



System Integration of Variable Renewable Energies

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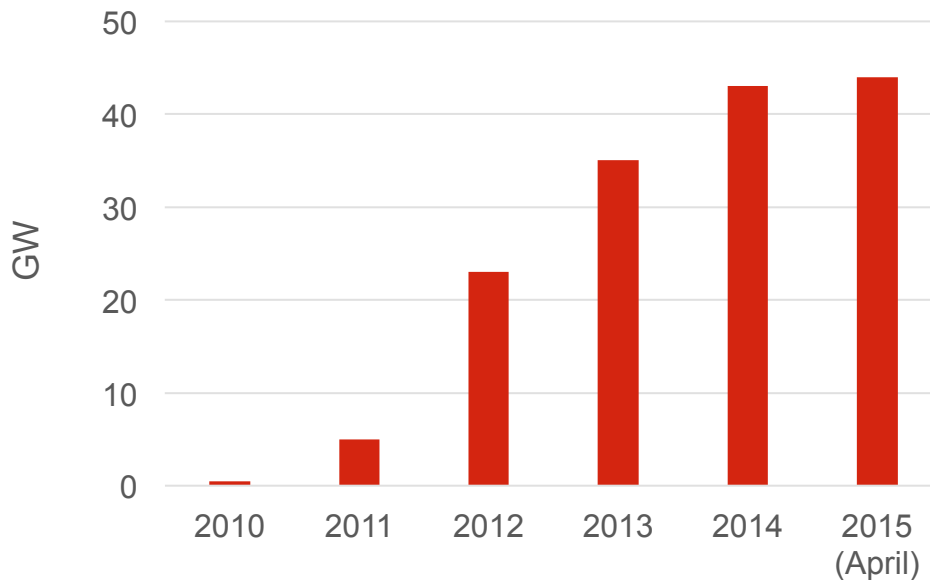
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1. Direct marketing of RE

1.1 The facts

Direct marketing of RE in Germany



- Predominantly onshore wind (32 GW) and solar PV (5.4 GW)
- 70 specialized direct marketing electricity trading companies
- Part of a balancing group and incentivizes demand response

From 2015: > 500 kW (e.g. On/offshore wind and PV utility scale, biogas)

From 2016: > 250 kW (e.g. PV factory rooftops)

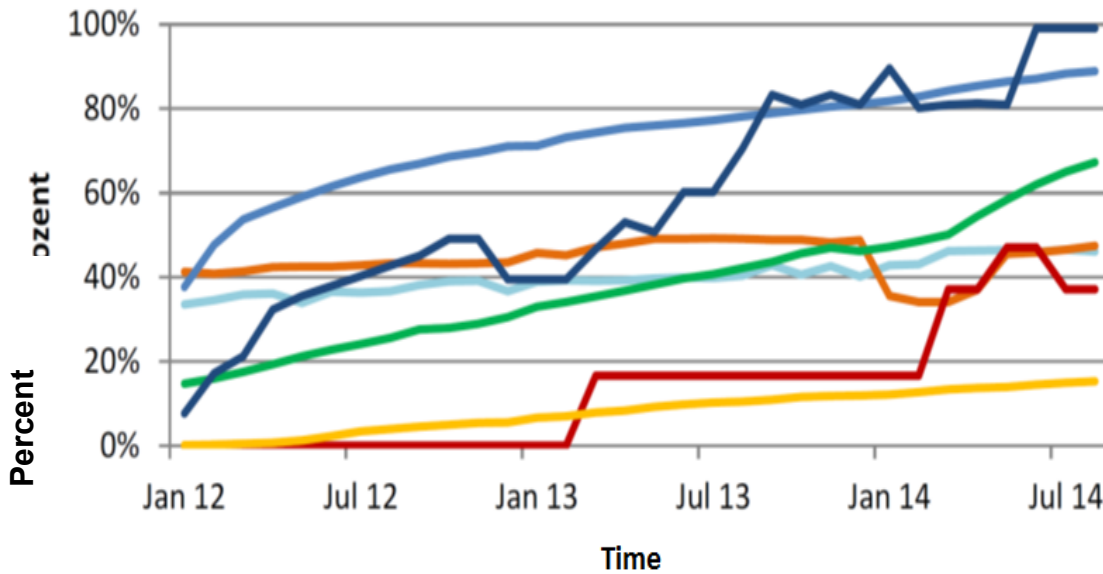
From 2017: > 100 kW (e.g. PV medium rooftops)

