

Synergies between Renewable Energies and Combined Heat and Power

Mihail Ketov, June 12th 2018, Bucharest

Supported by:



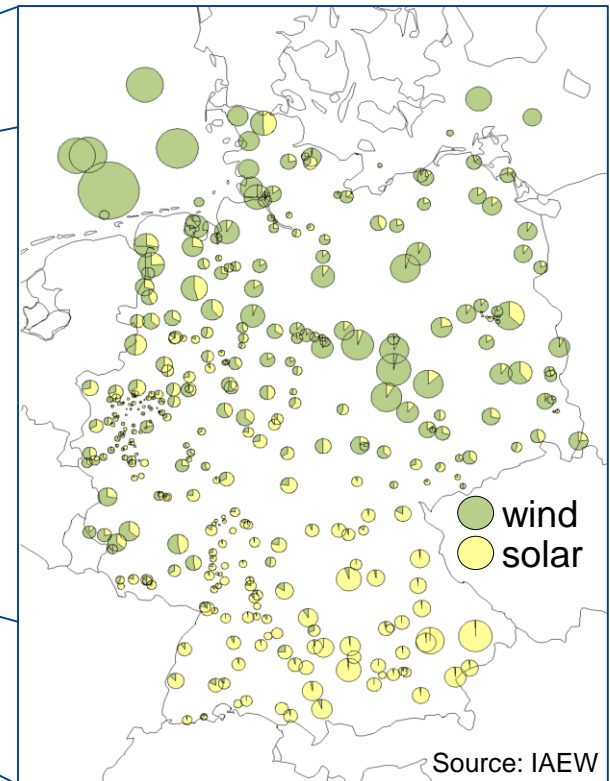
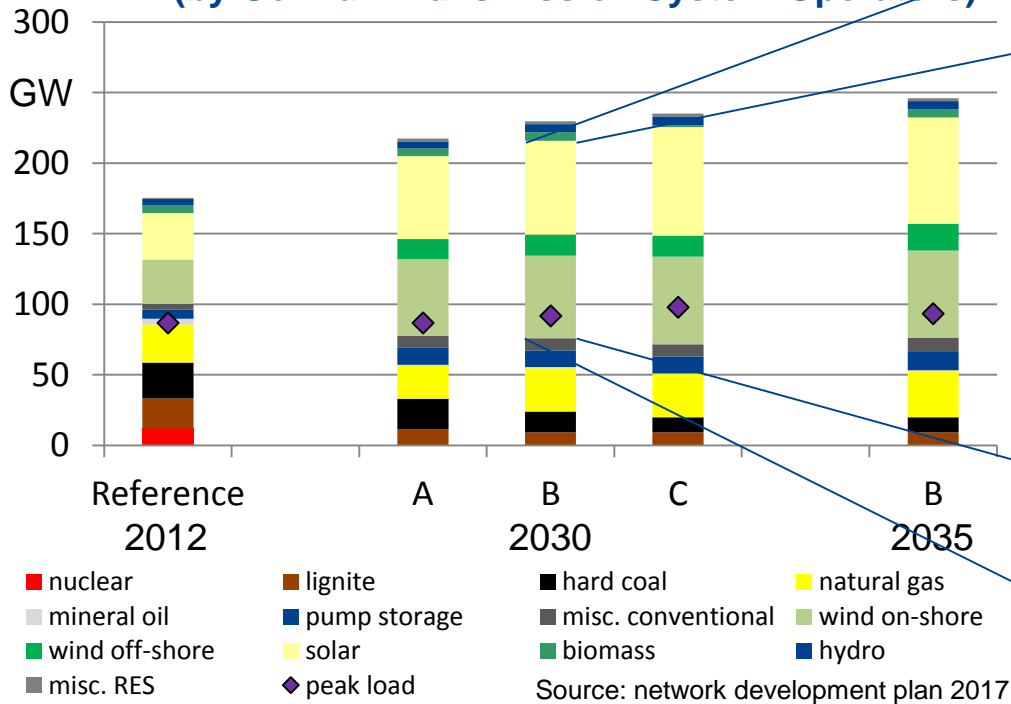
on the basis of a decision
by the German Bundestag

Climate Policy Targets lead to Energy Transition

Emerging Usage of Renewable Energy Sources (RES)

- German target: 50% share of RES in electricity consumption in 2030
- Especially intermitted sources like wind and solar

