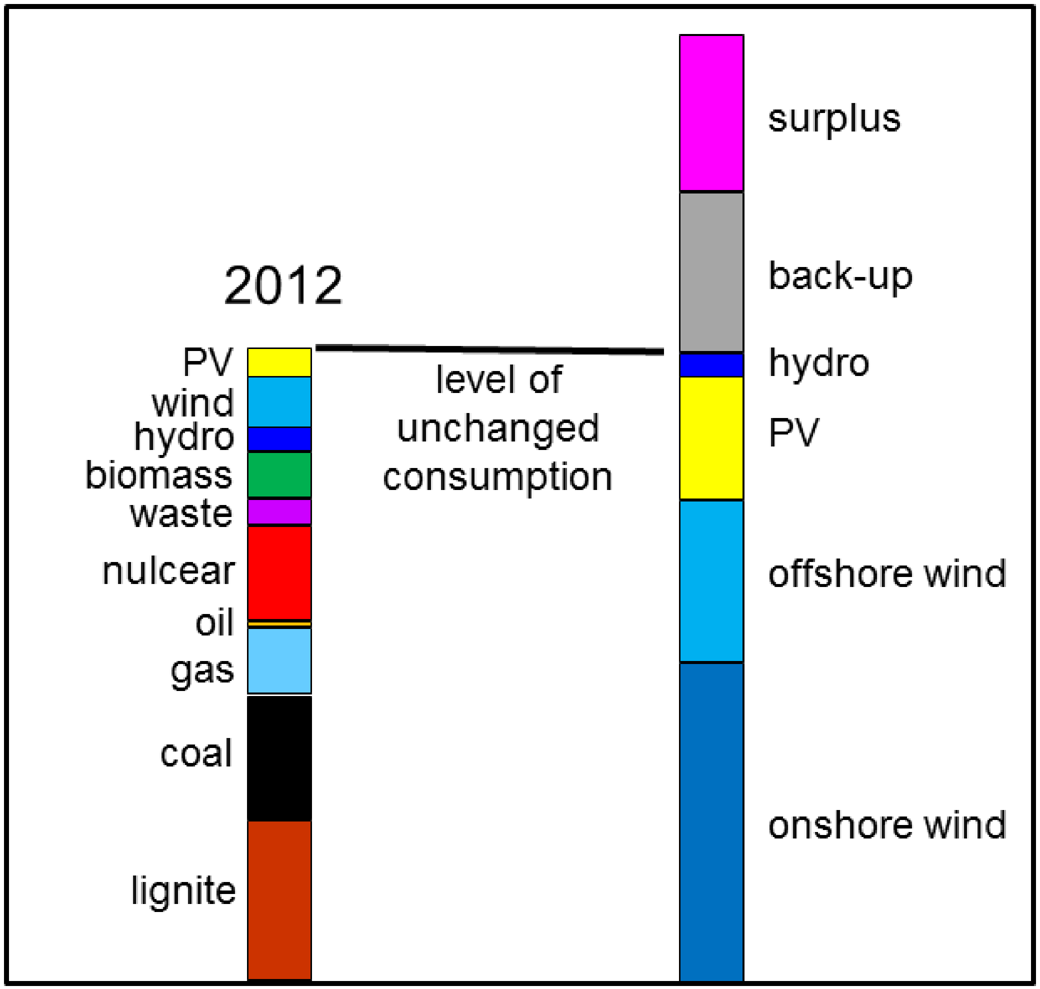
Electricity by Intermittent Sources

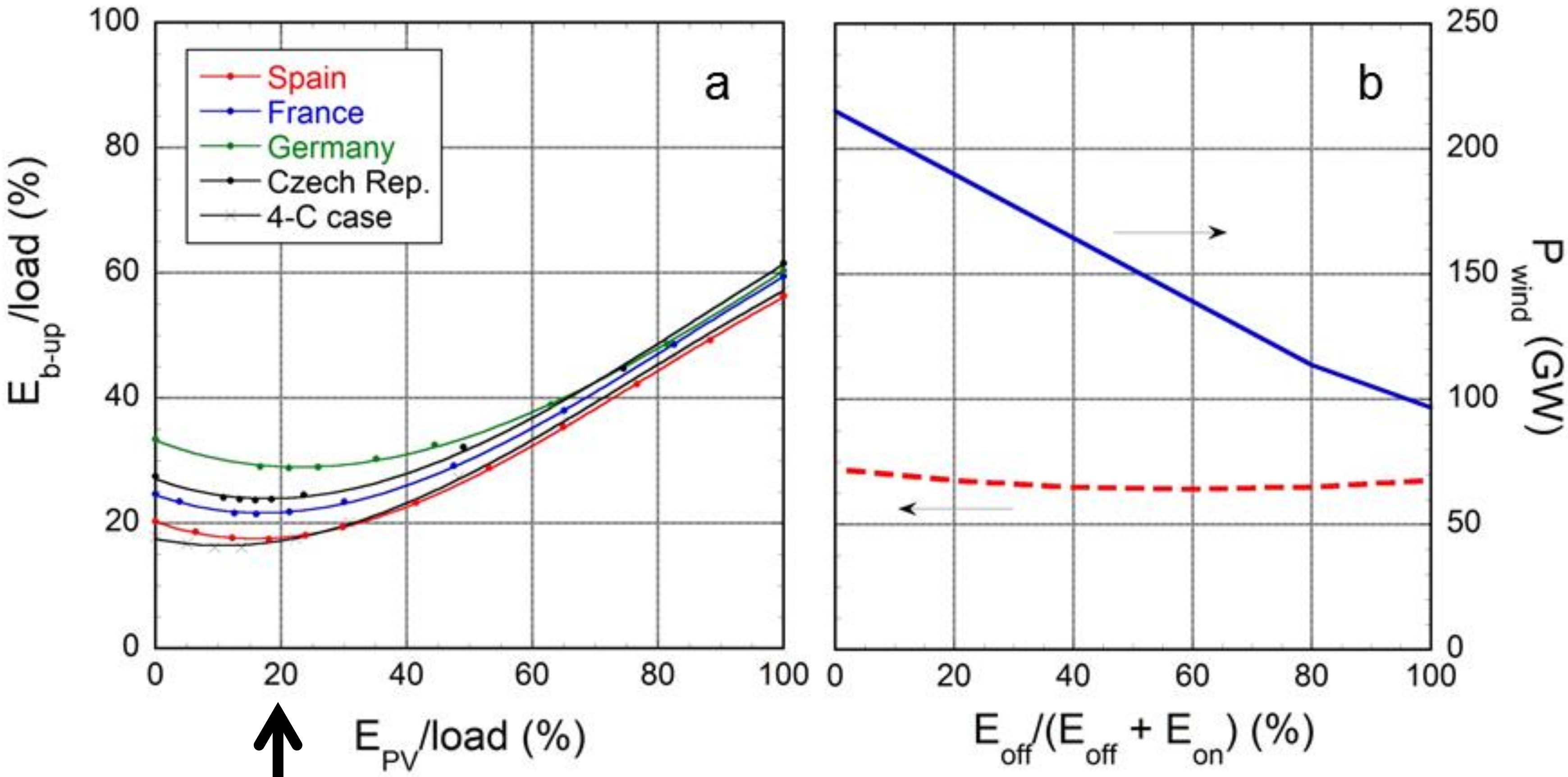
F. Wagner, IPP Greifswald

Supply by electricity – today and in the future



Mix between wind and PV, onshore and offshore wind

load = annual consumption



optimal mix

Method and assumptions

Method:

Take load-, wind-, PV-… data from 2012 and scale the intermittent RES to higher capacities (e.g. to the **100% case**)

Assumptions:

no savings in electricity consumption
hydro remains the same, subtracted from load → **reduced load**
no nuclear power
no biogas
no losses

Topics:

How much power has to be installed?
The remaining need for back-up power?
The extent of surplus energy?
Dimension of storage?
The dynamics of the back-up system?
The conditions for DSM (demand-side management)?

The amount of CO2 reduction?
Conditions of a 100% supply by RES?
What could be a reasonable share by intermittent RES?
The benefits of an EU-wide use of RES
Costs of RES?

