The Impact of Uncertain Future RES-E Deployment on the Electricity System - An Evaluation for Germany

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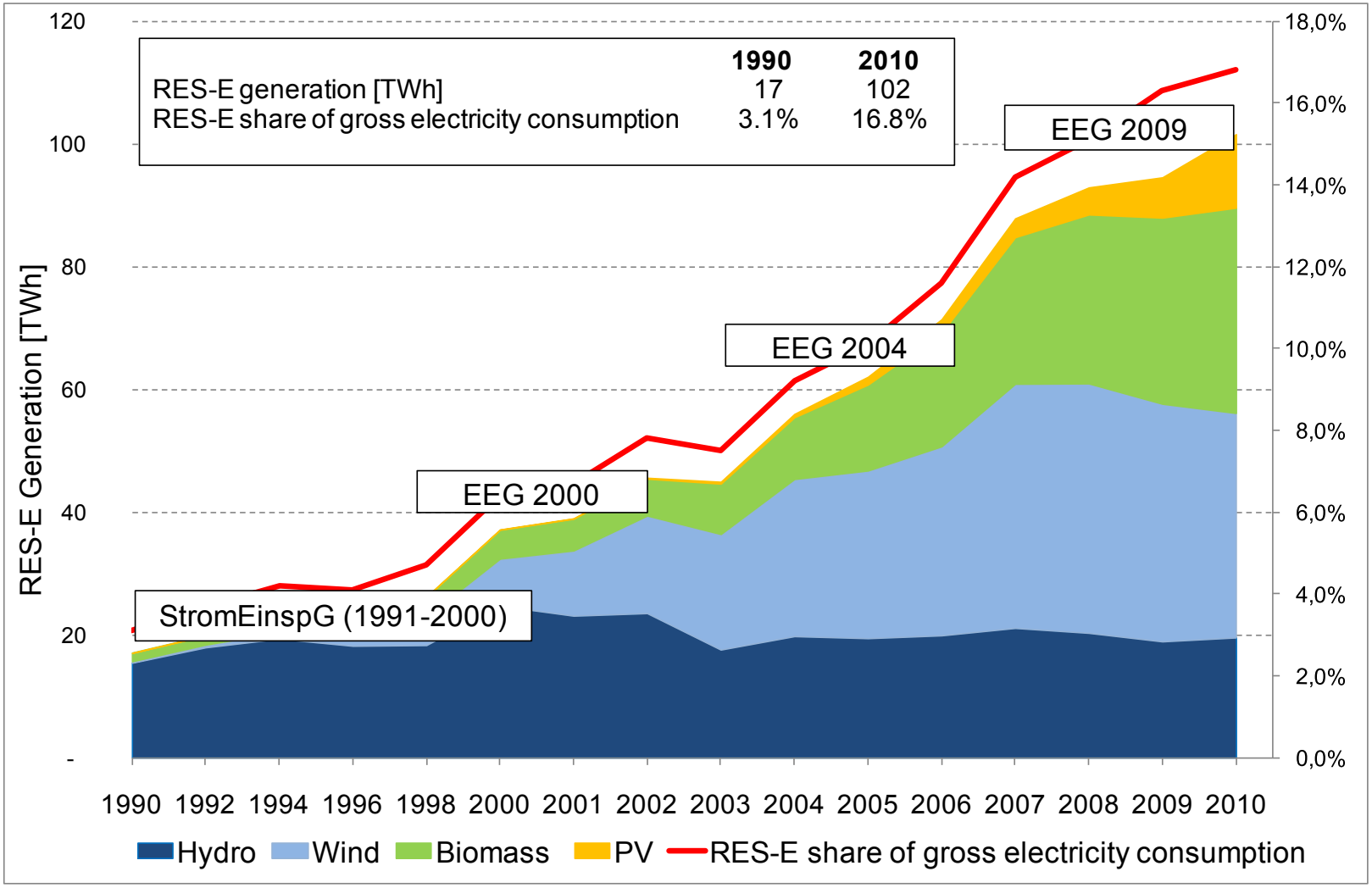
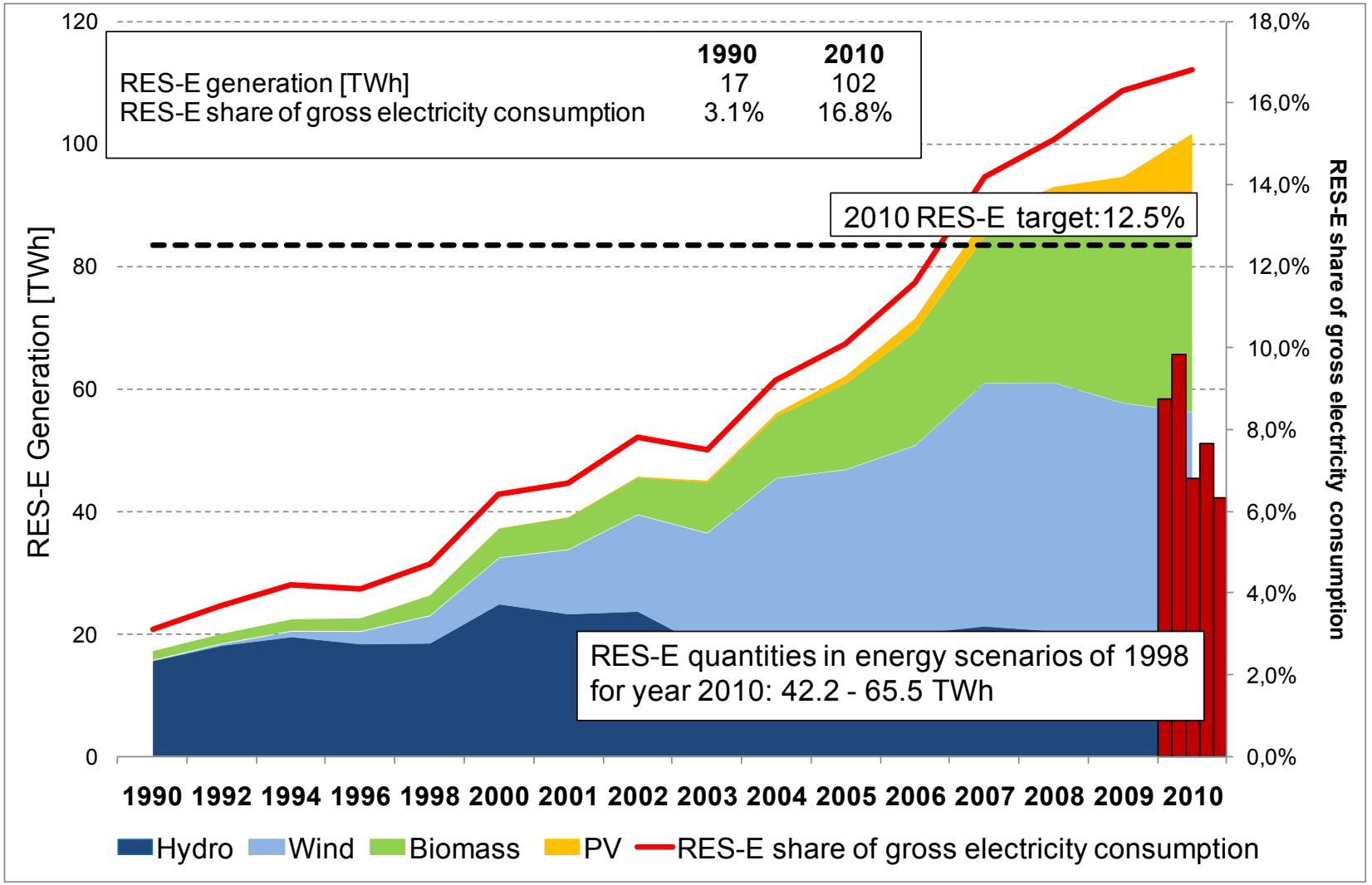
Content