**Electricity System Development Scenarios
(by German Transmission System Operators)**

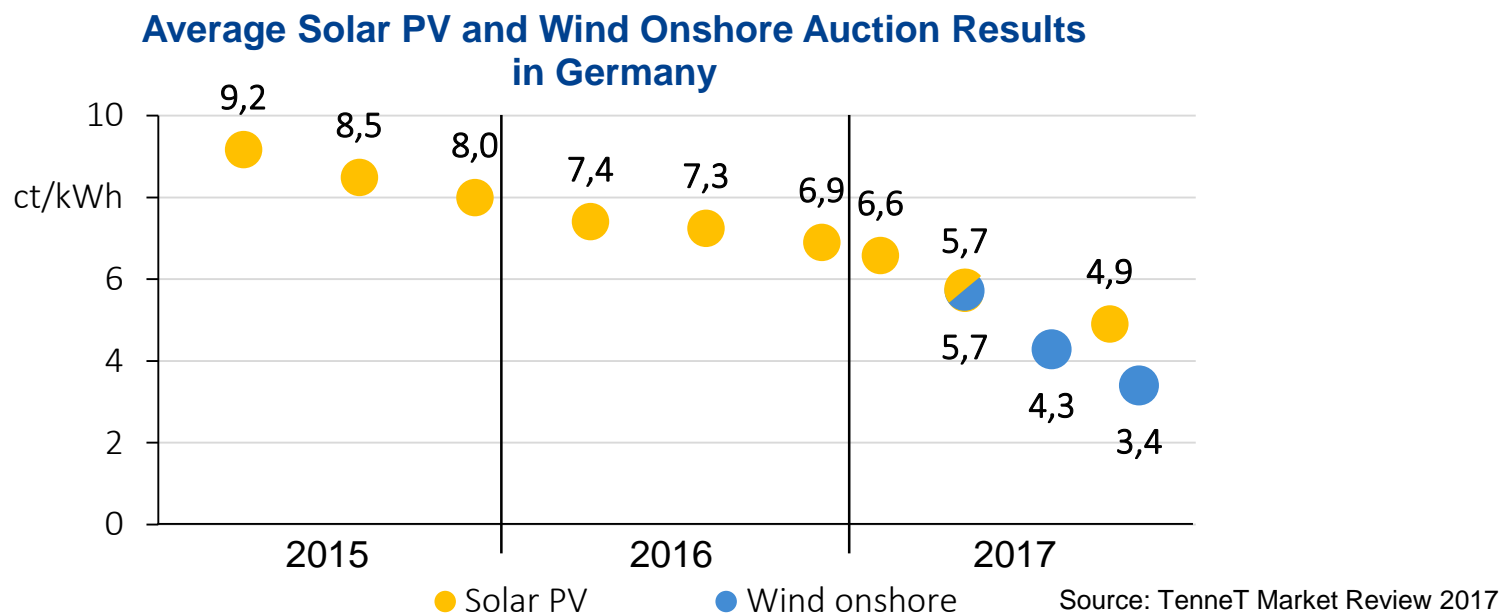


➔ Increasing feed-in from RES must be integrated into electricity markets

Costs of Renewables on Downward Trend

German RES capacity auctions (mandatory up from 750 kW)

