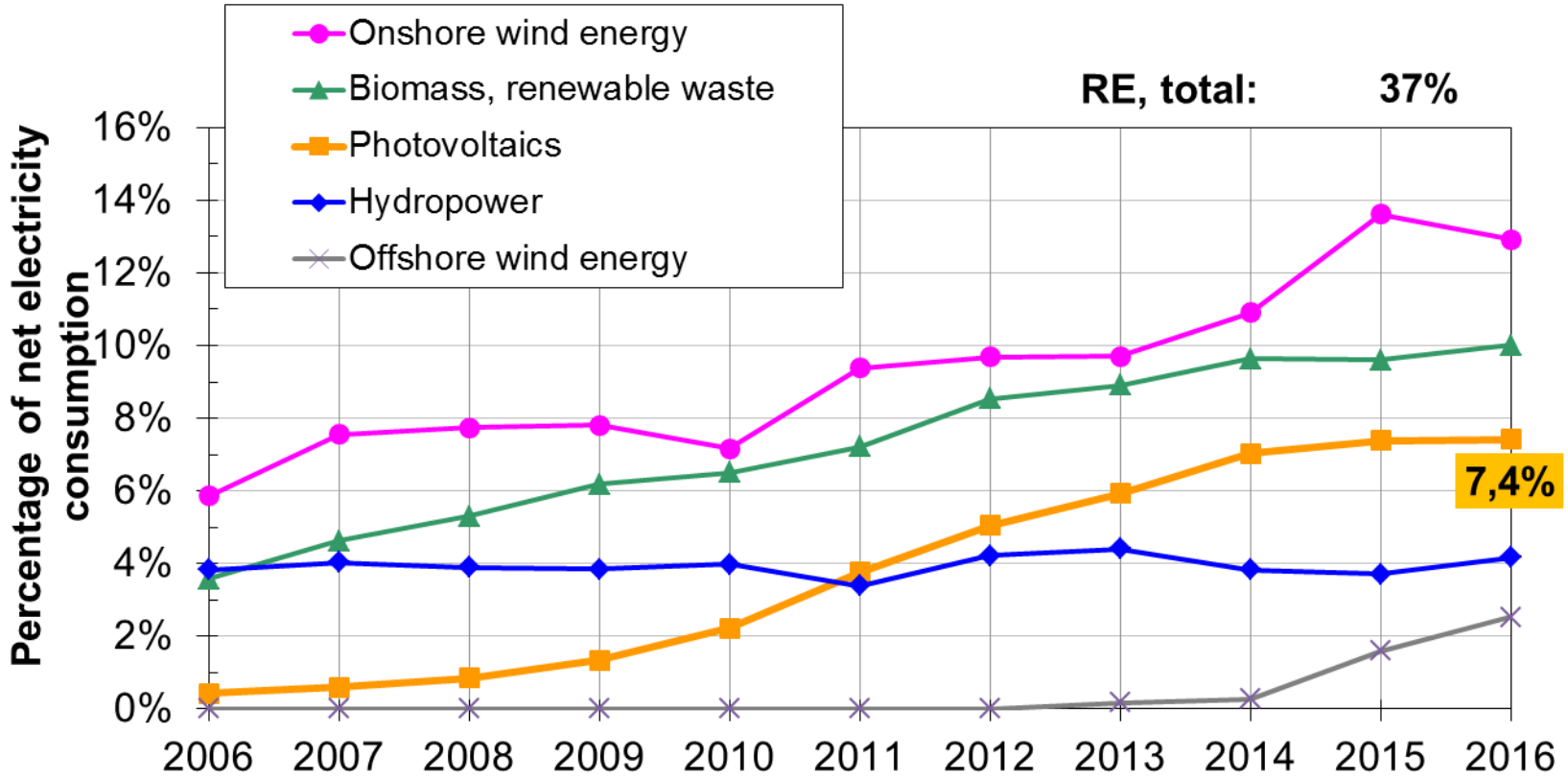
Current Status

Produced electricity



H. Wirth, Recent Facts about Photovoltaics in Germany, 2017

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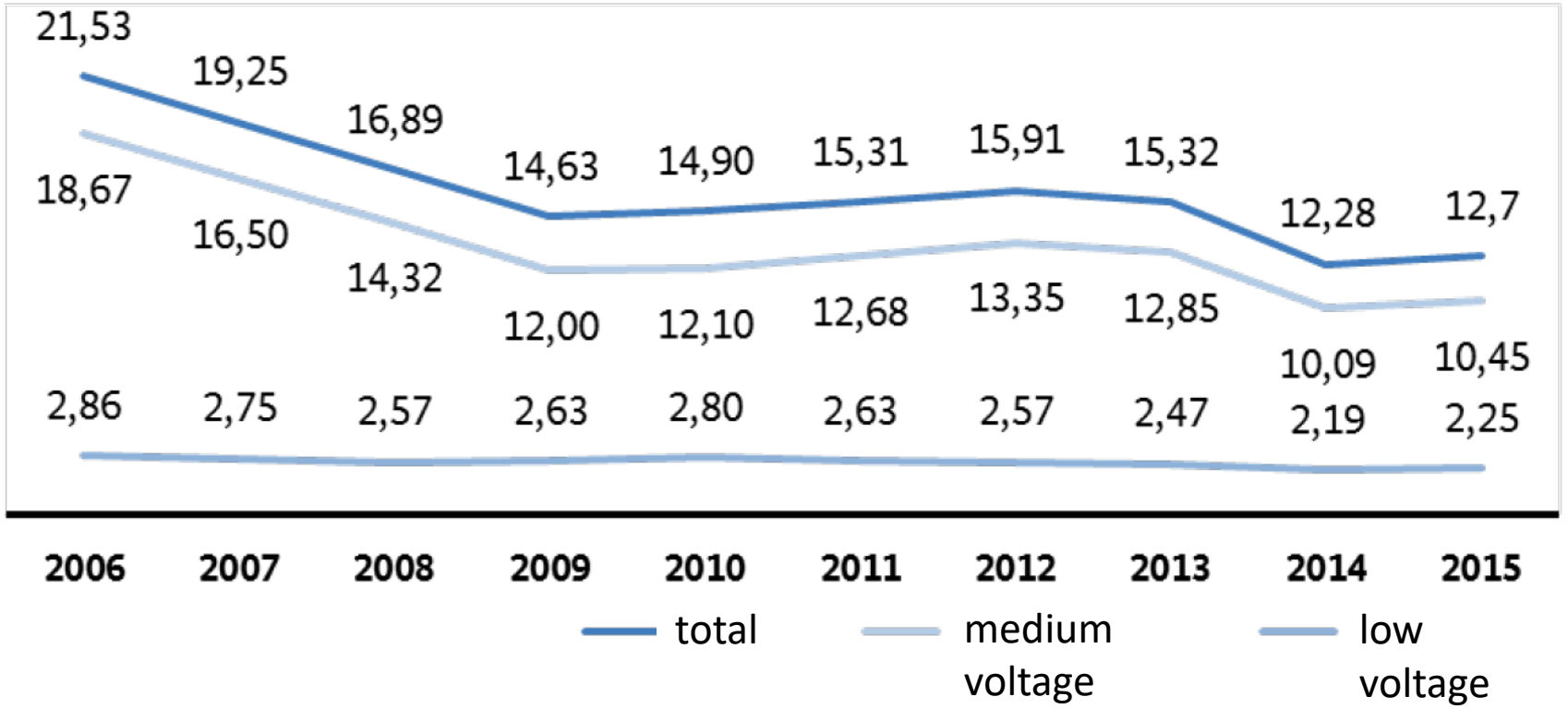
Current Status
Challenges

- technical
  - limited transmission capacity for wind electricity from north to south
  - little flexibility of coal and nuclear plant generation
  - power forecasting uncertainty
