Energy [R]evolution – Advancing to Megacities

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Overview

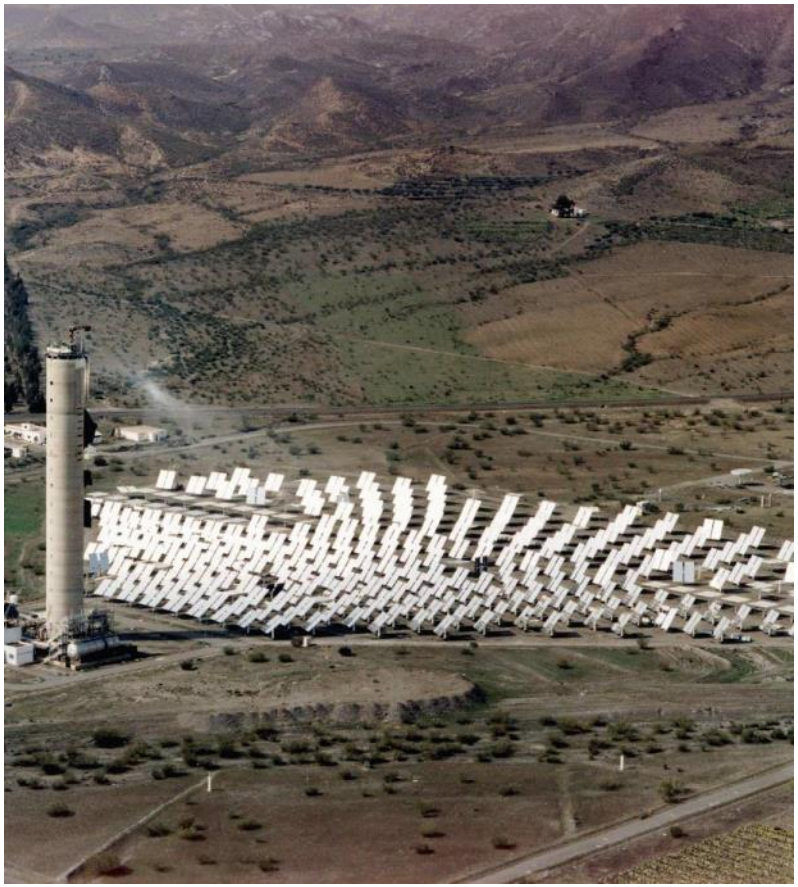
- Introduction of DLR energy research
- Background and experience: DLR in the Energy [R]evolution project series
- Energy modeling
- Scenario approach and results
- Outlook for the Megacity project

Research Areas at DLR

- Aeronautics
- Space Research and Technology
- Transport
- Energy
- Space Administration
- Project Management Agency

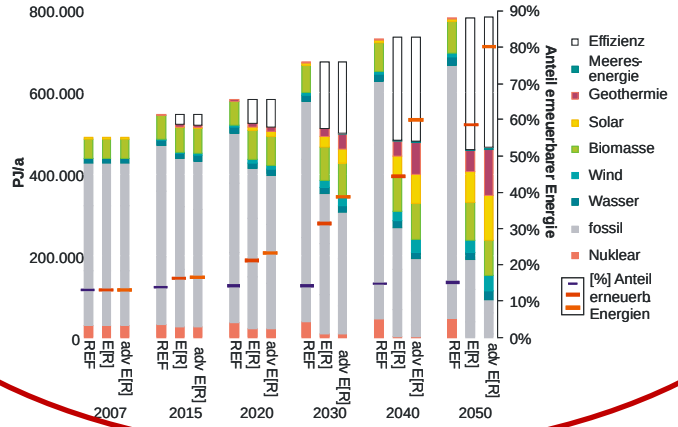
Energy Program Themes

- Efficient and environmentally compatible fossil-fuel power stations (turbo machines, combustion chambers, heat exchangers)
- Solar thermal power plant technology, solar conversion
- Thermal and chemical energy storage
- High and low temperature fuel cells
- **Systems analysis and technology assessment**
- Permanent team from the Institute of Solar Research at the Plataforma Solar de Almería (PSA)

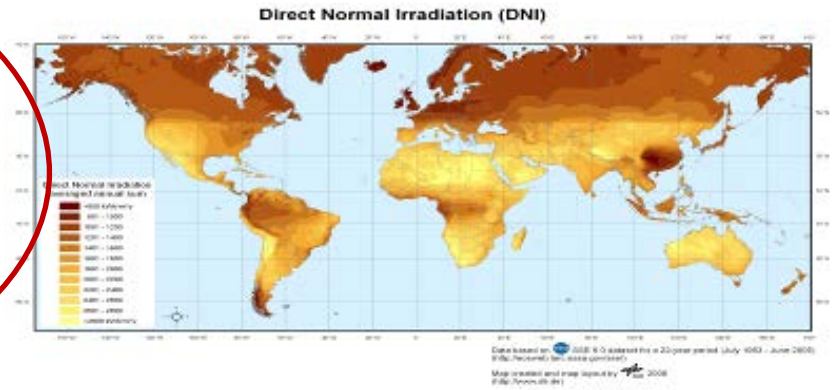


Department of Systems Analysis and Technology assessment

Energy System Modelling and Scenario s



Resources and Potentials



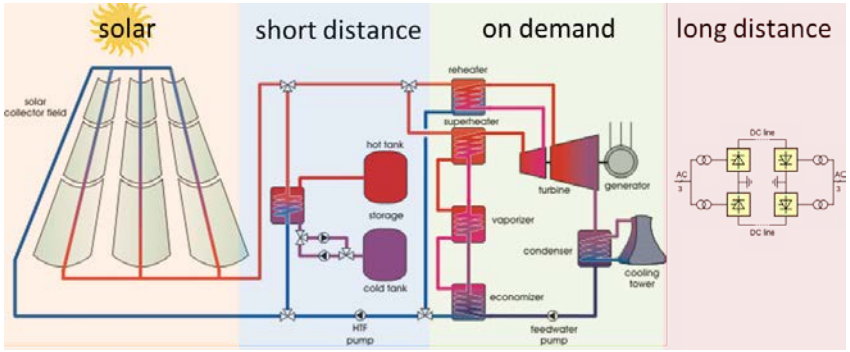
Funding Instruments and Energy Economics