Major Results

How much power has to be installed?
Enough to serve Europe in good days

The remaining need for back-up power?
88%

The extent of surplus energy?
Formally enough to serve Poland

Dimension of storage?
For the 100% case: 660 x present capacity

The dynamics of the back-up system?
From 0 up to the load; strong gradients

The conditions for DSM (demand-side management)?
Cheap electricity prices during the day

The amount of CO_2 reduction?
Not to the level of France, Sweden...

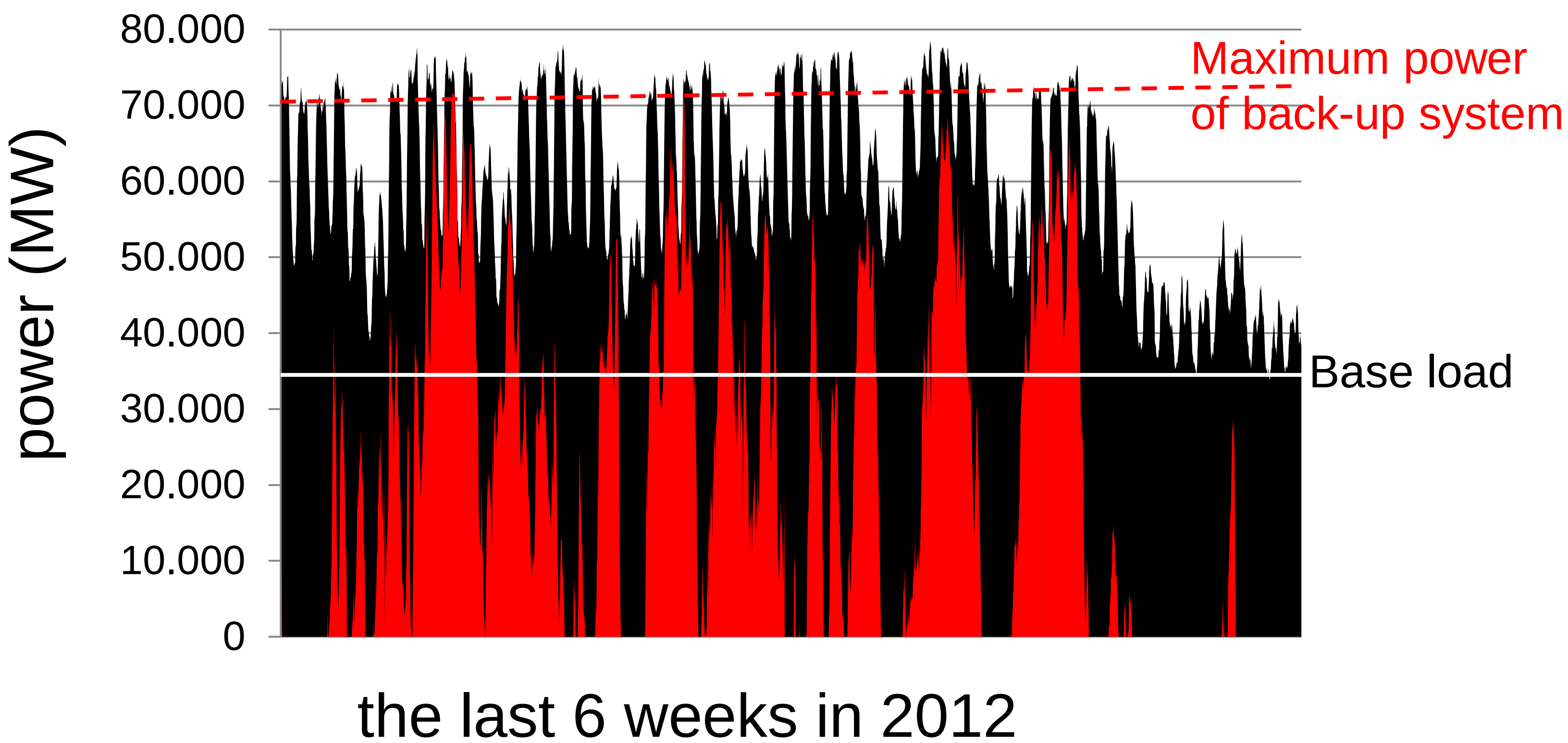
Conditions of a 100% supply by RES?
Use of biogas (e.g. 40 TWh) and savings (down to 30%)