Not included: Small hydro and small PV

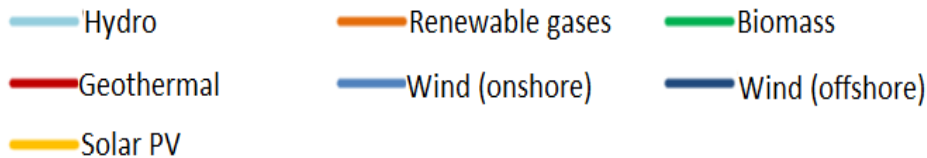


1.1 The facts

Direct marketed capacity in percent of installed capacity



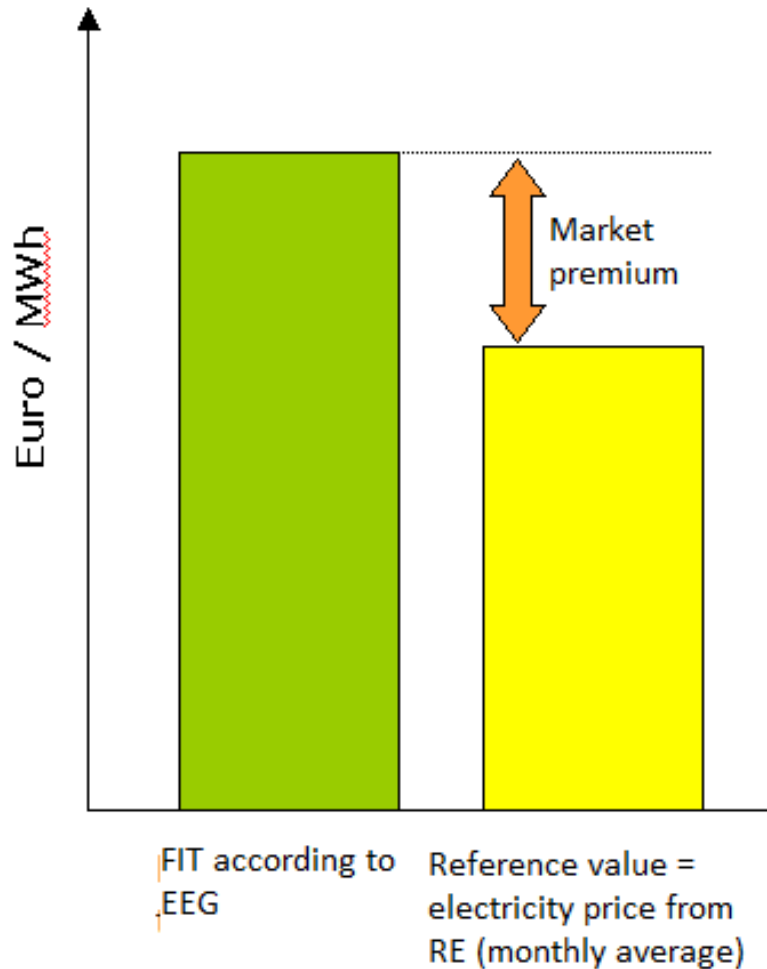
- 90% of wind is directly marketed
- More than 60% of biomass
- For PV < 20%



Fraunhofer (2014)