Energy System
Technical, organisational and financial Aspects

Change of policy framework

Behaviour patterns of actors → Agentent based modelling - AMIRIS -

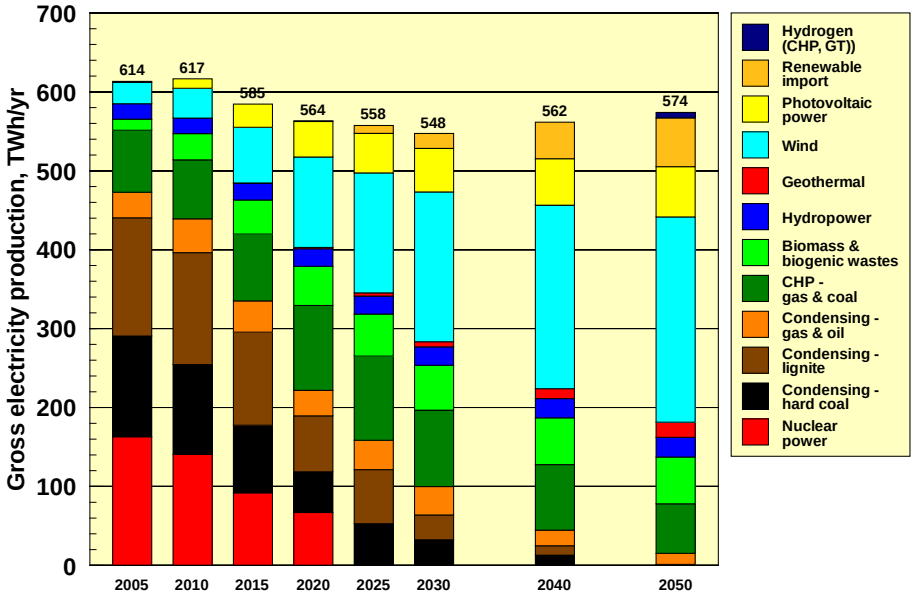
Market Strategies for CSP



27 Scientists including 5 PhD Students

Energy System Modelling and Scenarios: Scenario Development

- main objective: development of consistent and robust transformation concepts towards sustainable energy systems
- target oriented energy system scenarios with scenario development tool MESAP
- comprise full energy system, focus on sector coupling
- analysis of technical, ecological and economic consequences
- scenario validation with energy system model REMix



Background and experience

GREENPEACE

Projects

- **On global level**: Greenpeace **Energy [R]evolution – a sustainable world energy outlook** (long lasting project series since 2006)
- **On national level**: Greenpeace **Energy [R]evolution** series: A sustainable Chile Energy outlook (2009), a sustainable Brazil Energy outlook (2013), and multiple comparable projects (>40 countries) (see http://www.energyblueprint.info/)
- **On regional level**: for the Metropolitan Region of Santiago de Chile: **Risk Habitat Megacity** (- 2010)

DLR

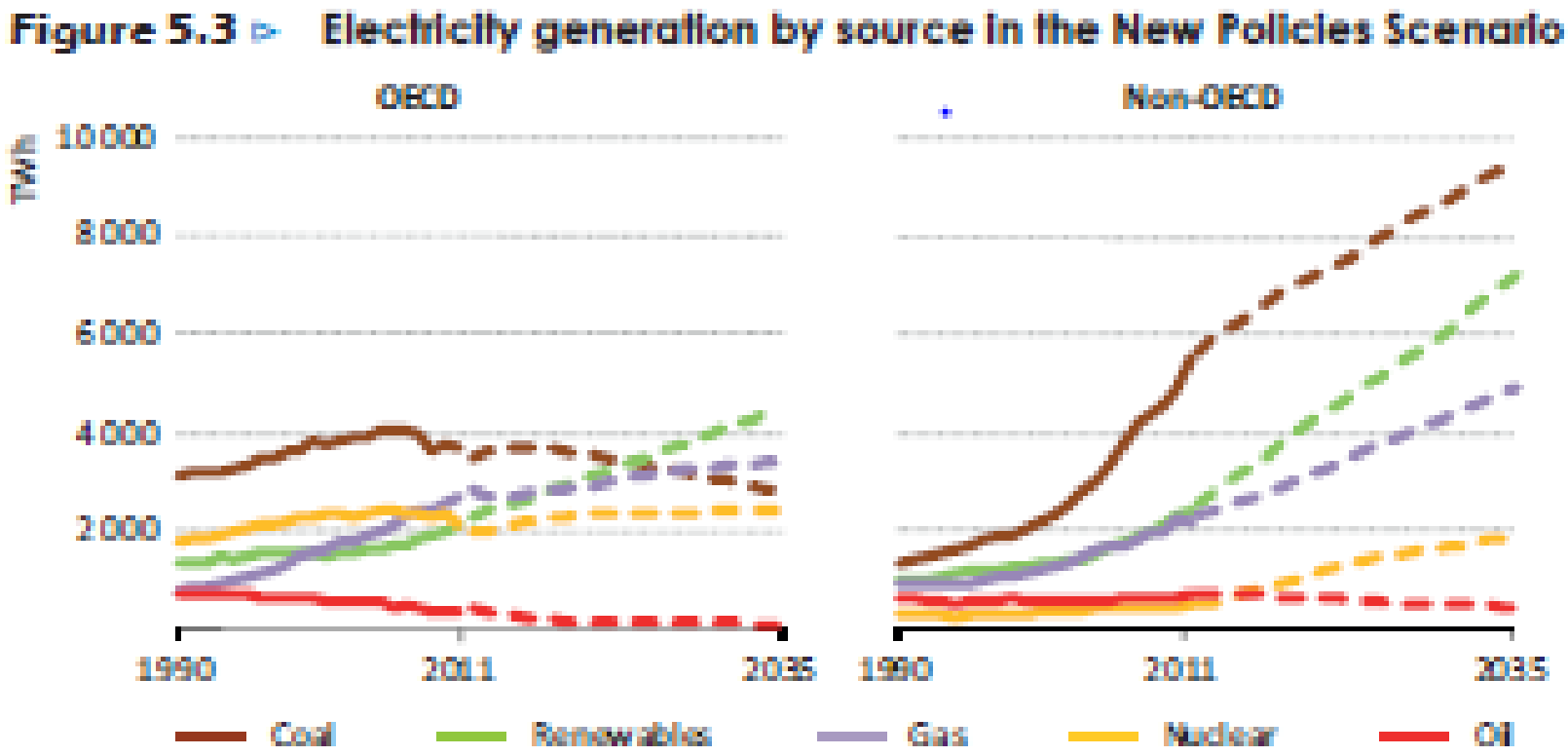
A Sustainable Mexico Energy Outlook (2012)