- political/economical
  - electricity pricing mechanism on stock exchange
  - cost distribution for energy transition
  - curtailment of PV capacity growth

Current Status

Security of electricity supply

Average supply disruption [min/y] on different grid levels



Monitoringbericht 2016, Bundesnetzagentur

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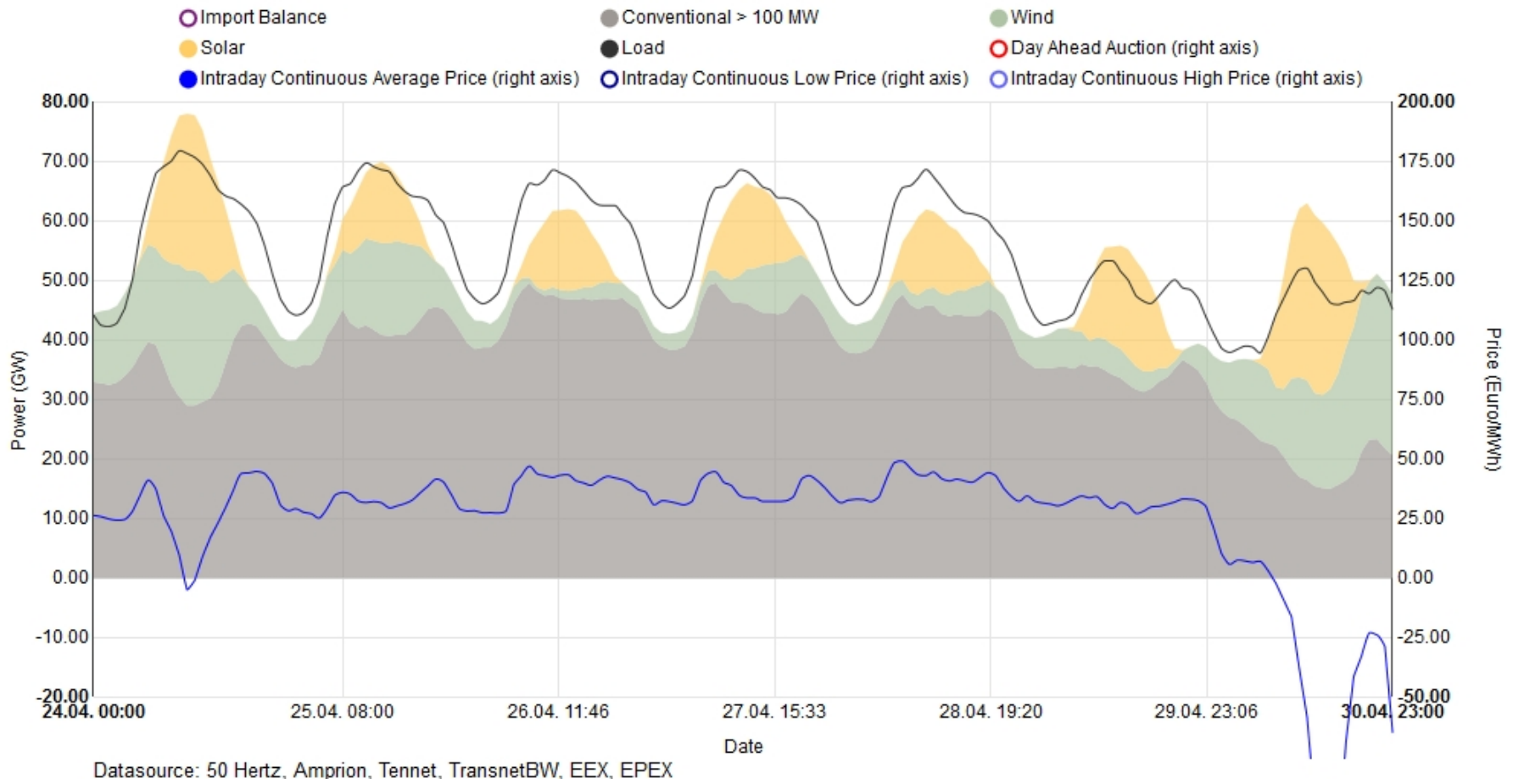
Current Status