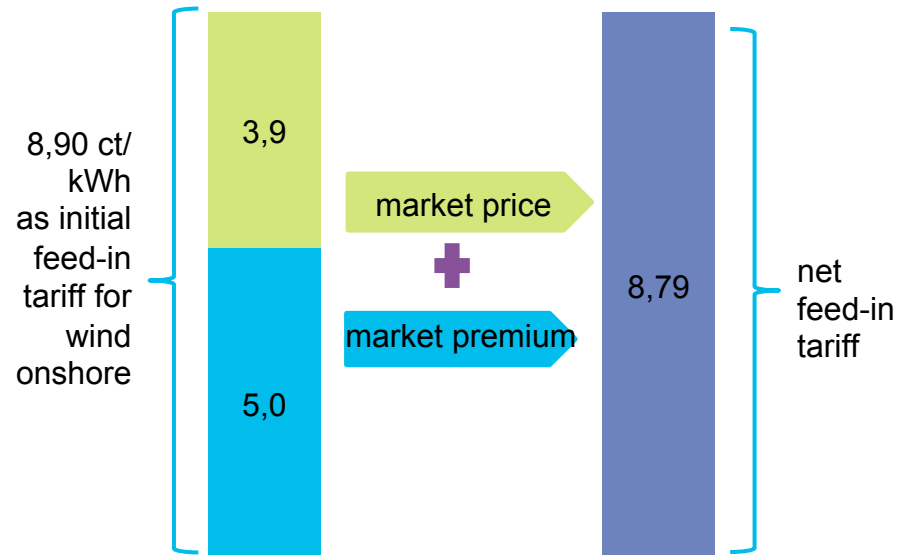
1.2 The market premium



- No payment of the FIT to participants
- The higher the market price, the lower the premium
- Responsibility of RE operators to sell electricity at the market
- Full integration of RE in current market questionable



1.2 The market premium



Agora Energiewende (2015)

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2. The balancing market

Participation in the balancing market requires:

- Direct marketing
- Minimum capacity of 5 MW, resp. 1 MW

 Pooling to form virtual power plants

Alt Daber PV plant



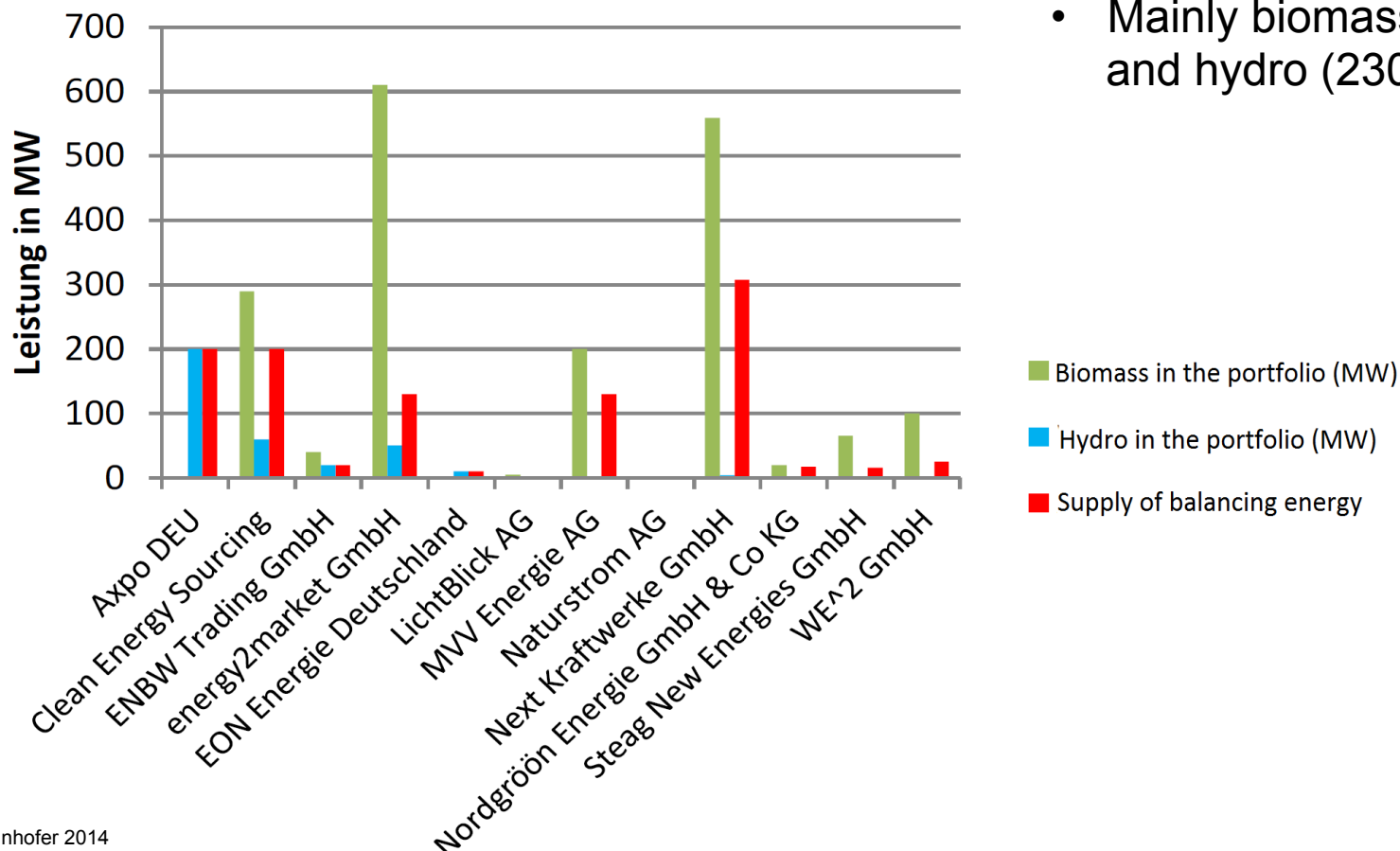
Alt Daber PV plant in Germany

- 67.8 MW capacity
- 2 MW battery storage
- Participation in the balancing market at the high voltage level