- **Reference Scenario:**
  - Business as usual
  - broken down from the World Energy Outlook (IEA)*

- **Energy [R]evolution scenario**:
  More than 80% of CO2 reduction by 2050 through:
  - Expanding renewables
  - Implementing efficiency measures
  - Phasing out unsustainable energy sources

* Current policy scenario

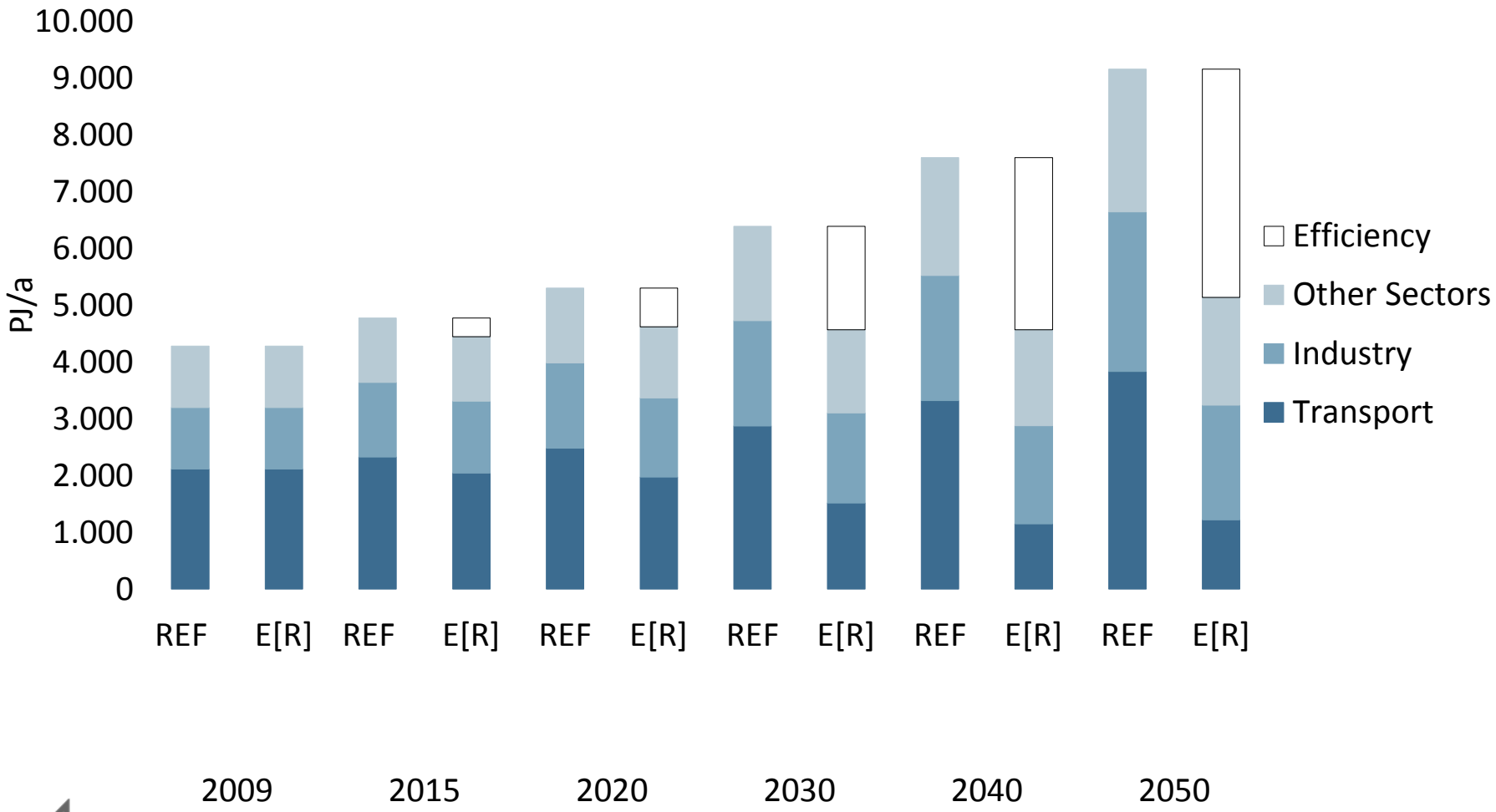