Load and generation profile example



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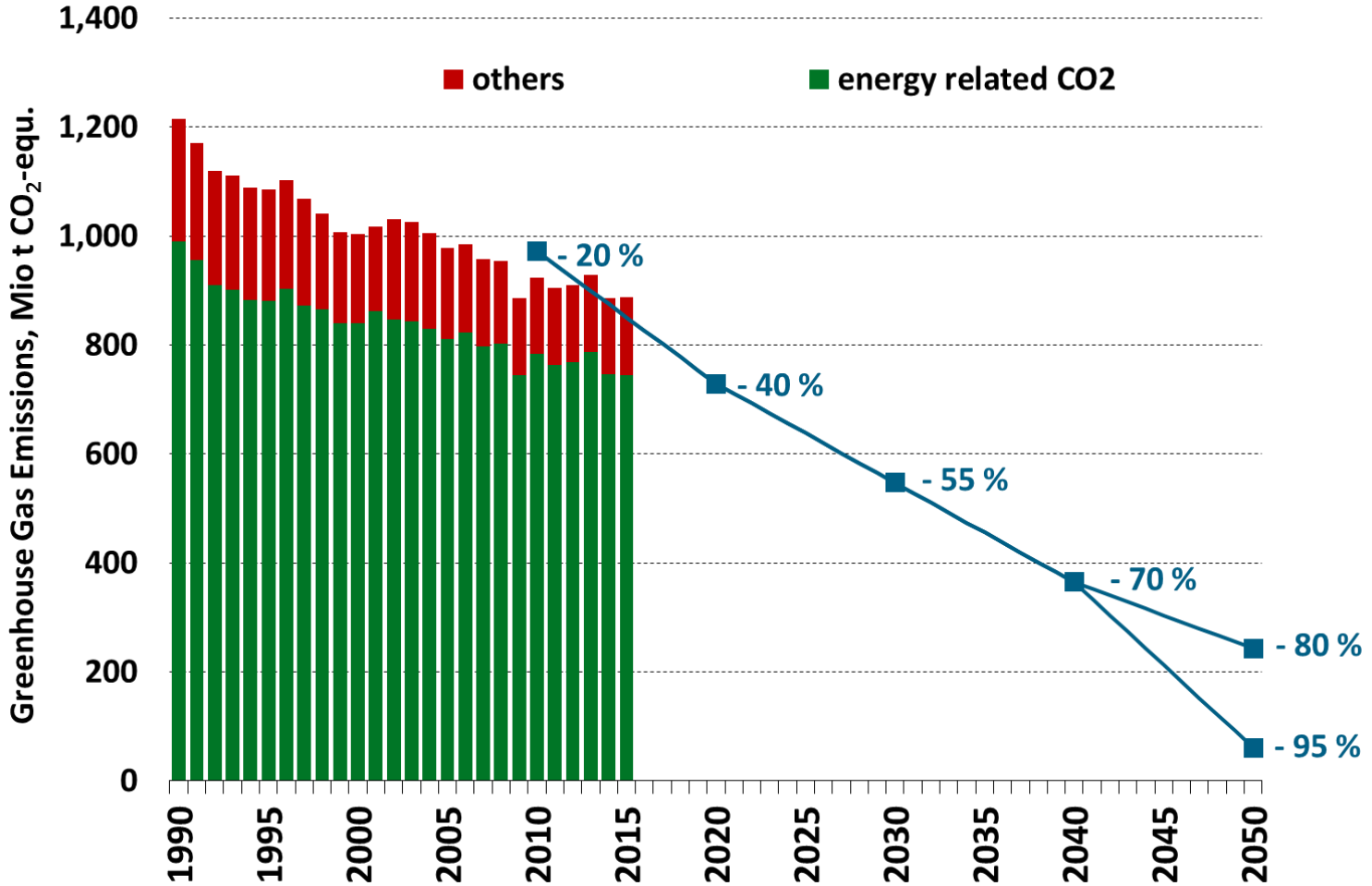
German Green House Gas (GHG) Emissions