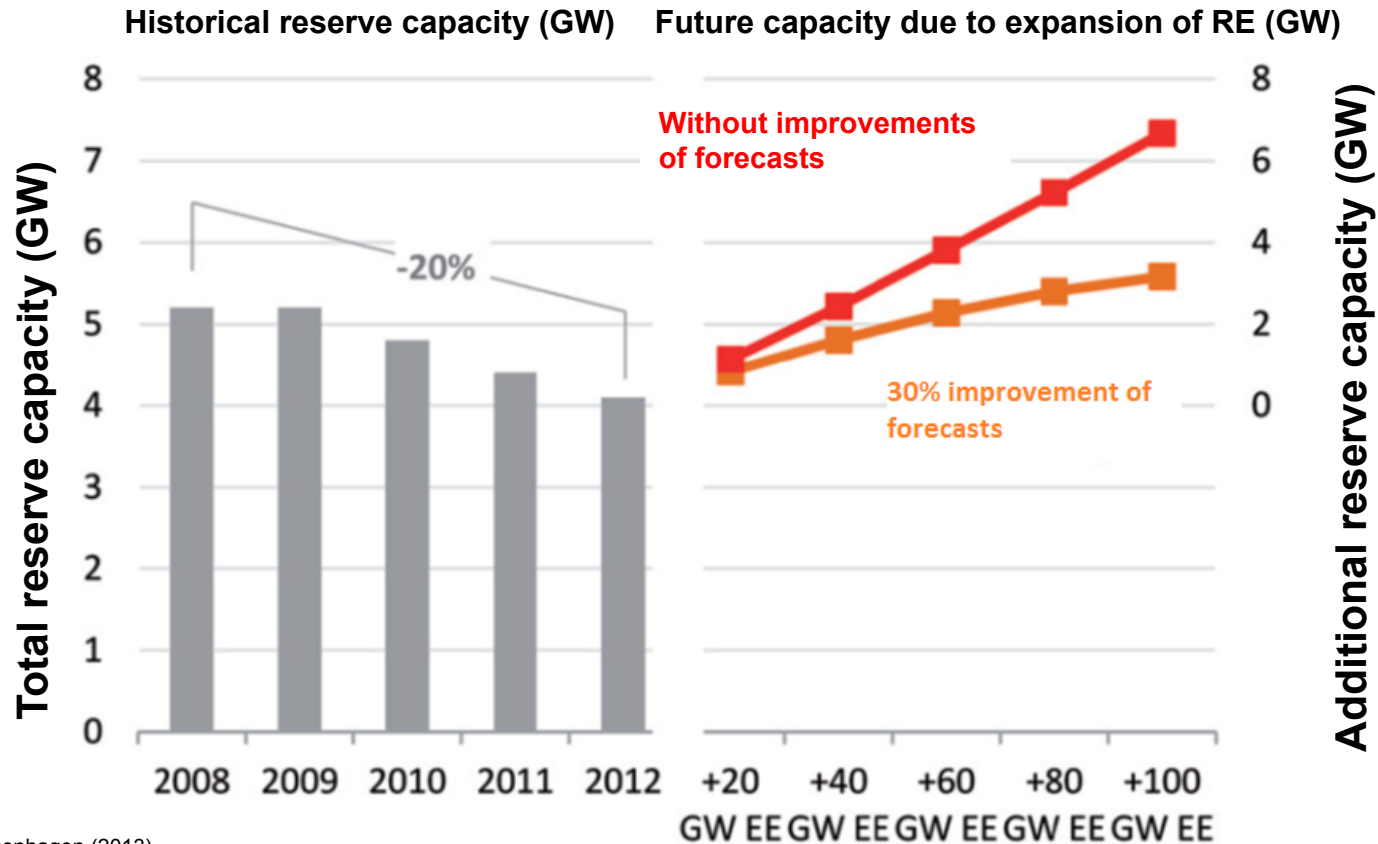
2.1 Contribution of RE

Participation of controllable RE in the German balancing market



- Mainly biomass (820 MW) and hydro (230 MW)

2.2 Operating reserve and RE



Hirth and Ziegenhagen (2013)

Rule of thumb: 1 GW of RE

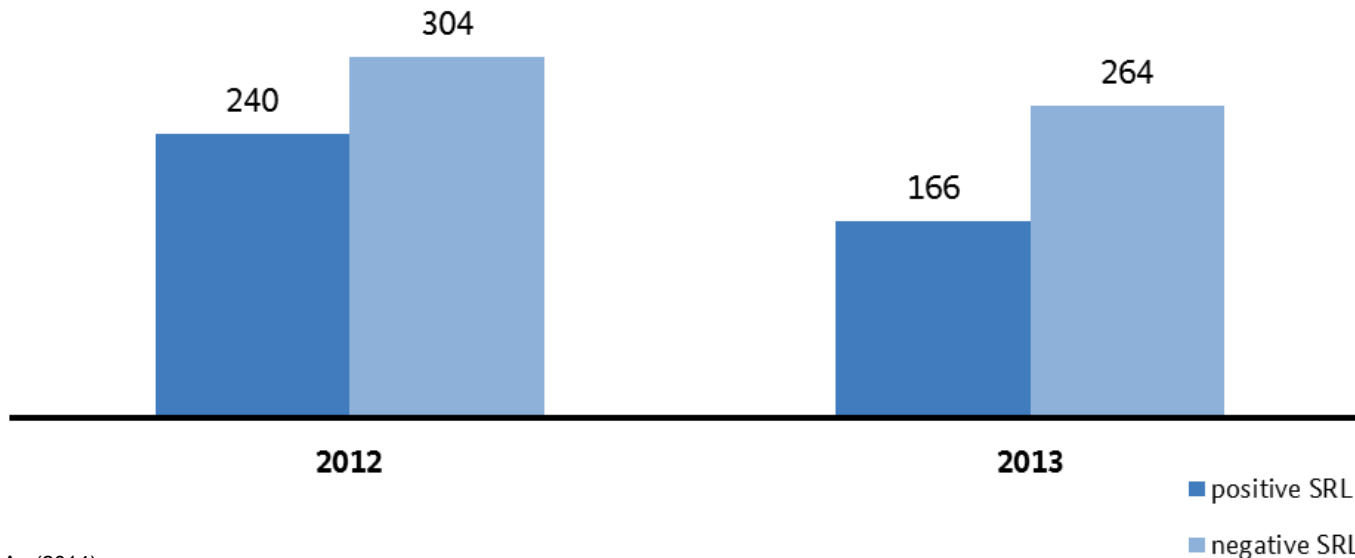
➔ 30-70 MW of additional operating reserve