Outlook on the WEO 2013



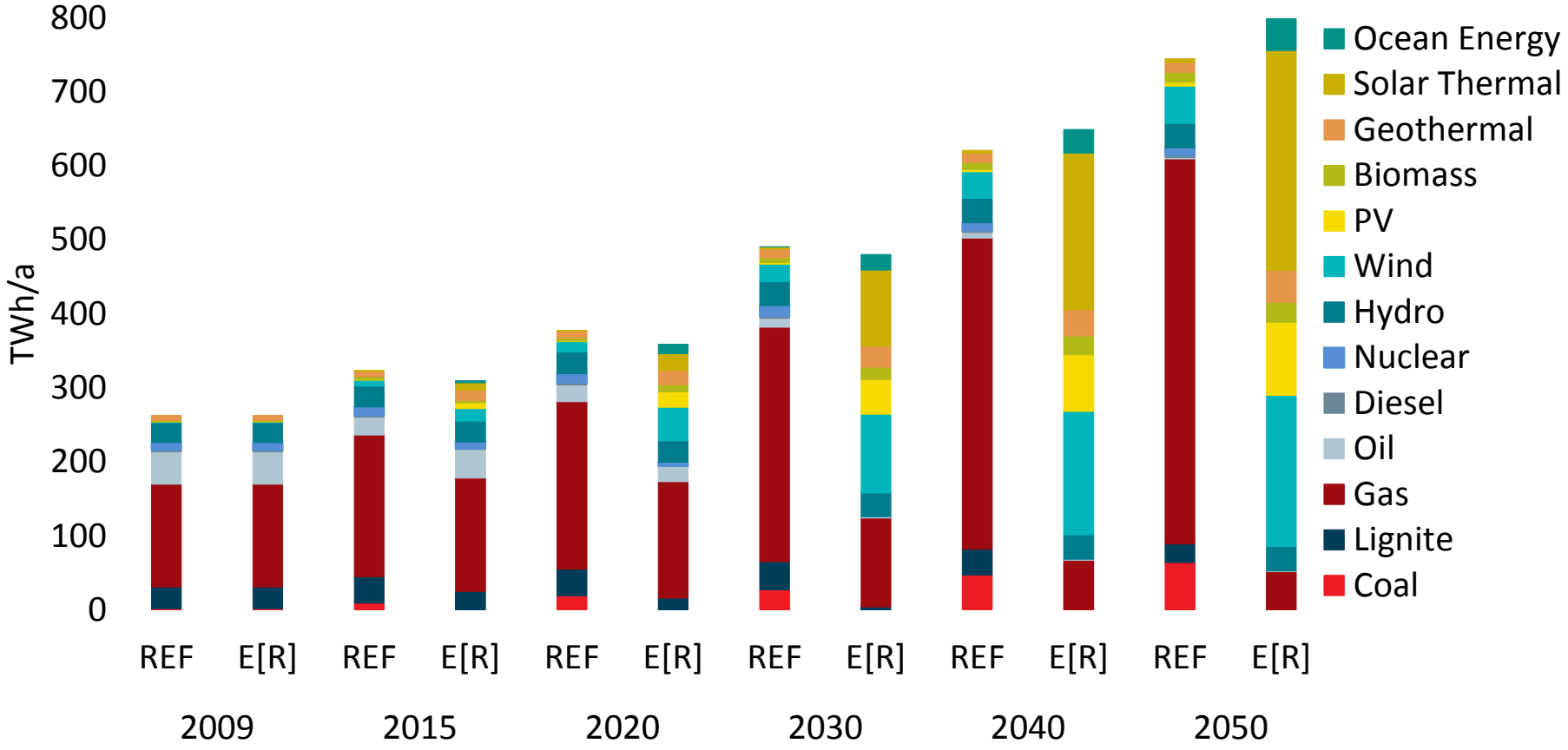
A Sustainable Mexico Energy Outlook: Results of the scenarios

- Projections of final energy demand by sector
- Electricity and heat generation
- CO_2- emissions

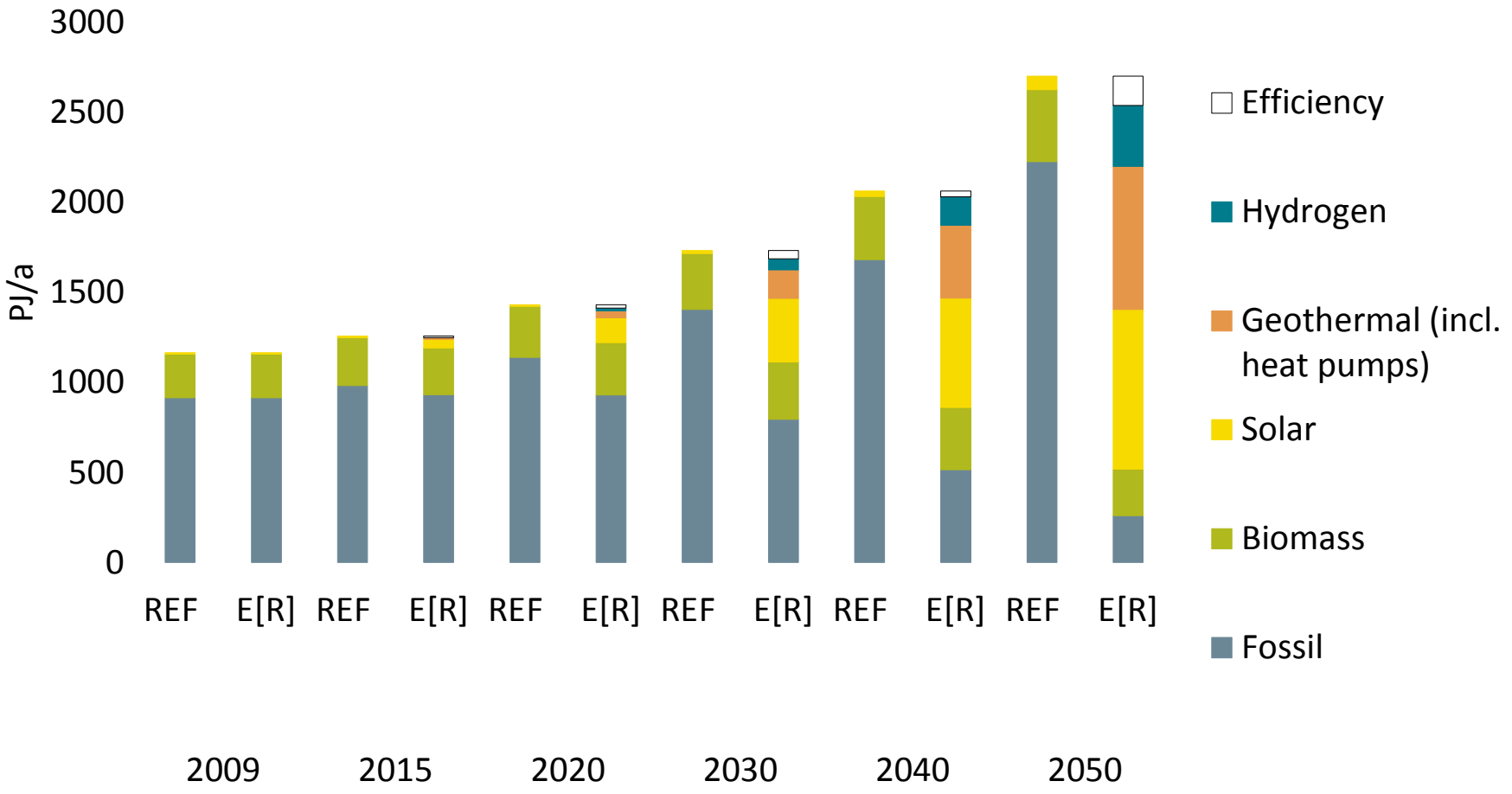
Projection of total final energy demand by sector – scenarios REF, E[R]