What could be a reasonable share by intermittent RES?
40%

The benefits of an EU-wide use of RES?
Effects in the order of 20-30%

Costs to implement RES?
high

Results in more detail: Back-up system



The power of the back-up system remains high

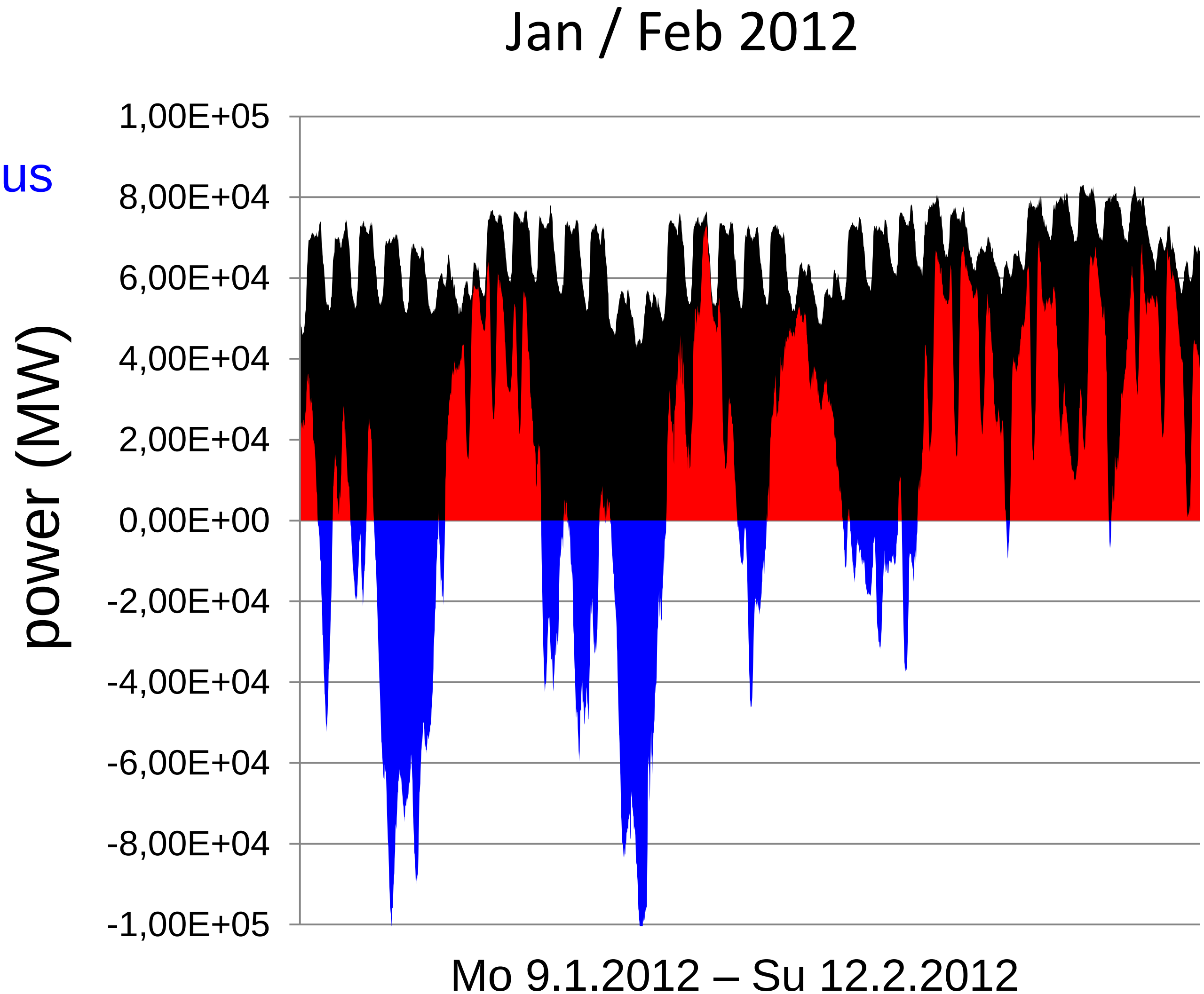
It has to meet the full dynamic range from 0 to nearly peak load