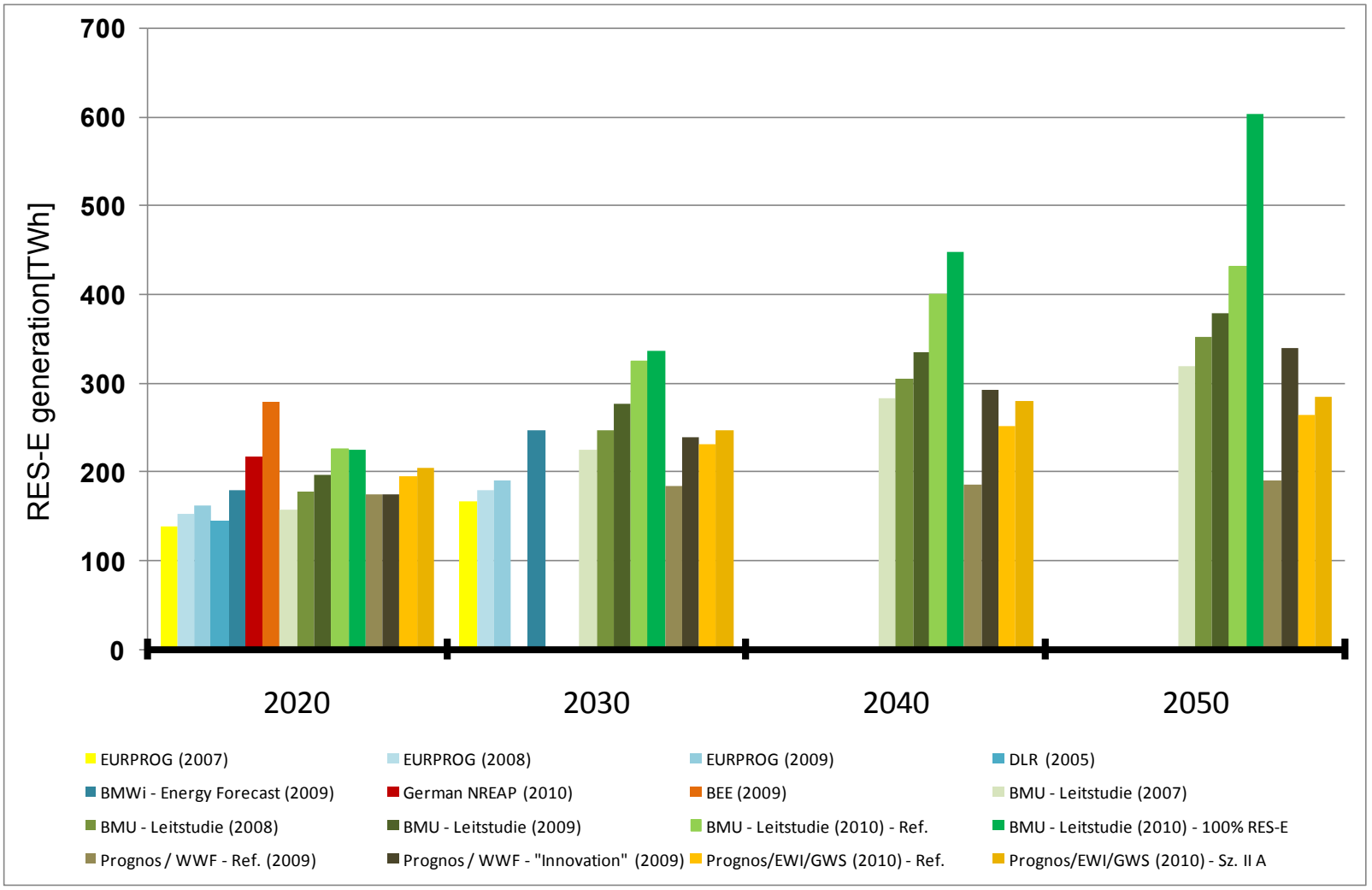
Motivation – RES-E deployment in Germany since 1990