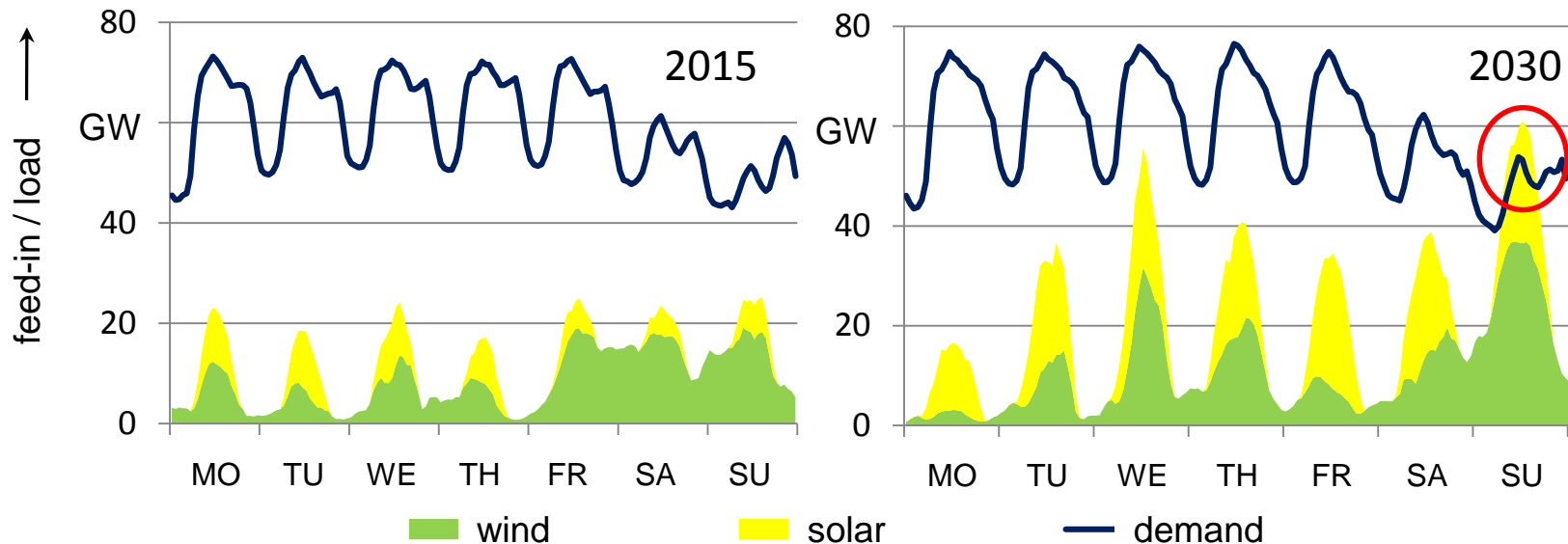
- Pay-as-bid principle based on merit order of bids (subsidy level and capacity)
 - ◆ Bids with lowest subsidy level will be granted until the total capacity reached
 - ◆ Total capacity based on expansion targets for each technology
- Take place three times a year since 2015



➔ RES close to economic break even and thus subsidies not necessary

Intermittent Renewable Generation requires Flexibility

Compare German RES feed-in 2015 and 2030 – Exemplary Week

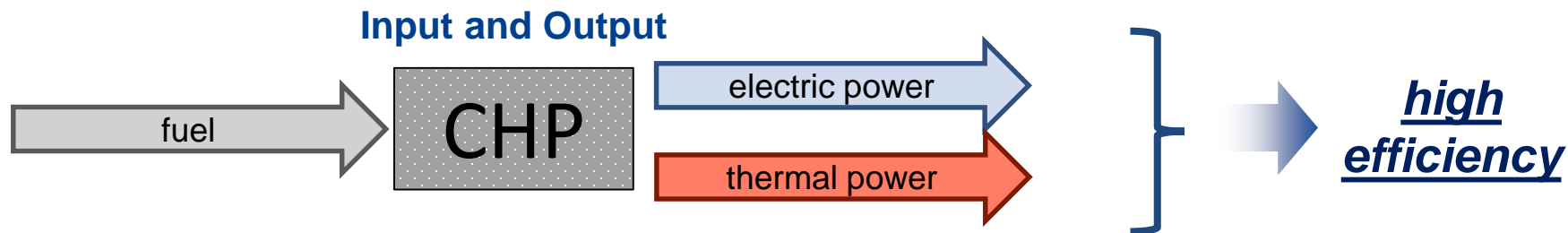


- In future RES feed-in will
 1. exceed demand temporarily
 2. nearly completely missing for up to two weeks
- ➔ Volatile and random RES generation needs to be compensated
- ➔ Flexible and secure generation capacity crucial in order to cover volatile difference between demand and RES feed-in (residual load)

Combined Heat and Power as Efficient Generation

Flexibility Option: Combined Heat and Power (CHP)

- CHP plants provide thermal and electric power simultaneously



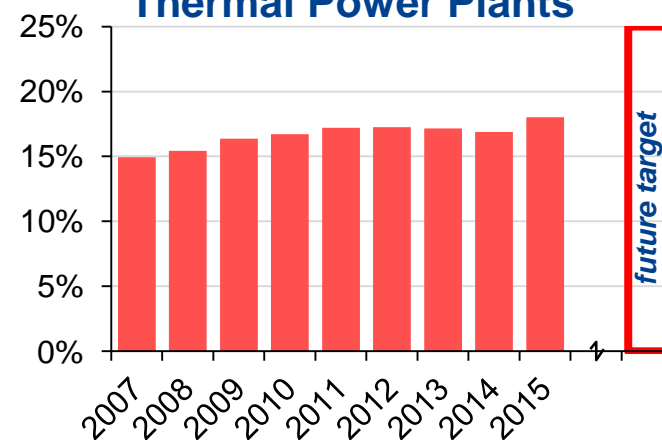
- ➔ High total efficiency due to usage of both energy types (up to 90 %)