→ the power gradients increase strongly

Storage

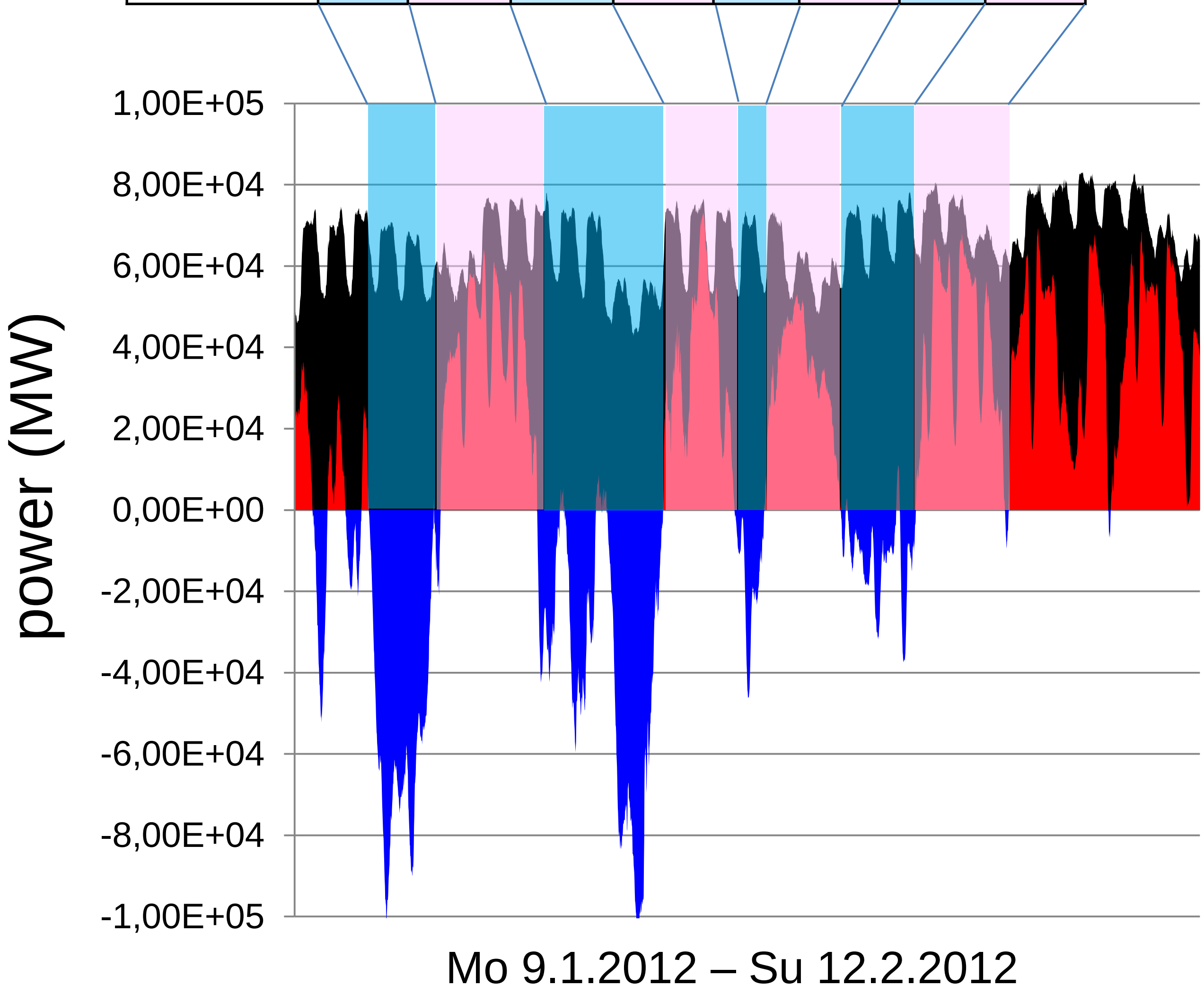
100%, optimal mix case

black: load
red: back-up