Motivation – Underestimation of current RES-E deployment



Motivation – Future RES-E deployment is uncertain



Research question: Consequences of uncertainty

Uncertain deployment of RES-E (policy-driven part of electricity system)

Uncertainty about level and structure of residual load

Competitive part of electricity system:
long planning, construction, amortization times

Consequences of uncertainty

Multistage stochastic model:
Optimal electricity mix under **uncertainty**

Deterministic solutions of branches:
Optimal electricity mix under **certainty**

Multistage stochastic Investment and Dispatch Model

$$min\ TCOST =$$

$$\sum_{n} p(n) \cdot disc(y) \cdot \sum_{t,reg} \Big[FC(t,n,reg) + FOM(t,n,reg) + VC(t,n,reg) + VCRTO(t,n,reg) - HB(t,n,reg) \Big]$$

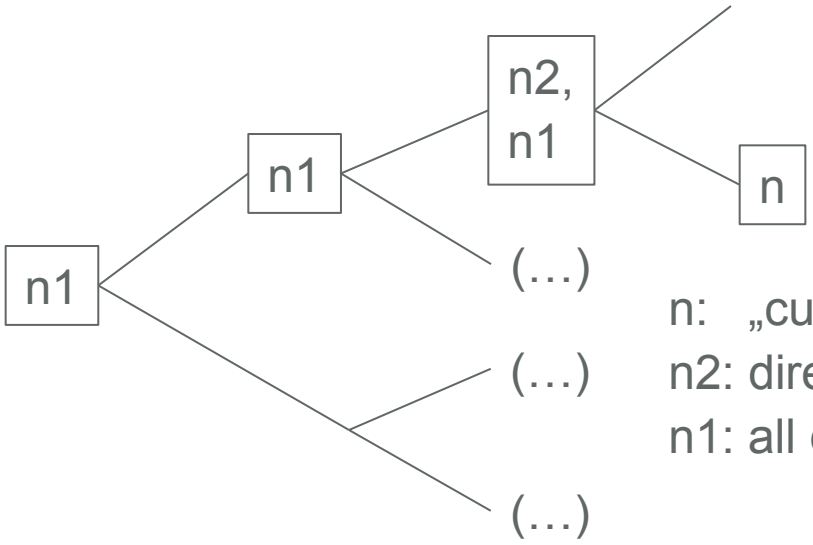
- linear dynamic investment and dispatch model
- minimizes total (discounted) system costs
  - needed to fulfill residual demand in each scenario node
  - considering occurence probability of each node