- Decreasing competitiveness of thermal plants due to high RES share with low marginal costs

- ◆ Increasing efficiency by using heat
- ◆ Additional revenue due to heat sales
- ◆ Target of German government:
25% of thermal generation with CHP

- ➔ CHP will coexist with RES during transition

German CHP Electricity Generation Share of Thermal Power Plants



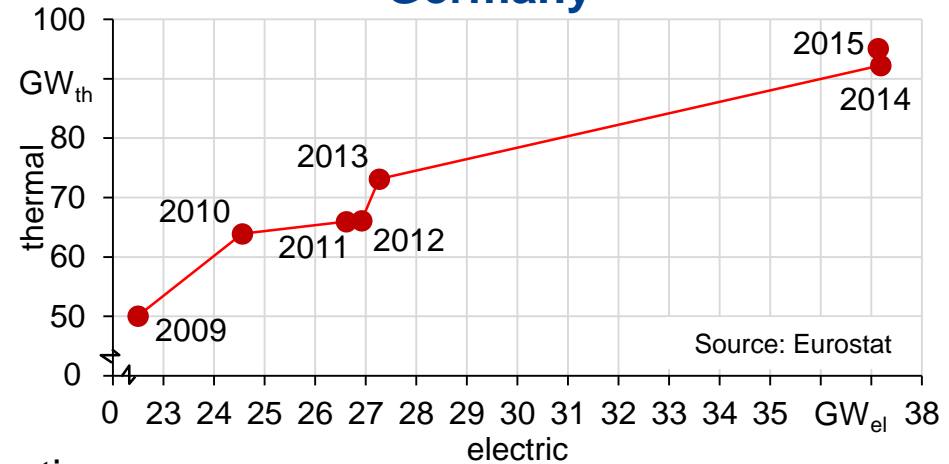
Source: Eurostat and BMWi

CHP in Germany and Europe

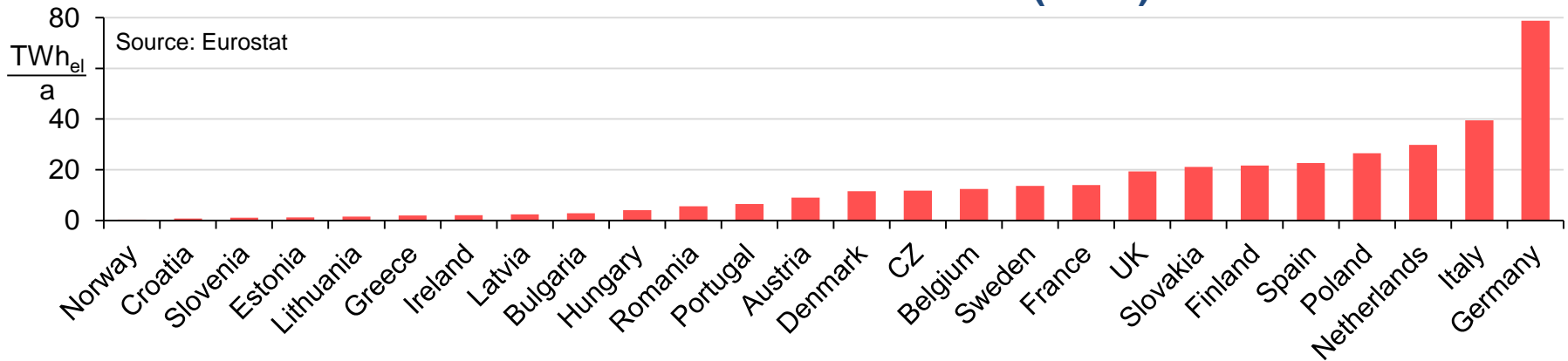
Installed CHP

- Thermal and electric output increased in Germany
- ➔ CHP increase parallel to RES
- CHP by countries in Europe
 - ◆ Widely used technology
 - ◆ Installed for utility services as district heating as well as for industrial applications