blue, negative: surplus



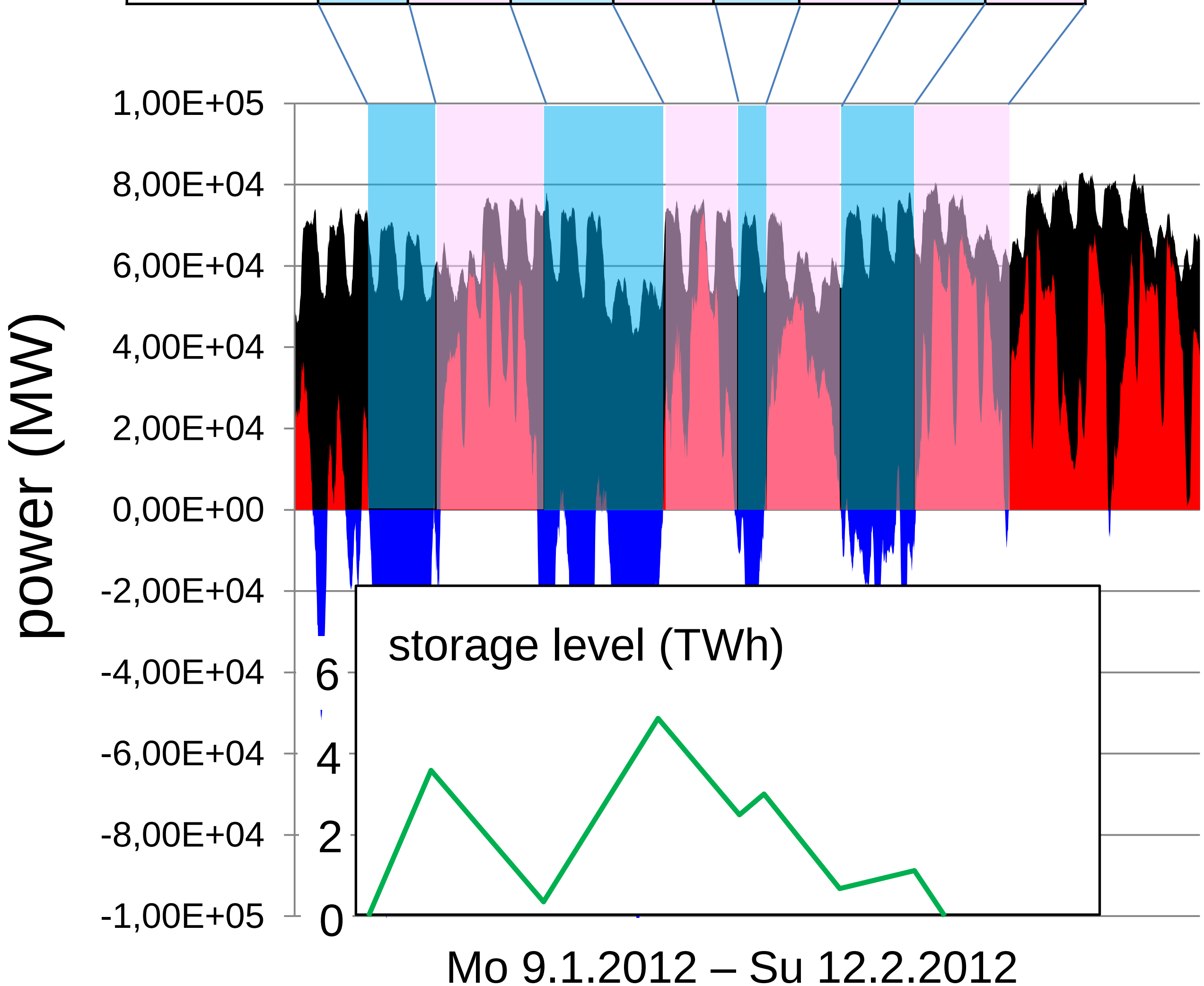
Storage

h	66	90	117	67	27	71	70	83
TWh	3.7	-3.5	4.5	-2.5	0.5	-2.4	0.8	-3.4