2.2 Operating reserve and RE

- Deployment of reserve capacity decreased since 2008
- Negative secondary reserve > Positive secondary reserve

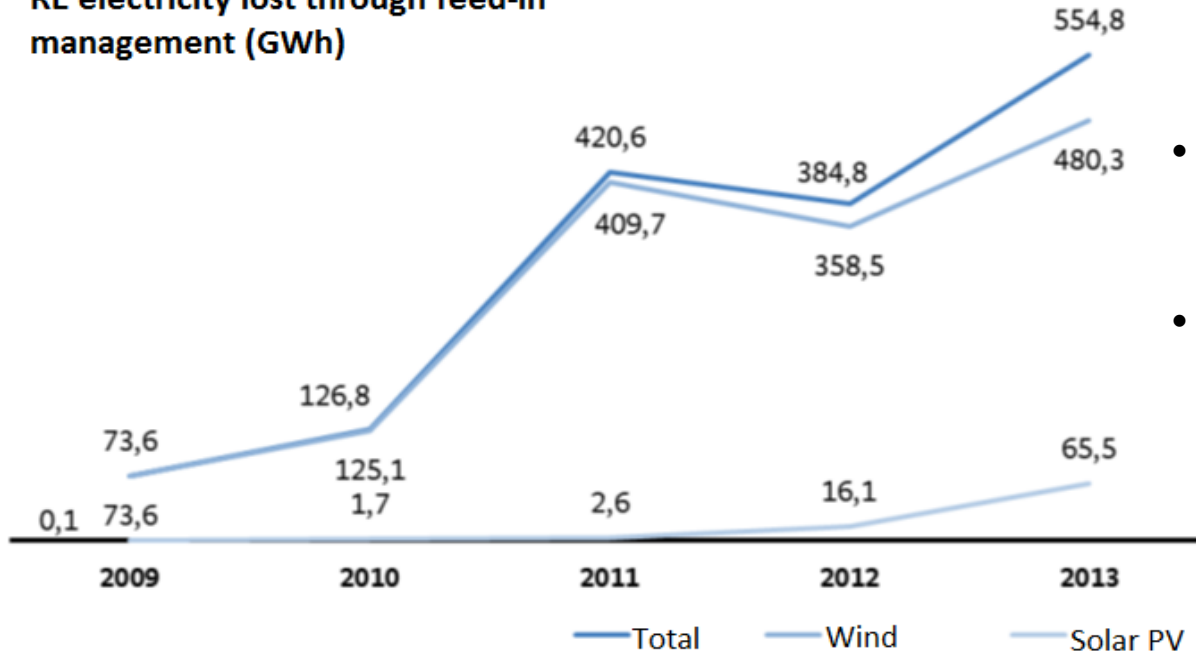
Average deployment of secondary reserve (MW)



BNetzAg (2014)

3. Feed-in management

RE electricity lost through feed-in management (GWh)



- Less than 1 % of entire EEG –remunerated electricity
- Compensation payment in 2013: 43.7 Million Euro

BNetzAg (2014)

Greenbook Electricity Market Reform (BMWi):

“The grids must be expanded at the transmission and distribution level“

“It makes economic sense not to extend the networks for the “last kilowatt hour generated”

4. Technical prerequisites/requirements

Remote Control:

Prerequisite for direct marketing and participation in balancing market:

VDE application guides

- Generators in the low voltage distribution network (VDE-AR-N 4105)
 - Phase balancing
 - Frequency-based power reduction
 - Reactive power control (through inverters)
 - Inverter reconnection conditions
 - Output power control
- Generators in the high voltage network (VDE-AR-N 4210)
 - Extended requirements for reactive power feed-in
 - Extended requirements for static voltage stability (up to several minutes)