Development of CHP Capacity in Germany



Electric CHP Generation (2015)

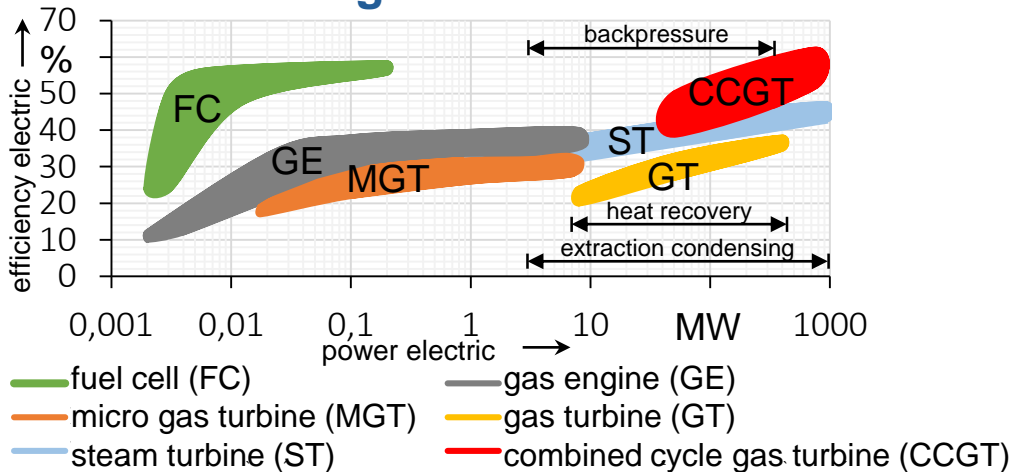


- ➔ Germany with most absolute CHP generation in Europe

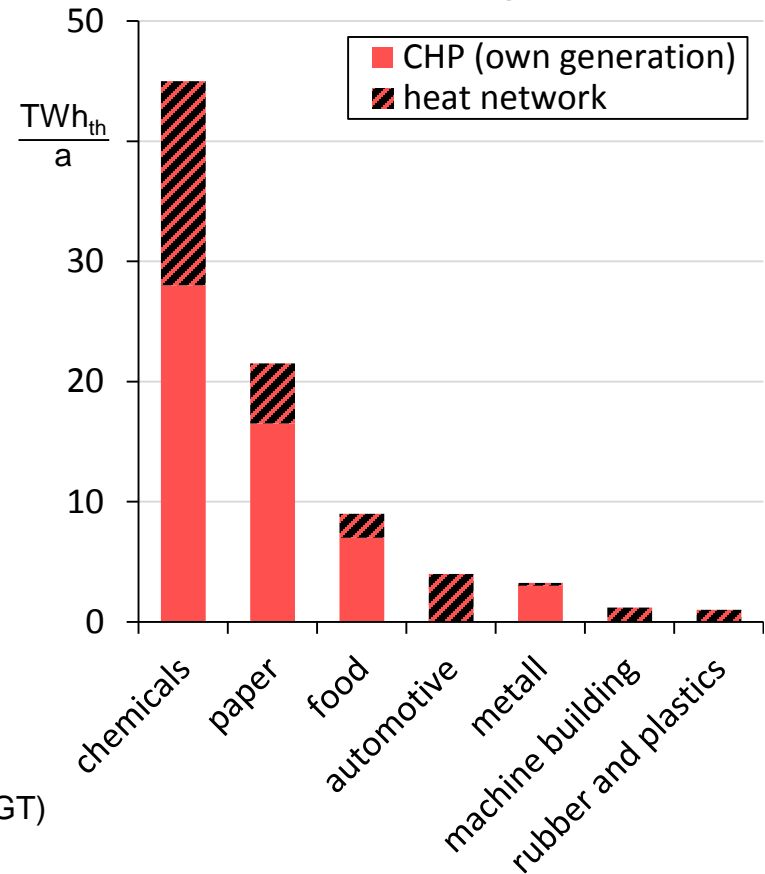
CHP Industry Applications in Germany

- CHP process heating applications
 - ◆ Steam processes up to 500 °C
 - ◆ Hot water processes
 - ◆ Cooling
- ➔ Primarily used in chemical, paper and food production

Technologies Available



CHP Applications in German Industry (2011)



Source: Bundesverband Kraft-Wärme-Kopplung e.V.