→ Optimal electricity mix under uncertainty

Multistage stochastic Investment and Dispatch Model

Determination of Installed Capacity in node n

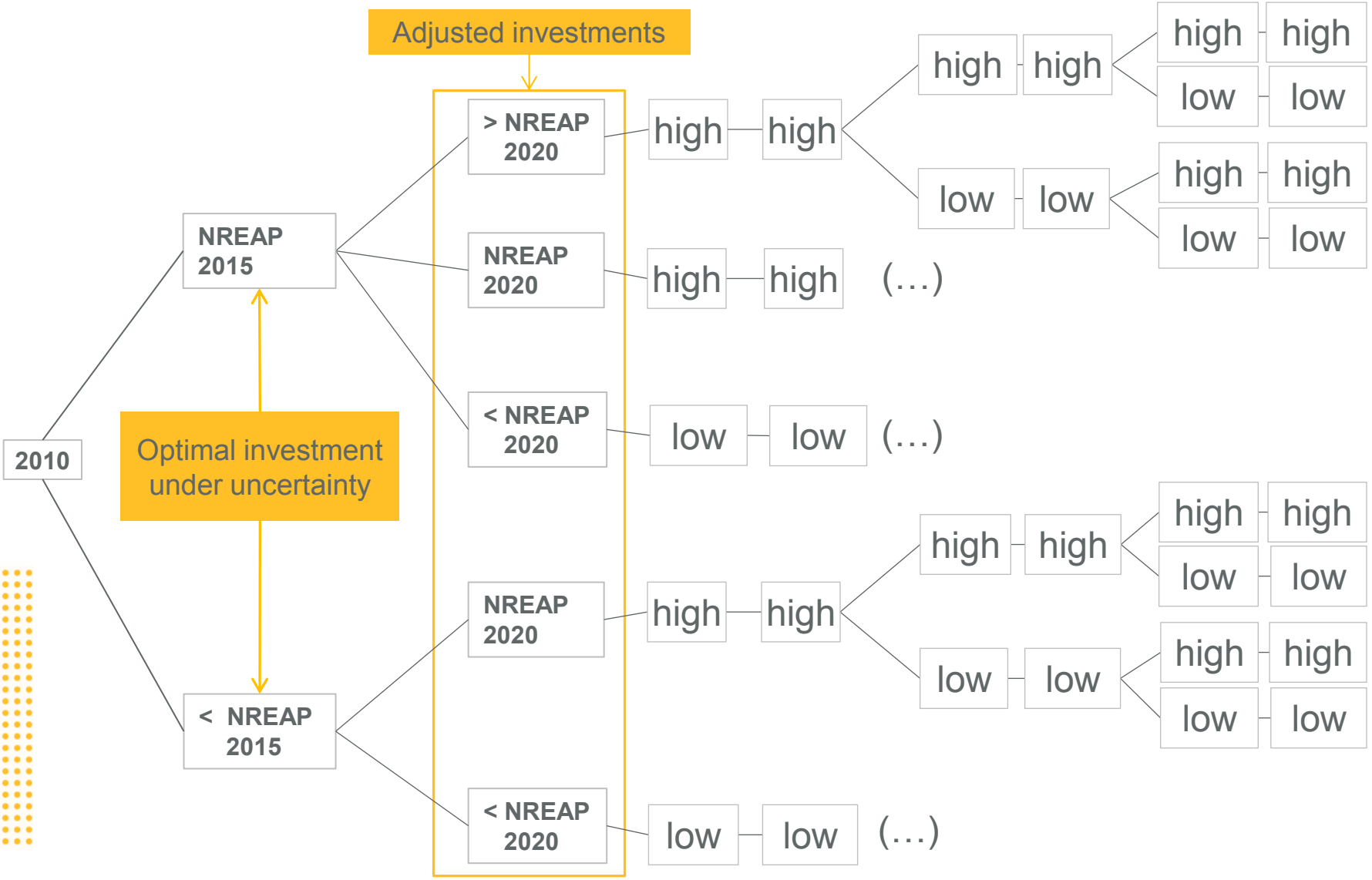
$$C(t,n) = \sum_{n2} \Big[C(t,n2) + CAD(t,n2) \Big] + ad(t,y) - CSUB(t,n) - sub(t,y) - \underbrace{\sum_{n1} \Big[CAD(t,n1) + ad(t,n1) \Big]}_{\text{if technical lifetime exceeded}}$$



n: „current“ node
n2: direct ancestor of n
n1: all direct and indirect ancestors of n