Historical values 1990-2015 and target values until 2050



Hans-Martin Henning, International Energy Workshop 2017

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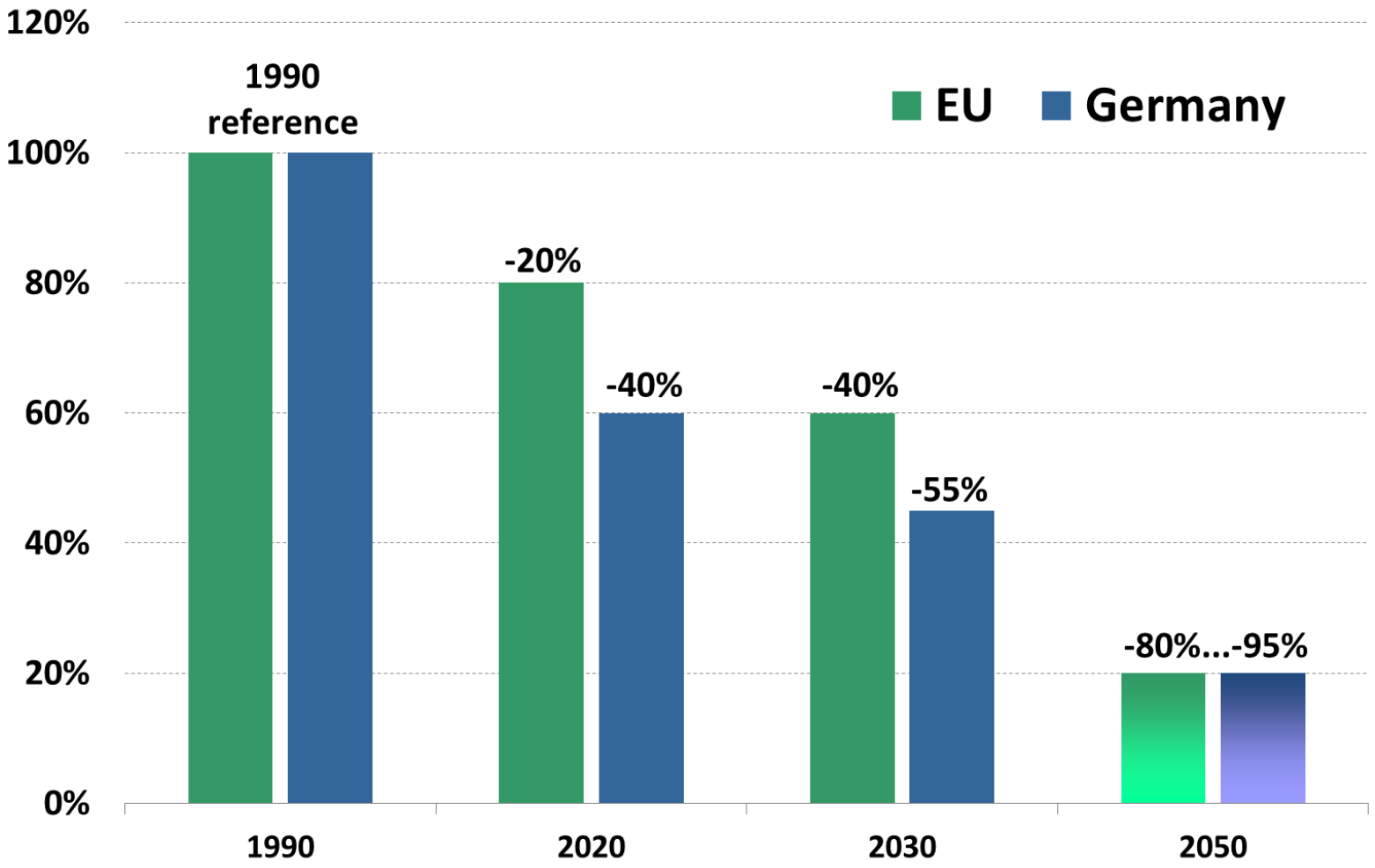
GHG Target Values