- ➔ Various technologies available depending upon application

CHP as a Part of Heat Generation Portfolios

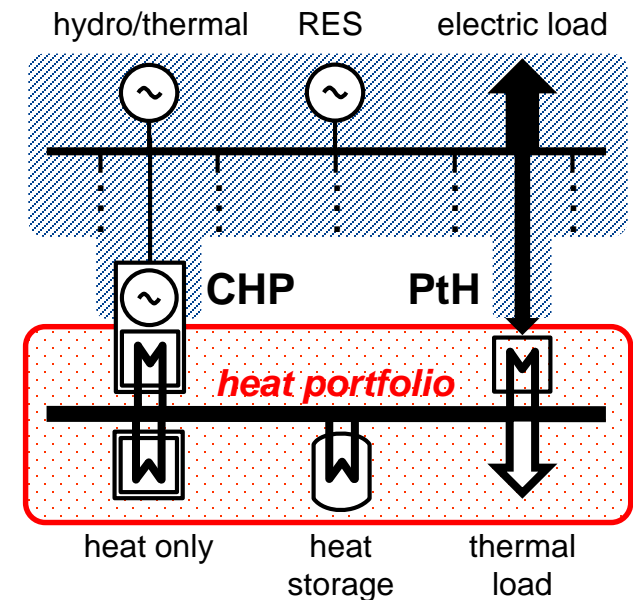
Heat Demand

- Depending on connected heat consumers, temperature and time
- ➔ Heat demands needs to be covered at all times

Heat Supply

- CHP units provide heat and electric energy simultaneously
 - Power-to-Heat (PtH) as heat generation for peak load through electric consumption
 - Heat storages for equalizing demand
 - ➔ Heat generation portfolio provides a degree of freedom in unit commitment
-
- ➔ Flexibility given in electric generation (CHP) and electric consumption (PtH)

Coupled Electricity and Heat Sector



Heat Portfolios in Germany

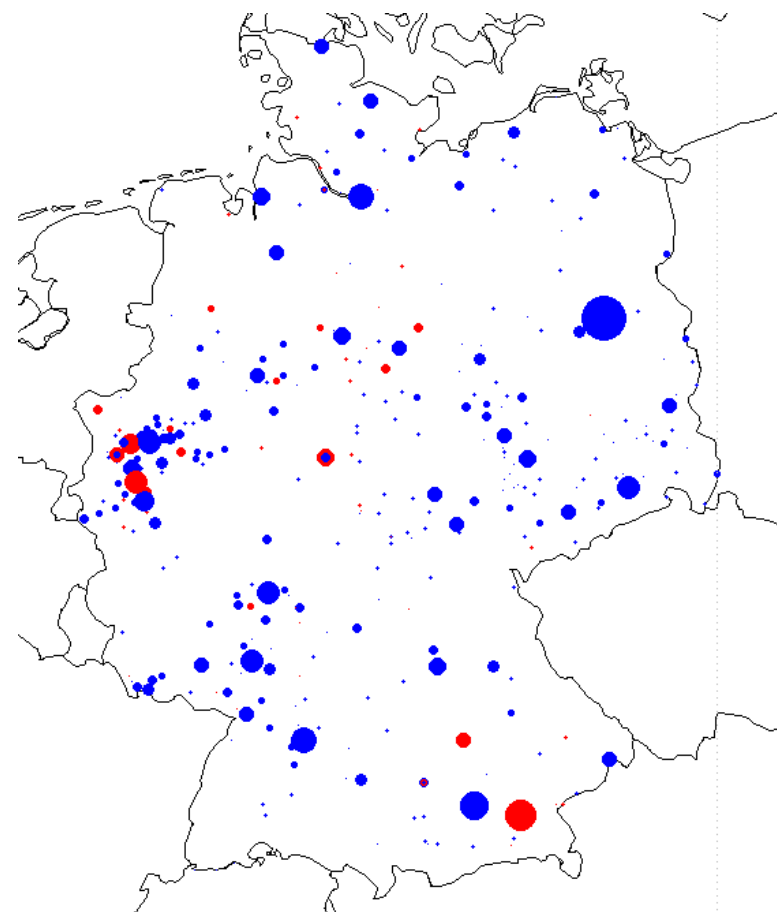
Industrial heating

- Temperature independent process heat
- Large-scale consumption
- ➔ High utilization and secure supply due alternative generation units