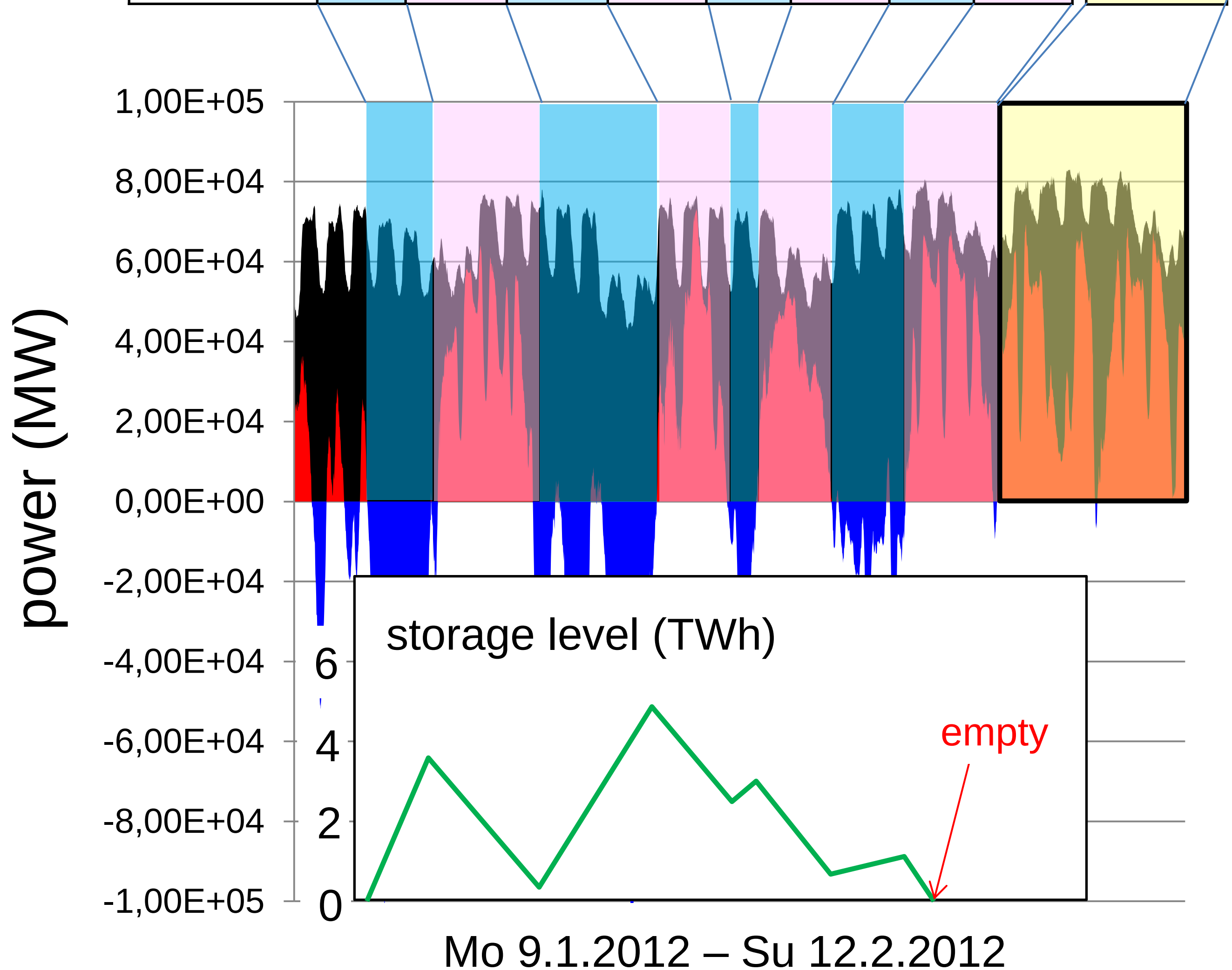
Storage

h	66	90	117	67	27	71	70	83
TWh	3.7	-3.5	4.5	-2.5	0.5	-2.4	0.8	-3.4