Hans-Martin Henning, Eurosun 2016

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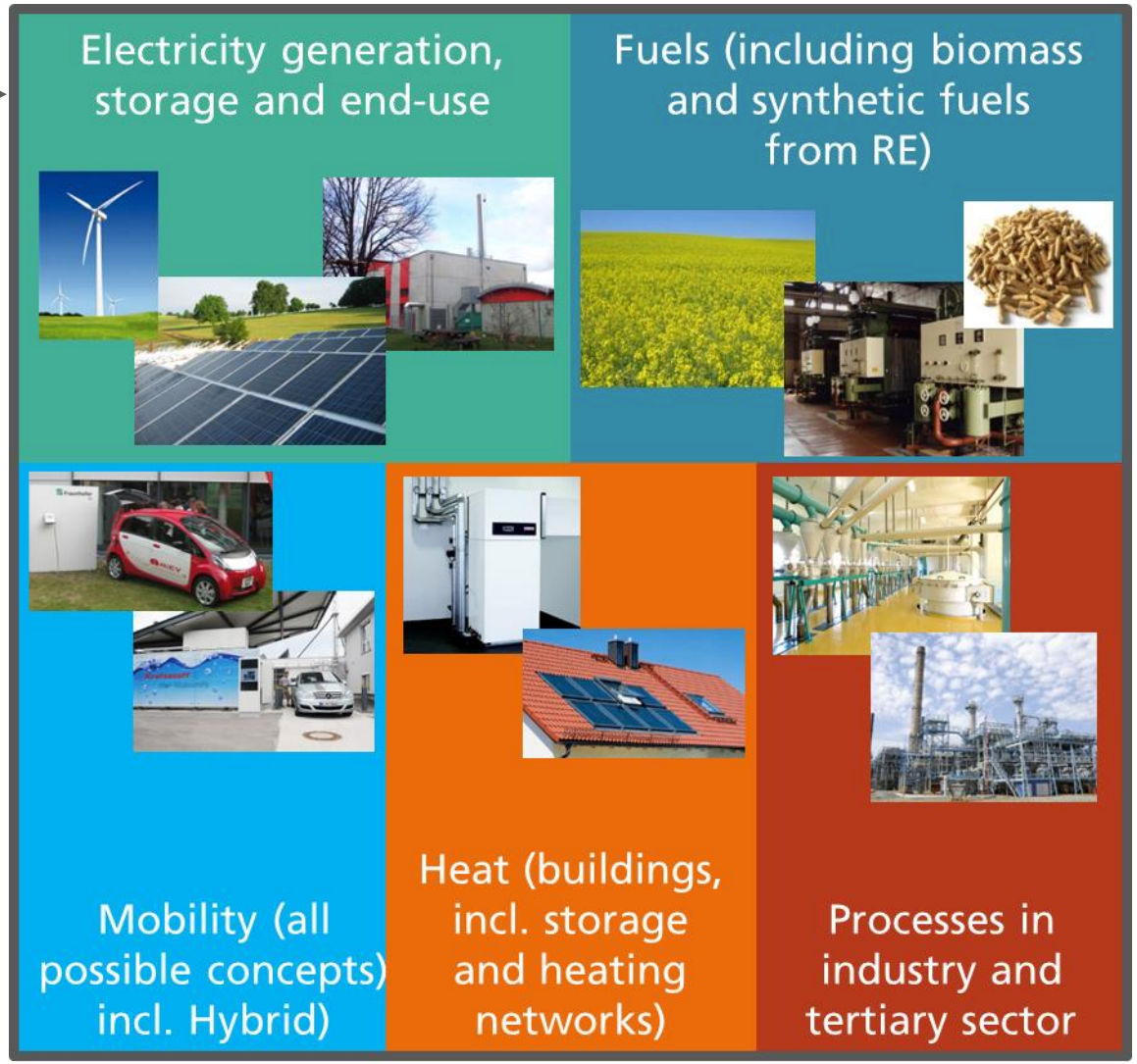
Renewable Energy Model »REMod«

Minimize total annual costs →



REMod

Strictly model-based techno-economic optimization of transformation pathways based on comprehensive simulation of energy systems (hourly time scale)