5. Outlook

5.1 The electricity market reform

Debate in Germany

“Energy-only market” (Electricity market 2.0) vs. Capacity market

Features of the EOM and the capacity market

EOM	Capacity market
Electricity market provides incentives for capacity (high price of electricity during some times)	Maintenance of capacity is refinanced through an additional capacity market
No price cap from the regulator’s side	Explicit payment for capacity (apportioned to customers)
Measures needed: Faster, shorter and more flexible day-ahead, intra-day and balancing markets	Measures needed: State introduces a capacity market and regulates it

German government favors the EOM



5.2 Smart metering

Current rollout scenarios for Germany are economically not viable¹

Overview of different rollout scenarios¹

Results for 2014-2022	EU scenario	Continuity scenario	Rollout scenario Plus
Net benefit in bl. Euro	-0.1*	-0.6*	1.5*
Rollout rate in %	80	23	68
Cost per final customer in Euro/year	29	14	21

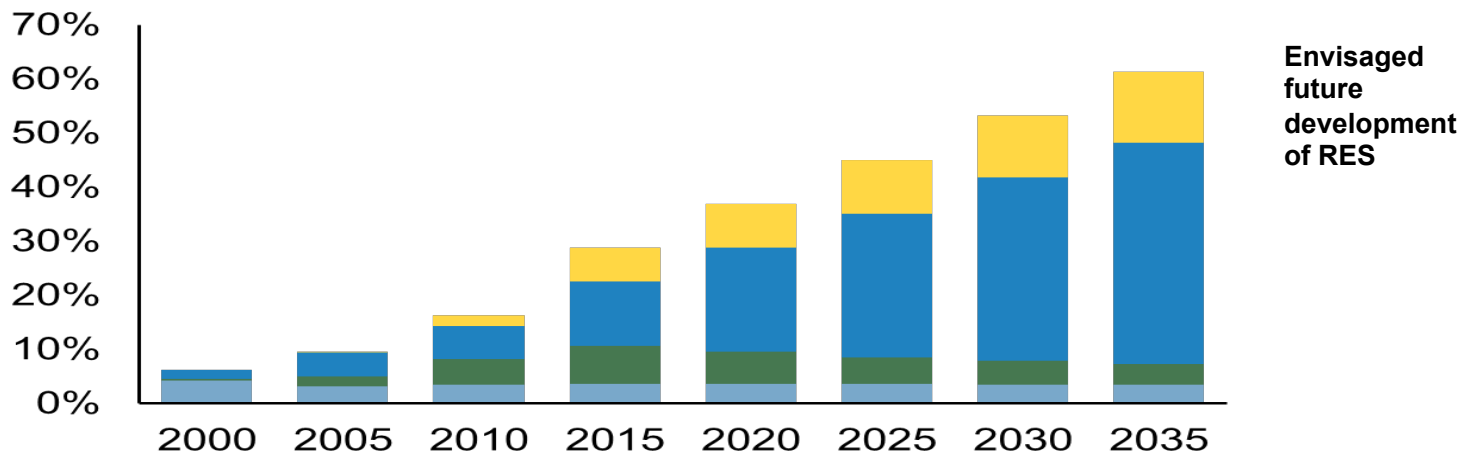
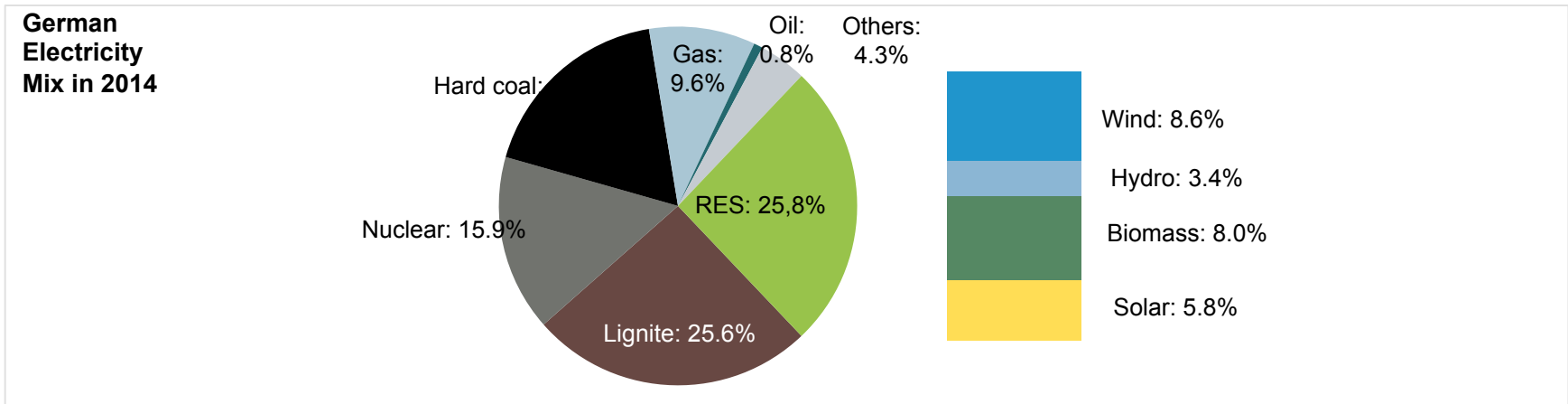
* 2012-2032