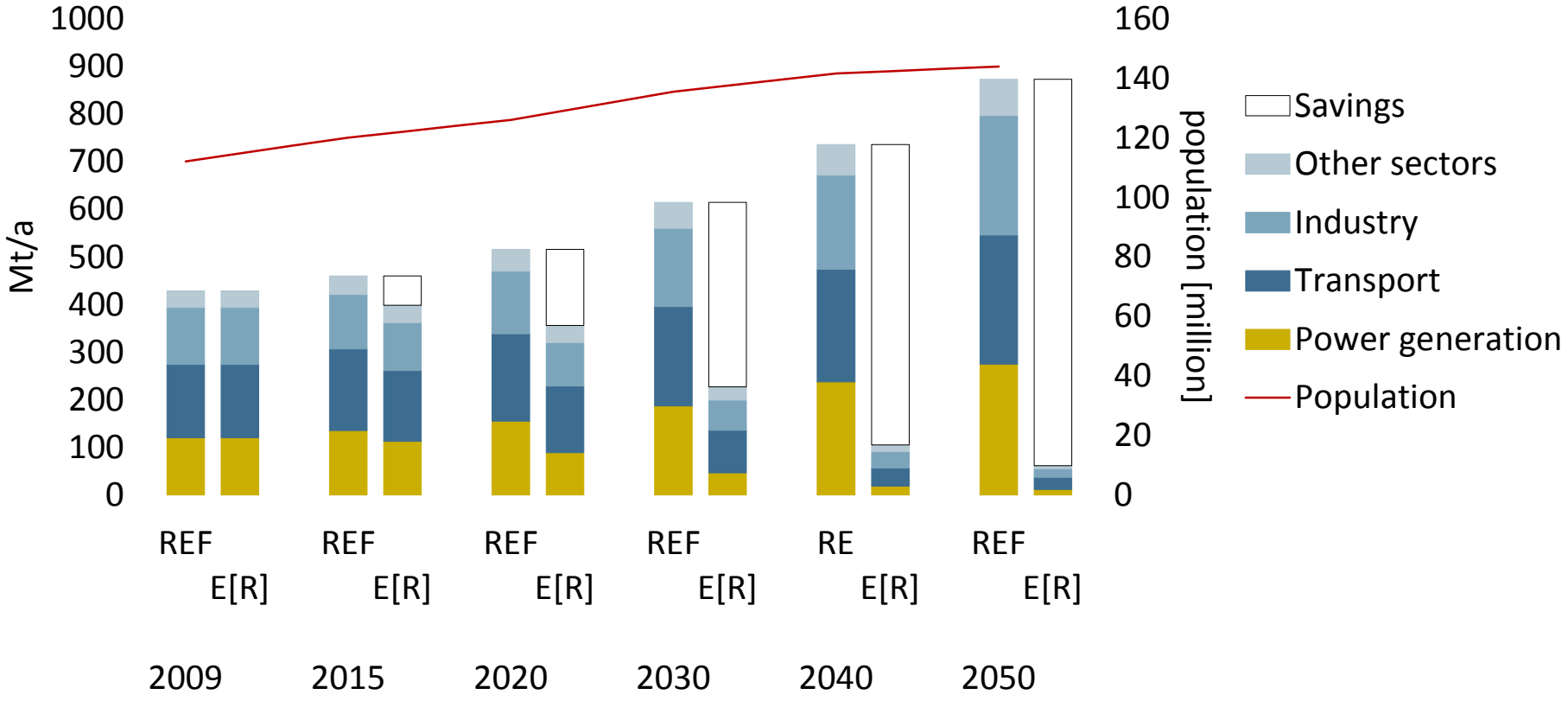


electricity generation under the REF and E[R] scenarios



Heat generation under the REF and E[R] scenarios




1000
900
800
700
600
500
400
300
200
100
0
Mt/a
160
140
120
100
80
60
40
20
0
population [million]
Savings
Other sectors
Industry
Transport
Power generation
Population
REF
E[R]
REF
E[R]
REF
E[R]
REF
E[R]
RE
E[R]
REF
E[R]
2009
2015
2020
2030
2040
2050

Methodology

- Overview
- Scenario approach
- Energy System modeling

Working structure for E[R]

energy system inventory

- demand
- supply
- political framework

scenario analysis

- sustainability deficits
- renewable energy potential
- energy efficiency measures