Hans-Martin Henning, Eurosun 2016

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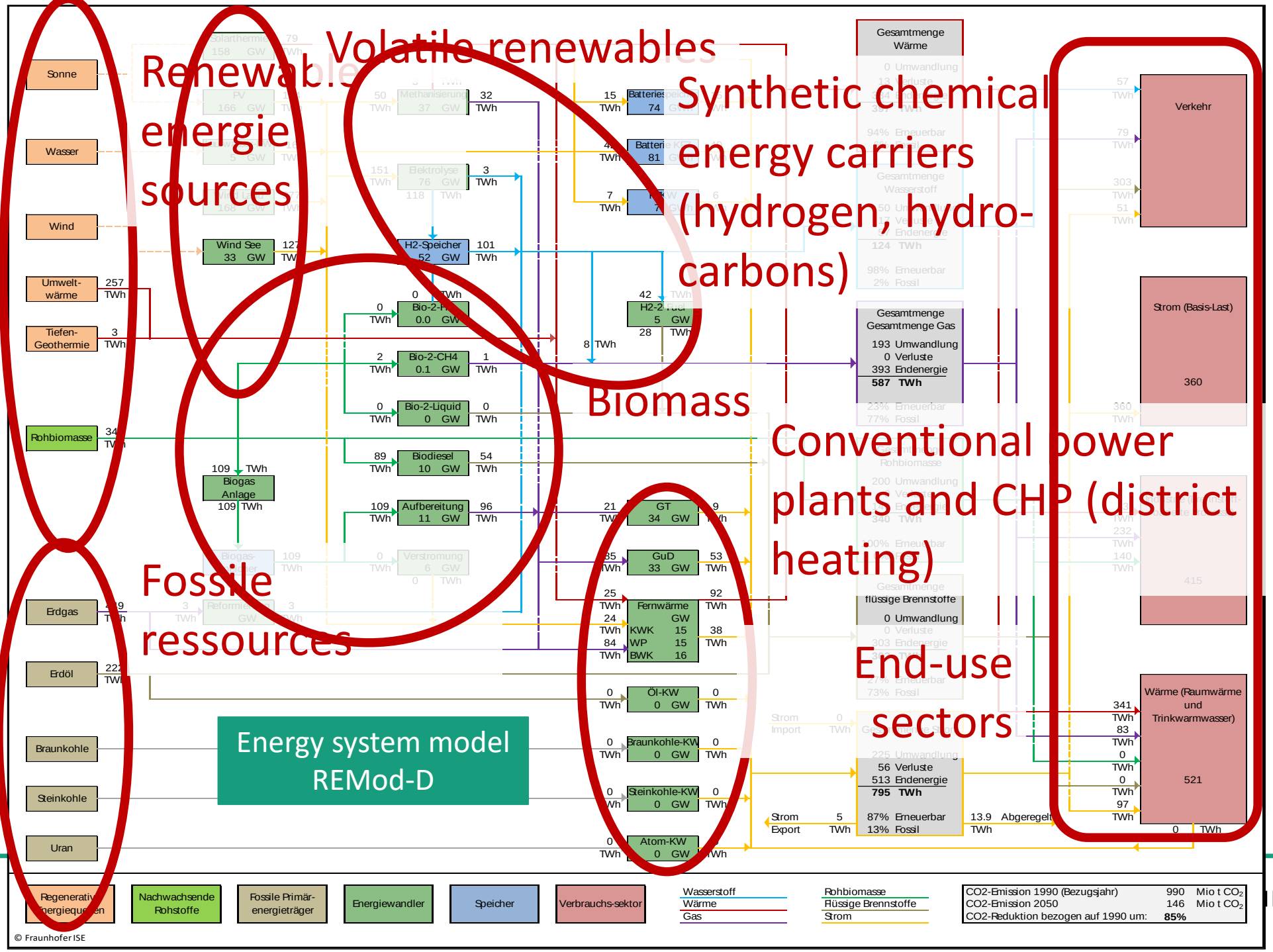
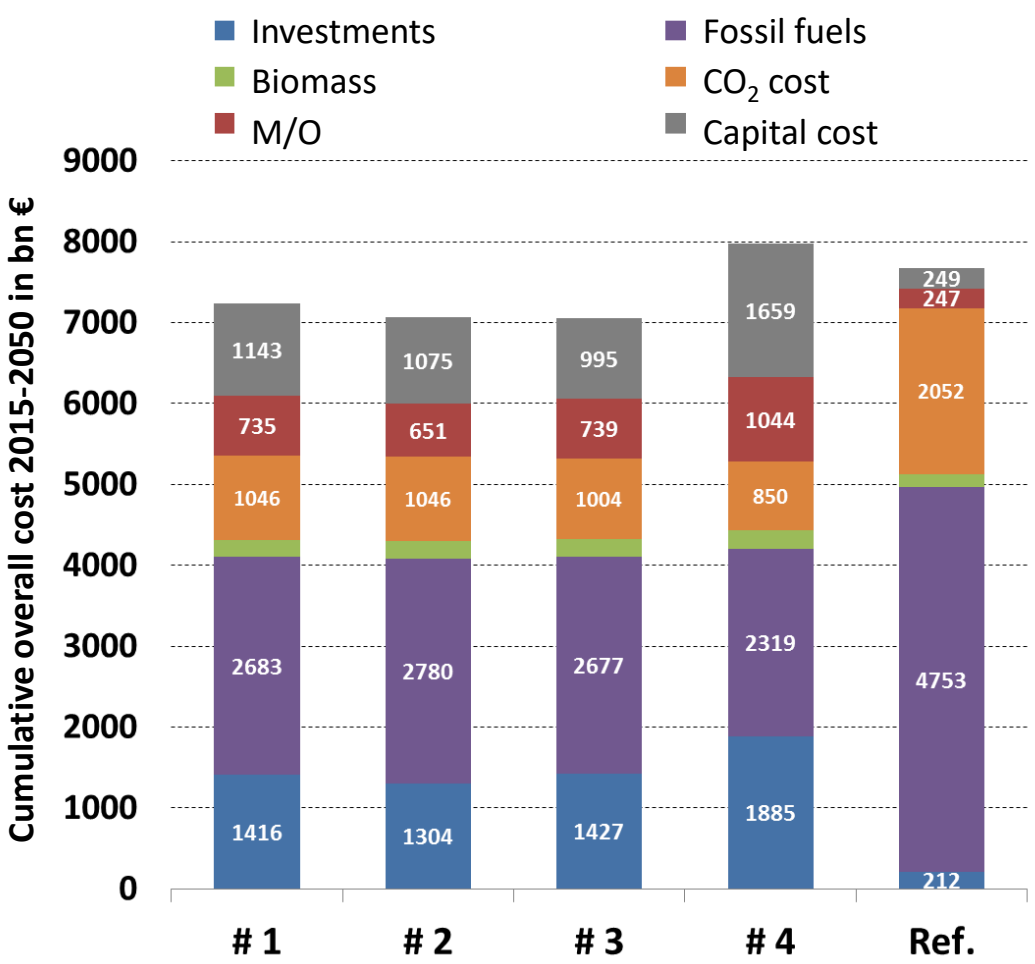