District heating

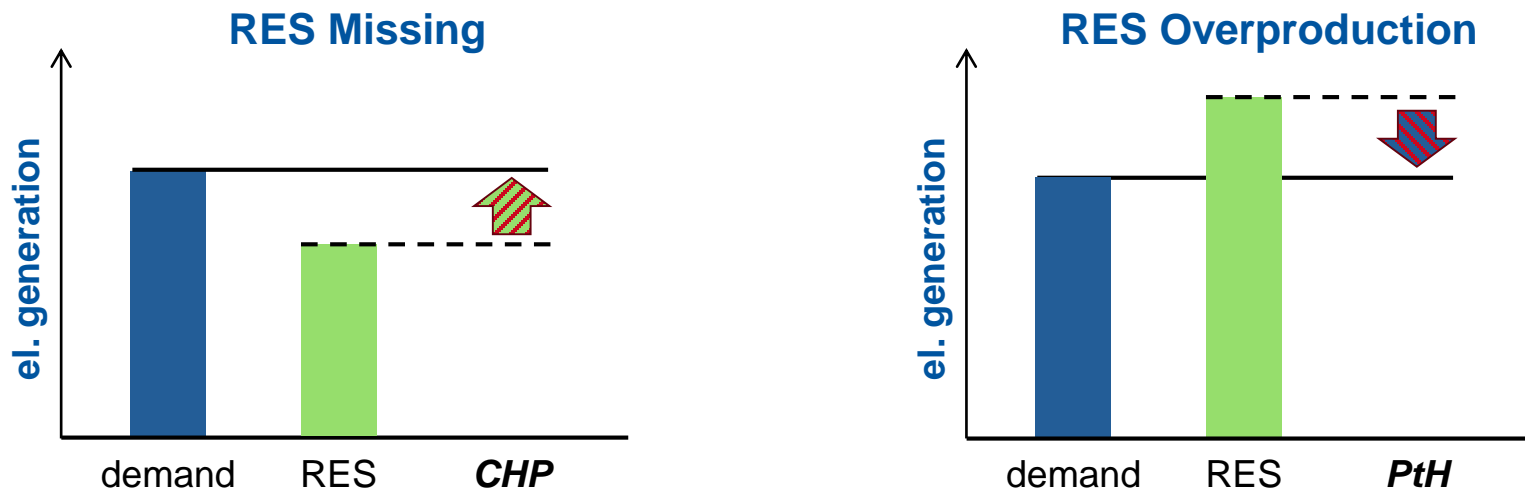
- Mainly in urban areas
- Consumers mostly small scale businesses and private households
- ➔ Volatile demand leads to lower utilization and back-up capacities
- ➔ Both types can provide flexibility

Large Scale Heat Portfolios



● industry ● district heating ● ~31 PJ_{th}/a

Coverage of Residual Load with CHP and PtH



RES Integration and Market Incentives

- CHP and PtH used to cover thermal demand
 - ◆ RES feed-in exceeds demand
 - ◆ RES feed-in is missing
 - PtH uses RES overproduction
 - CHP fills electric demand gap
- Capacity for positive and negative residual load
- Flexibility demand will result in corresponding incentives at the electricity market
- Integration of RES by using flexible CHP and PtH
- CHP and RES complement each other

Key Take Away

Introduction

- Intermittent and random feed-in from RES results in flexibility demand

Analysis

- CHP with high total efficiency due utilization of thermal and electric output
 - ◆ Efficiency up to 90 %
 - ◆ Germany with the largest CHP generation in Europe
 - ◆ CHP will coexist with RES
 - ◆ CHP for heat provision used in chemical, paper and food production
 - ◆ Diversity of technologies for different production applications
- Flexibility given by CHP in electric generation and PtH in consumption

Flexibility

- Electricity market will reflect flexibility demand by price incentives
- CHP and RES complement each other

Any further questions?

Institute for Power Systems and Power Economics (IAEW)
RWTH Aachen University

Mihail Ketov, M.Sc.

Mobile: +49 (0)162 80 252 88

Mail: mihail.ketov@rwth-aachen.de

Web: www.iaew.rwth-aachen.de

Director of IAEW
Univ.-Prof. Dr.-Ing. Albert Moser

Supported by:



on the basis of a decision
by the German Bundestag