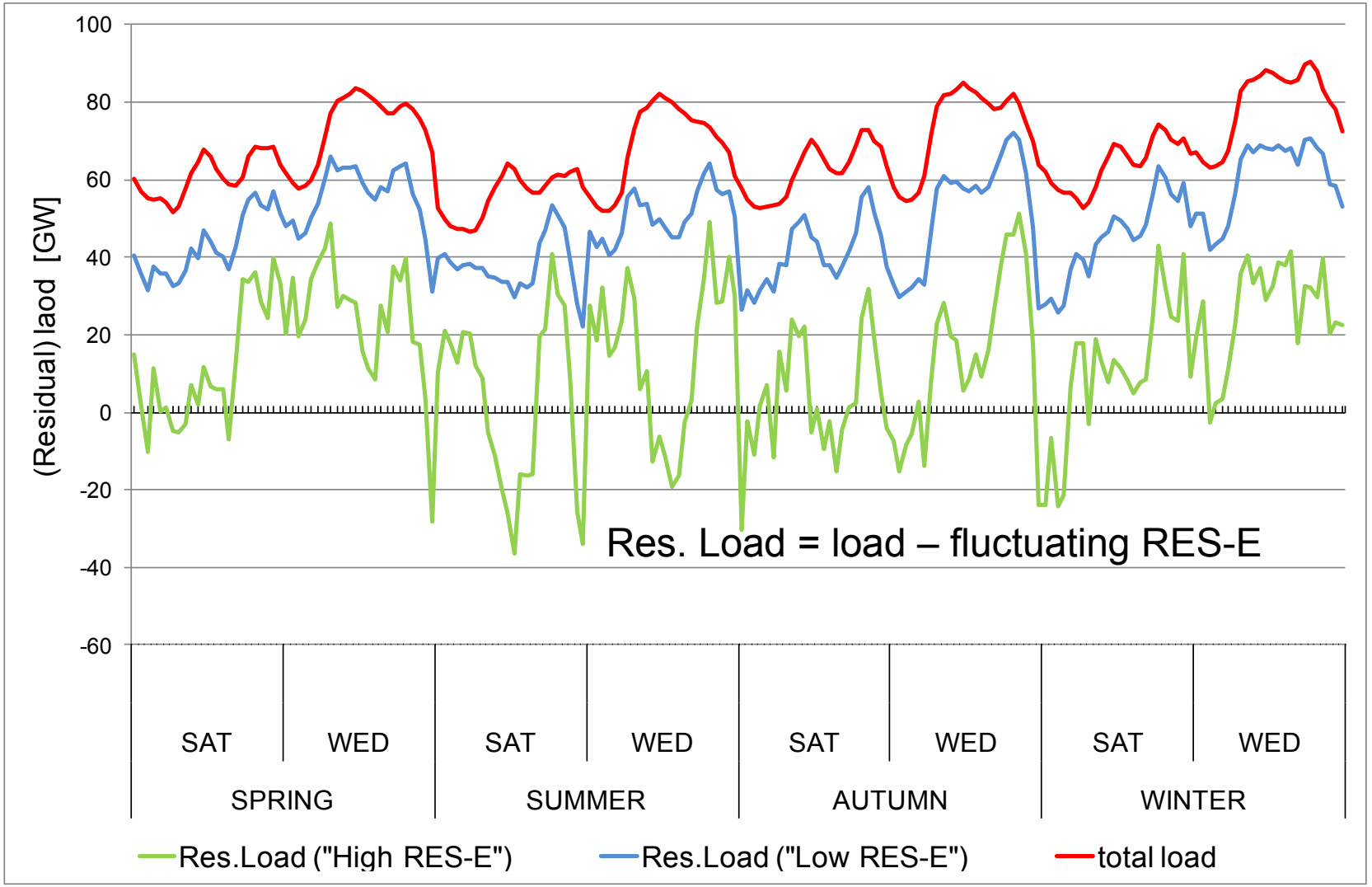
Scenario tree

based on RES-E scenarios and forecasts for Germany



Scenario tree – resulting residual load curve (2050)

(Scenario 1 (max. RES-E) vs. Scenario 20 (min RES-E))