REMod Results

Comparison of Cumulative Overall Cost



- Increasing cost CO_2 emissions up to 100 € per ton in 2030; then fix value
- Annual price increase of fossil fuels 2%

#1 -80 % CO_2, phase-out of coal not accelerated

#2 -80 % CO_2, phase-out of coal accelerated

#3 -85 % CO_2, phase-out of coal accelerated

#4 -90 % CO_2, phase-out of coal accelerated

Ref today's system without change

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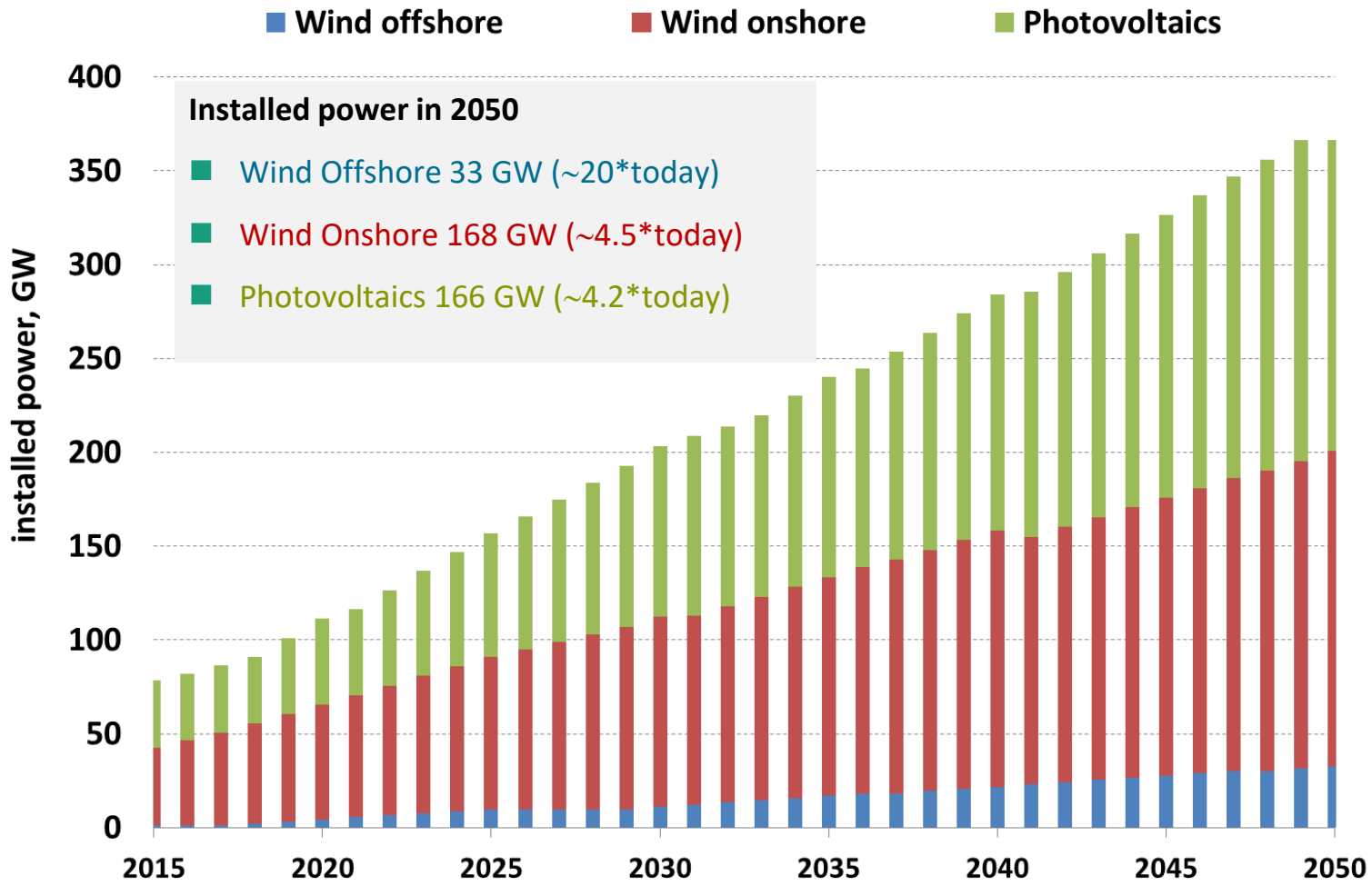
REMod Results