energy system simulation model

future risks

- air pollution
- energy security
- growing inequality

→

(political) measures

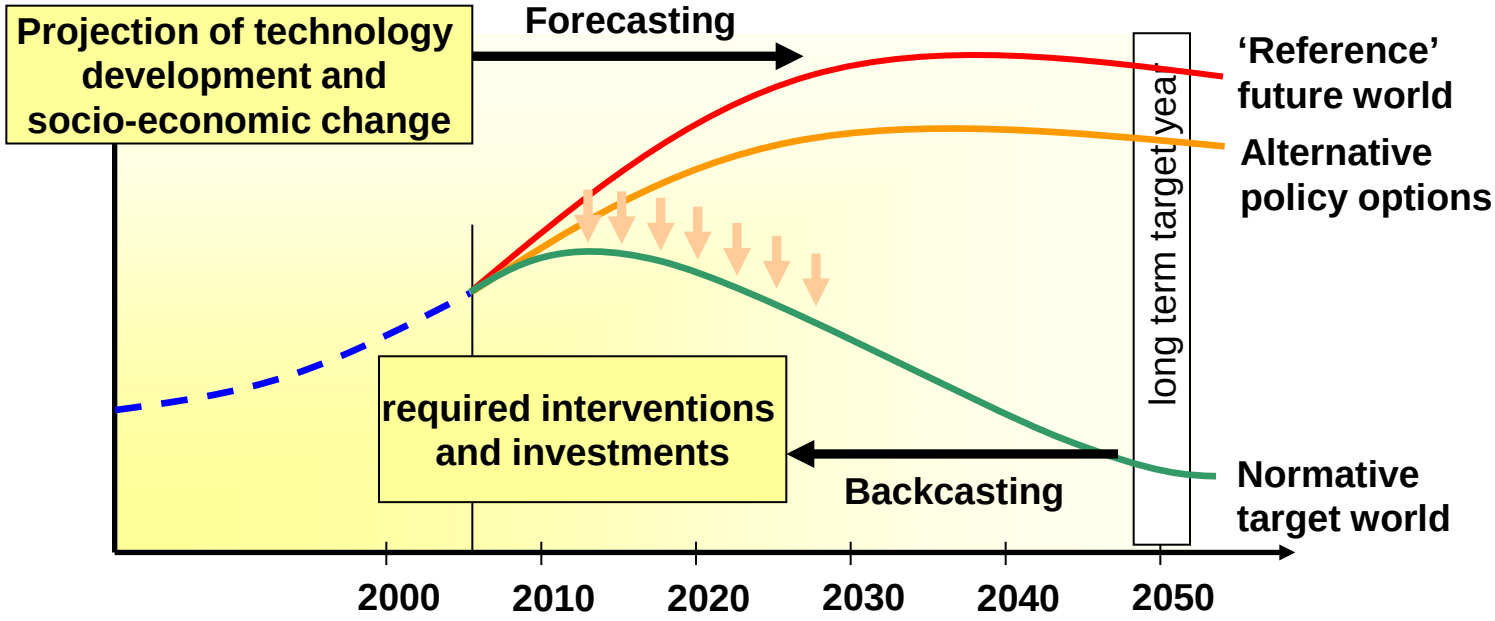
- CO_2-emission trading
- stakeholder participation
- feed-in tariffs
- …

obstacles & win-win situations

Scenario development in E[R]

- Methodology of scenarios in E[R]: normative scenarios

Scenario Development for E[R]: Backcasting



- long term scenarios starting from **normative targets** (backcasting)
- needed developments based on **RE potentials, plausible market developments, sustainable and robust strategies**
- model calibration with **energy balances, population** & **GDP** development etc. as drivers of demand
- development paths of **proven technologies** (no speculative options)
- **review process, validation (dynamic modelling), analysis of economic effects**

Scenario development in E[R]

- Methodology of scenarios in E[R]: normative scenarios
- Formulation of story lines for scenarios: main normative parameters and basic assumptions

Basic assumptions for the Scenarios

Reference Scenarios

Business as usual

- Development of the energy system according to the WEO (IEA 2012)
- Current policies scenario: currently implemented policies, without newly developed policies
- As WEO covers only the years until 2035 → extension of trends until 2050

Energy [R]evolution Scenarios

More than 80% of CO2 reduction by 2050

- Fossil generation system: expansion of flexible gas power plants and CHP
- Ambitious long lasting efficiency targets (up to now based on results by Universiteit Uetrecht/Netherlands)
- Limited use of biomass
- Mobility: modal shift towards public transport, e-mobility….
- Technical limitations: rough assessment of secured capacity, local potential of renewable energy sources

Scenario development in E[R]

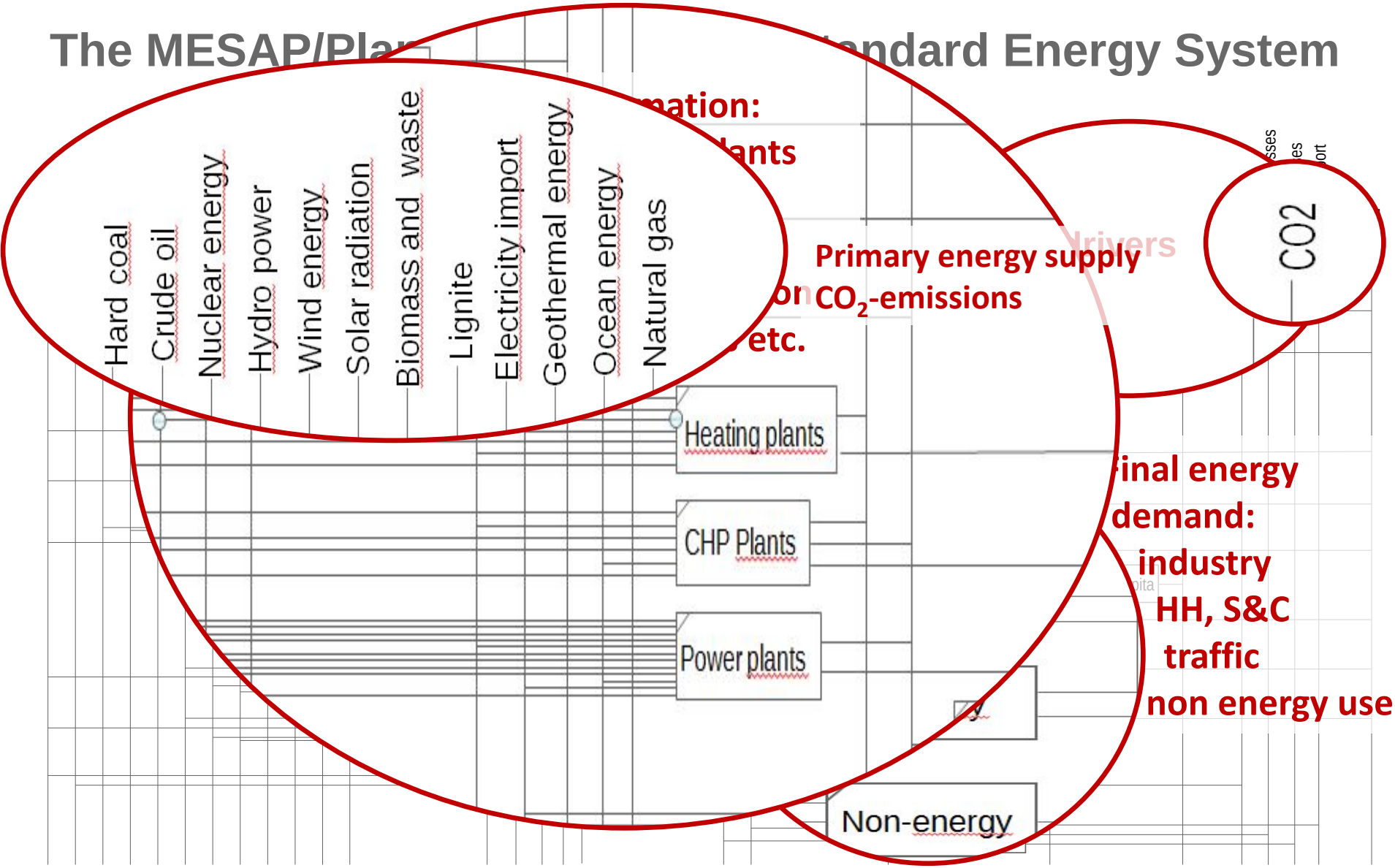
- Methodology of scenarios in E[R]: normative scenarios
- Formulation of story lines for scenarios: main normative parameters and basic assumptions
- Energy system Inventory:
  - Calibration of model with statistical data
  - Transfer to MESAP/Planet
- Development of framing parameters (GDP, population, …)
- Development of techno-economical parameters
- Transfer to of drivers and parameters to MESAP model: calculation of useful, end and primary energy, CO2-Emissions, installed capacity, power and heat production, levelized cost of electricity
- a posteriori analysis of costs and secured capacity