Key points of Rollout Scenario Plus:

- Differentiate between intelligent measurements system and intelligent meter
- Equip decentralized RE from 0.25 kW (not from 7 kW)

1) Ernst & Young, 2013, "Kosten-Nutzen-Analyse für einen flächendeckenden Einsatz intelligenter Zähler"

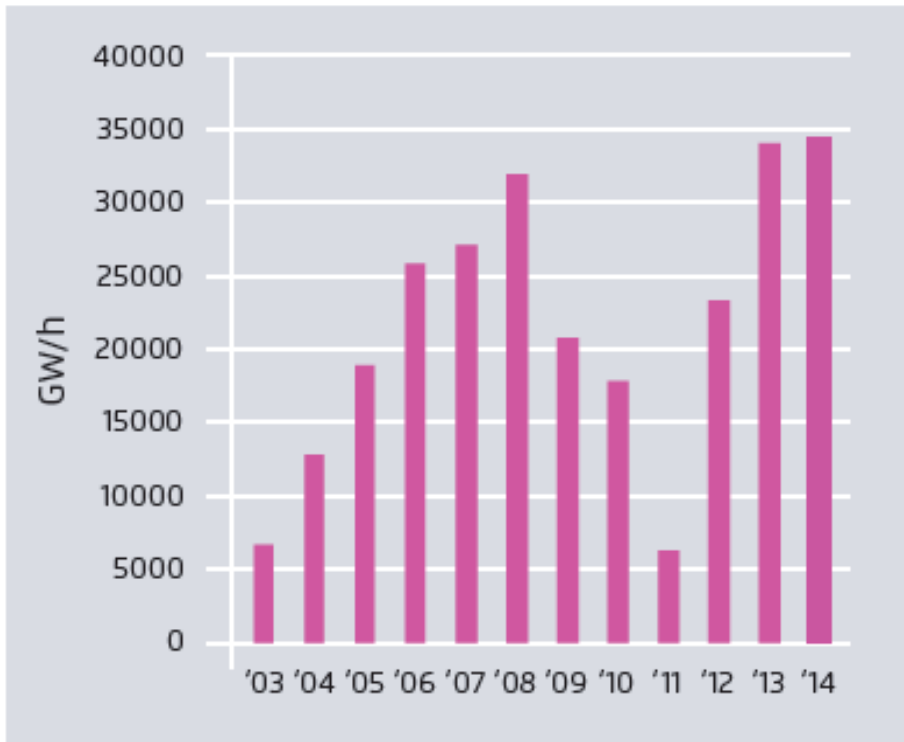
Dominant position of Wind and Solar PV in the future





Electricity Import and Export

German Import/Export balance 2003-2014 (GWh, physical flows)



Agora Energiewende (2015)

- Germany is a net electricity exporter
- Biggest export markets: The Netherlands and Austria
- 21 GW of interconnecting capacity
- Closer links to neighboring markets in recent years