Optimum for Germany in -85% Scenario



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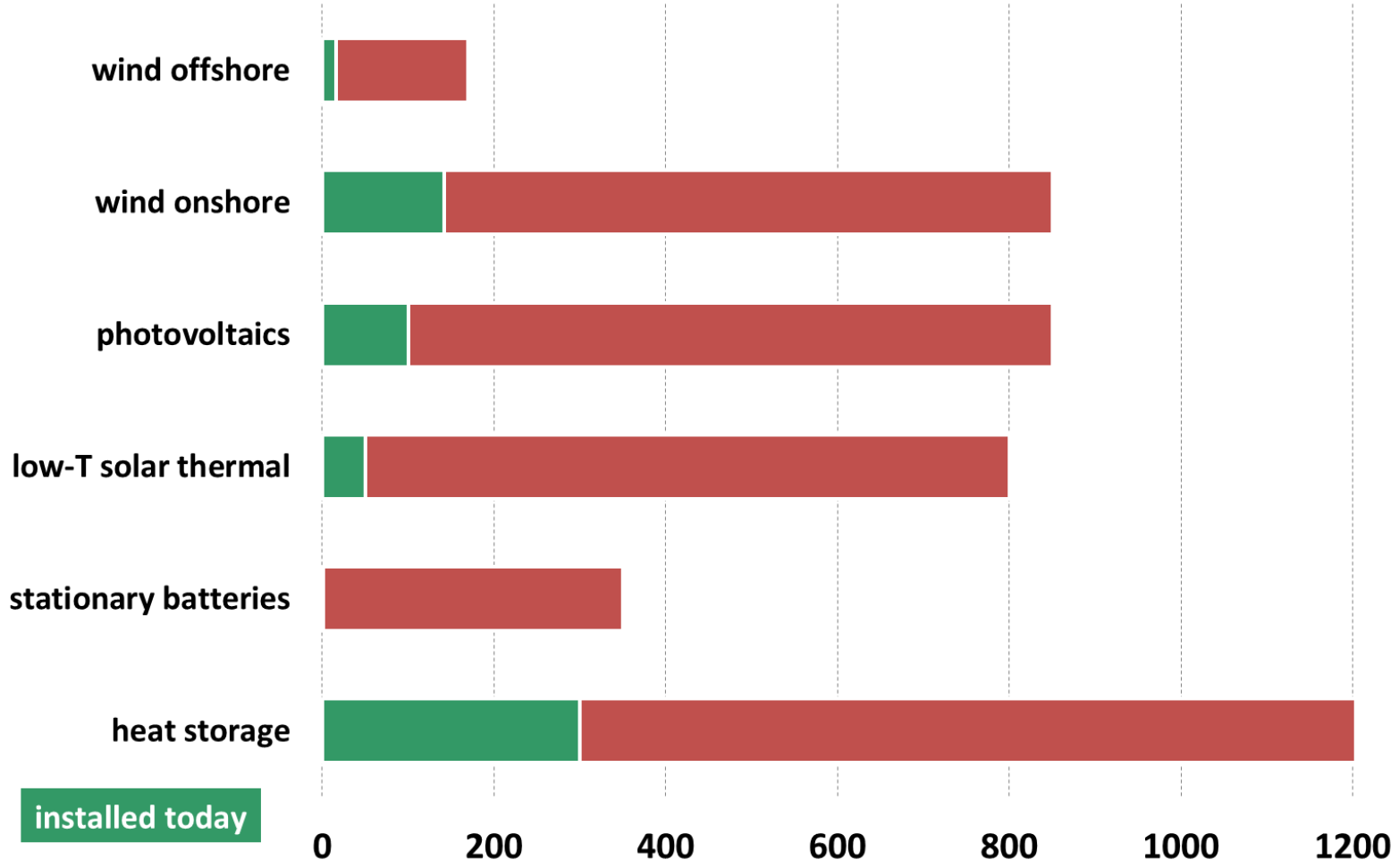
REMod Results

Extrapolated optimization for Europe: capacities



Hans-Martin Henning, Eurosun 2016

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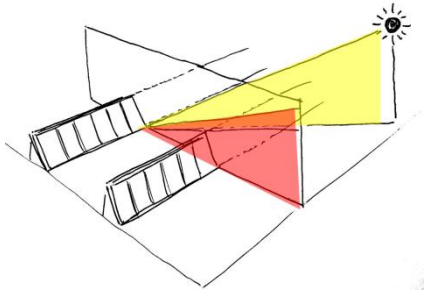
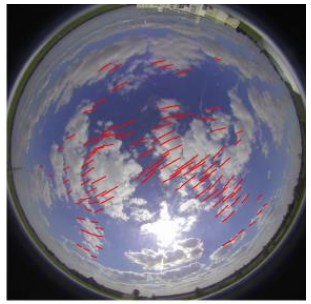
PV Monitoring and Simulation Demand

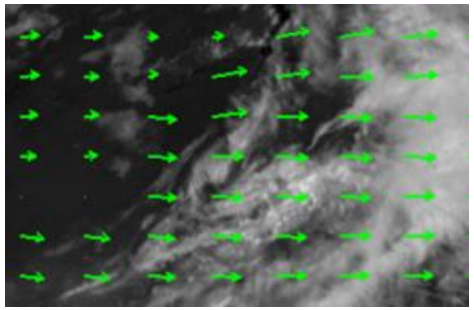
- yield simulation and monitoring for
  - economic and engineering calculations
  - O&M

+

- real time PV monitoring for nowcasting
- irradiance forecasting and (aggregate) power plant simulation for management of
  - grid
  - flexible loads
  - residual generation
  - storage (batteries, thermal, renewable fuels)







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Thank You Very Much for Your Attention!

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