Results
Stochastic Solution

Deterministic vs stochastic:
- **5 GW Coal**
- **2 GW CCGT**

2010

NREAP 2015

CAP_ADD
6.9 lignite
5,1 coal
3.4 CCGT
0.5 OCGT

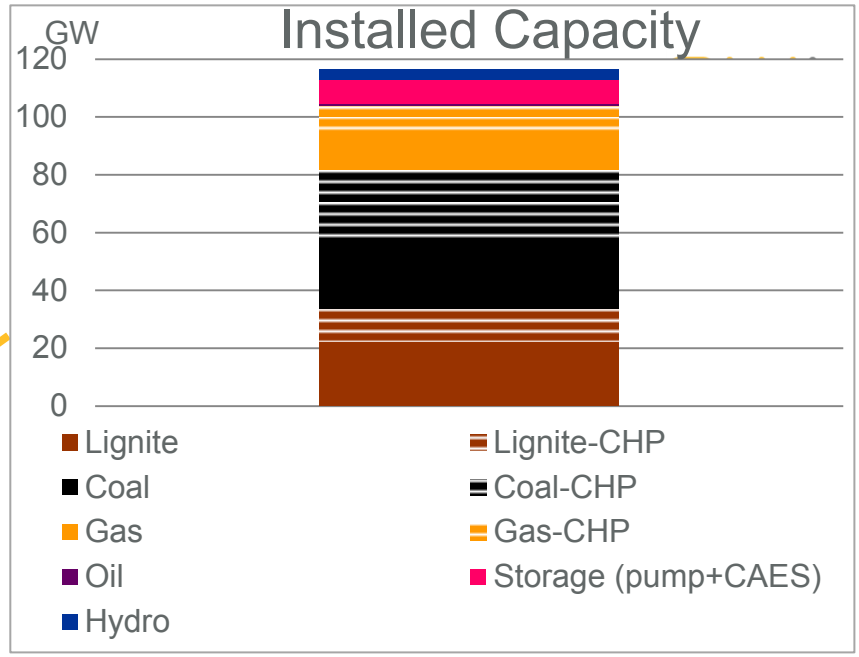
> NREAP 2020 ++

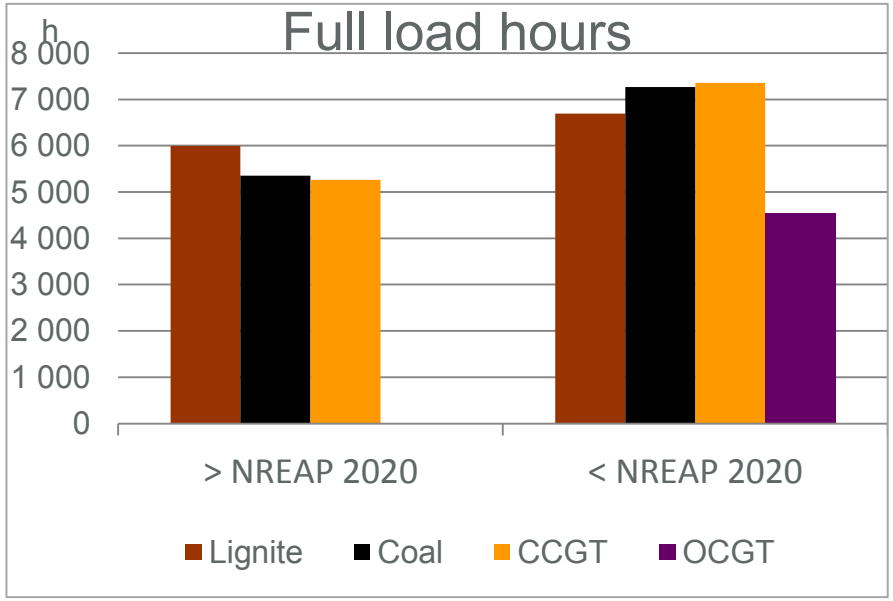
NREAP 2020 ++

< NREAP 2020 +

< NREAP 2015

Deterministic vs stochastic:
+ 10 GW Coal
- 4 GW CCGT





Results - Costs

Extra costs of stoch. solution

	Mio € until 2050 (discounted 5%)	Mio € until 2070 (discounted 5%)
Branch 1	4106	4465
Branch 2	3291	4275
Branch 3	1913	2677
Branch 4	1553	3465
Branch 5	2286	2898
Branch 6	1549	2316
Branch 7	1571	2639
Branch 8	1166	2480
Branch 9	2853	2774
Branch 10	723	1924
Branch 11	2015	2471
Branch 12	382	2643
Branch 13	3165	3735
Branch 14	2386	2612
Branch 15	2118	3054
Branch 16	1852	2600
Branch 17	2498	2164
Branch 18	369	1036
Branch 19	760	1577
Branch 20	90	1402
AVERAGE	1832	2660

Severe Consequences of uncertainty?

- Extra costs seem not very significant, compared e.g. to RES-E promotion costs in 2010
- **BUT:**
  - Extra costs depend e.g. on gas-coal spread, discount rate etc.
  - only costs if form of uncertainty is known

Conclusions

1. Uncertain RES-E deployment paths
   => Uncertainty about level + structure of residual load
2. Uncertainty leads to suboptimal electricity mix
3. Uncertainty induces extra costs (depending e.g. on gas-coal spread)

→ Benefit of flexibility in RES-E policy has to be weighted against costs of uncertainty

Thank you for your audience.

Questions, comments?

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BACK-UP

Fuel and CO_2-price assumptions

€/MWhth	2020	2030	2040	2050
lignite	1,4	1,4	1,4	1,4
coal	13,1	13,6	14,2	15,6
gas	24,5	27,5	30,5	34,5

€/t	2020	2030	2040	2050
CO2	25,0	30,0	35,0	40,0