Energy System modeling in E[R]: The MESAP/Planet environment

➢**Graphic interface for structuring and simulating energy systems**

- Consistent balancing of material and energy flows:
  drivers → useful energy → final energy → primary energy → emissions
- Calculation of capacities, power production costs
- No optimisation model!

The MESAP/Pla ndard Energy System



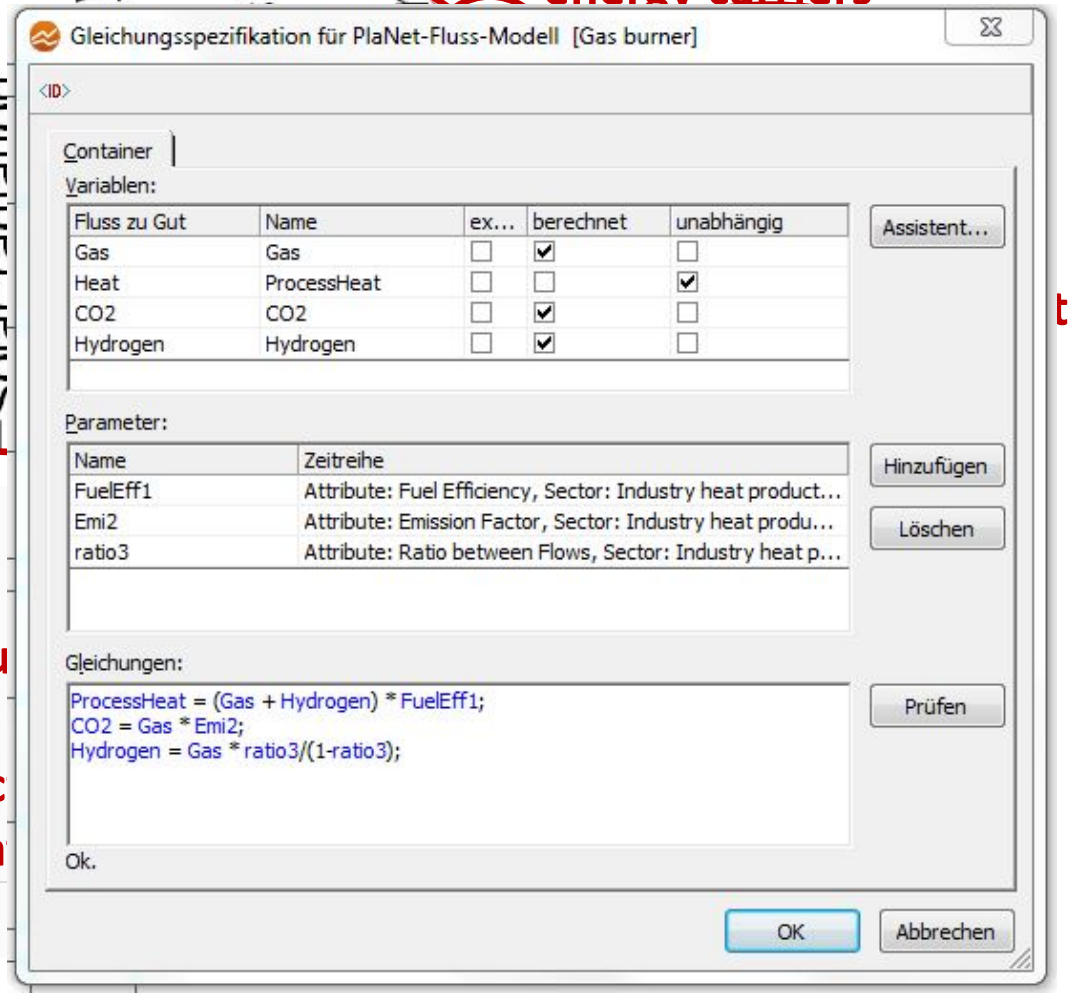
mation:
lants
Primary energy supply
CO_2-emissions
etc.
drivers
inal energy
demand:
industry
HH, S&C
traffic
non energy use

Sub structure: heat in households

energy carriers

Lignite
Gas
Other S. el. Cons.
Hard coal
Solar radiation

technologies:
- gas und oil
- biomass bu
- heat pump
- solar collec
- district hea
- …



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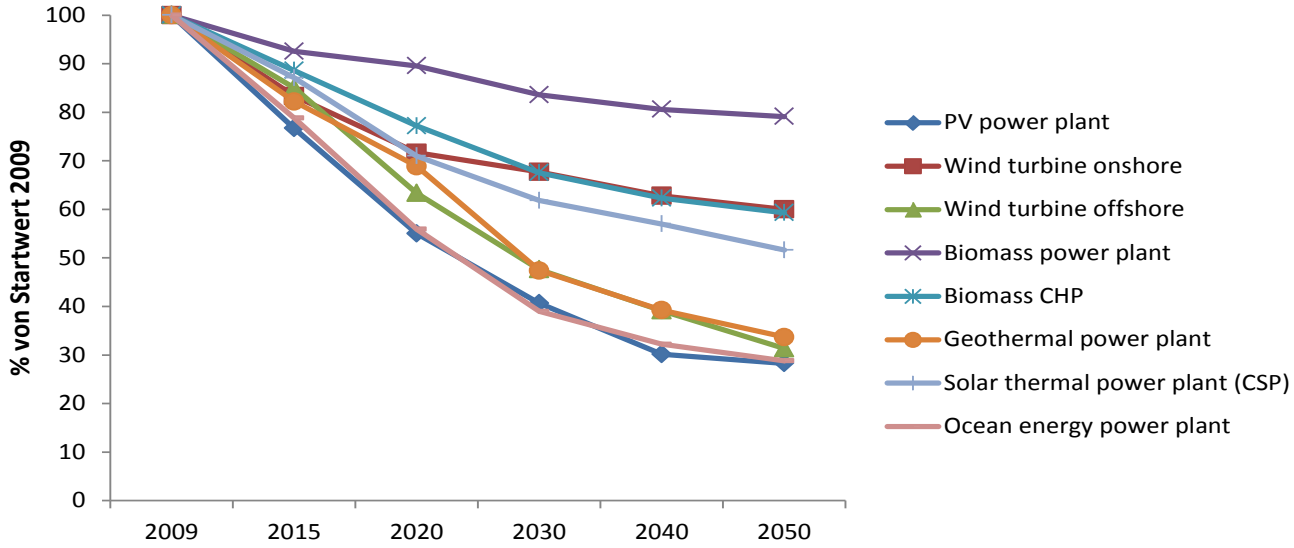
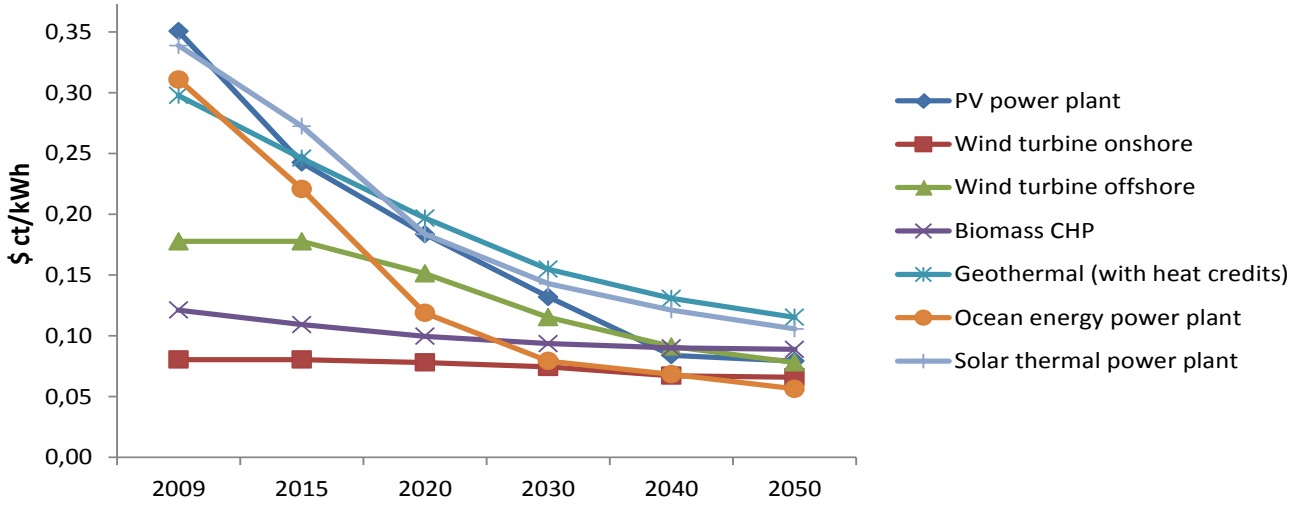
➢ **Database**

- Technical and economical parameters (efficiencies, CHP coefficients, investment costs, O&M-costs,…) in time series
- Input Scenario: drivers, market shares, energy carriers
- Outputs: final energy demand, emissions, costs, …

Including Renewable Energy Cost Projections





Energy System modeling in E[R]: The MESAP/Planet environment

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➢ **Excel-Interface:**

- Input sheet for drivers and parameters → transfer to database
- Embedded output reports (tables, graphs)

Next steps: targeting Megacities

Megacities are drivers of economic growth. They are centers of energy and water-use and produce large amounts of waste, waste-water and energy-related GHG emissions.

28 megacities (2014) with 453 million people
(12% of urban dwellers)

Sustainable development of Megacities is essential for improvements of the whole system

Our aim: Outlook on the potential future of Megacities

Is there a future development of a megacity that can consistently integrate the most important societal, economic, structural and ecologic targets of the cities and regions surrounding them?

– Transferable model for the energy system of mega cities

– Development of scenarios for the future of the energy system focusing on the exploitation of efficiency potentials and the integration of renewable energy sources.

– Case Study: Mexico City → possible pathways towards a sustainable development

– Transfer of the project to other cities → starting with Sao Paolo

Residential Sector (Master Thesis)

Driving factors (example):

Population development
Economic development
Political framework
Technological development
Others

- Number of consumers
- Share of each group
- Energy intensities
- Others

Standard households

Group 1
Income X

Group 2
Income Y

Group 3
Income Z

Typical demand

Electricity consumption
Fuel consumption
CO2 emissions

Electricity consumption
Fuel consumption
CO2 emissions

Electricity consumption
Fuel consumption
CO2 emissions

Cooperation:

- Information exchange and direct discussions with Greenpeace,
- local universities and municipal organisations:
  - UNAM
  - GIZ
  - CONUEE

→to integrate societal, economic, structural and ecologic targets of the cities and regions surrounding them.

Thank you for your attention!

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Department Systems Analysis and Technology Assessment, DLR

in cooperation with
Sven Teske, **Greenpeace**

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