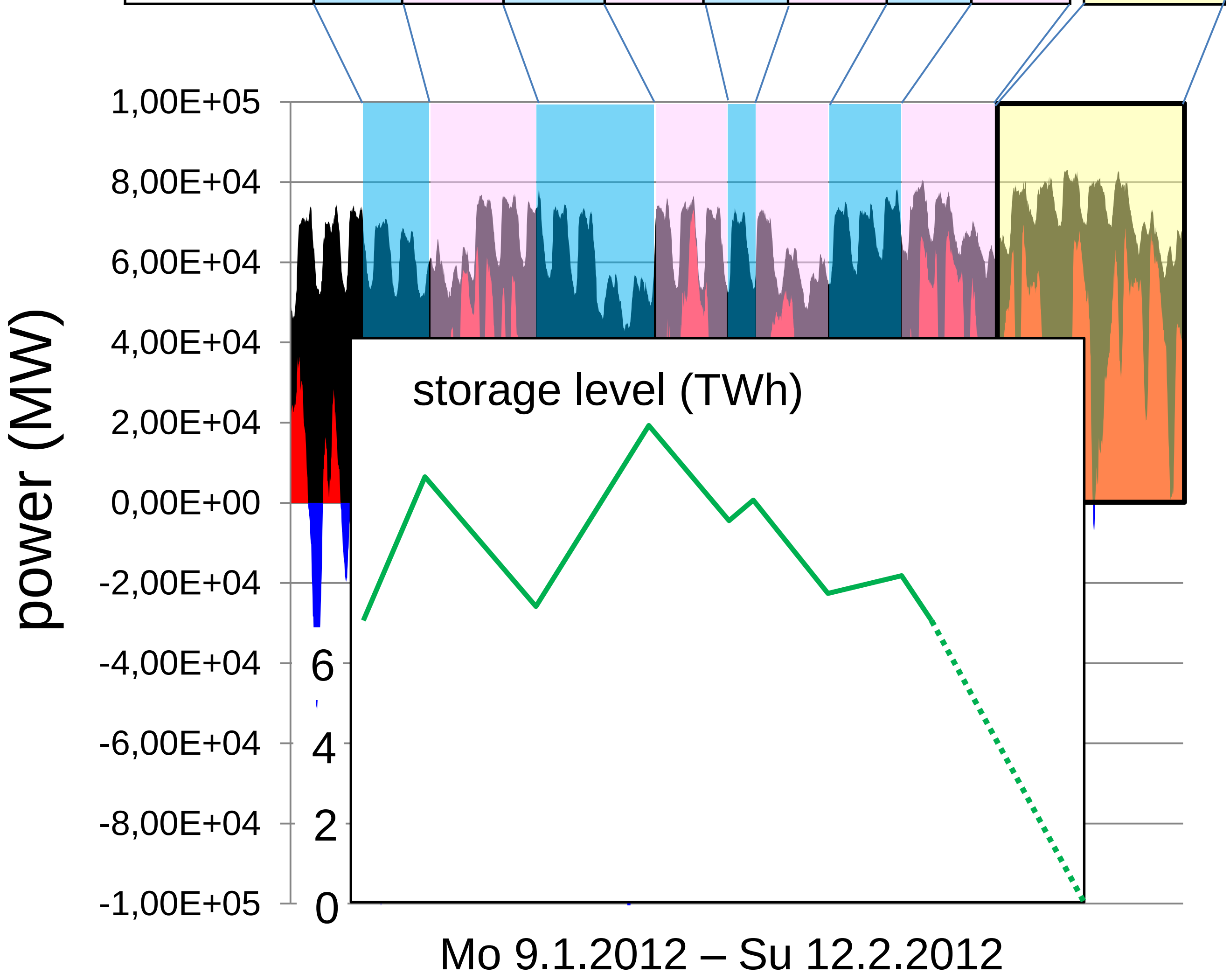
Storage

h	66	90	117	67	27	71	70	83	**181**
TWh	3.7	-3.5	4.5	-2.5	0.5	-2,4	0.8	-3.4	**-7.1**



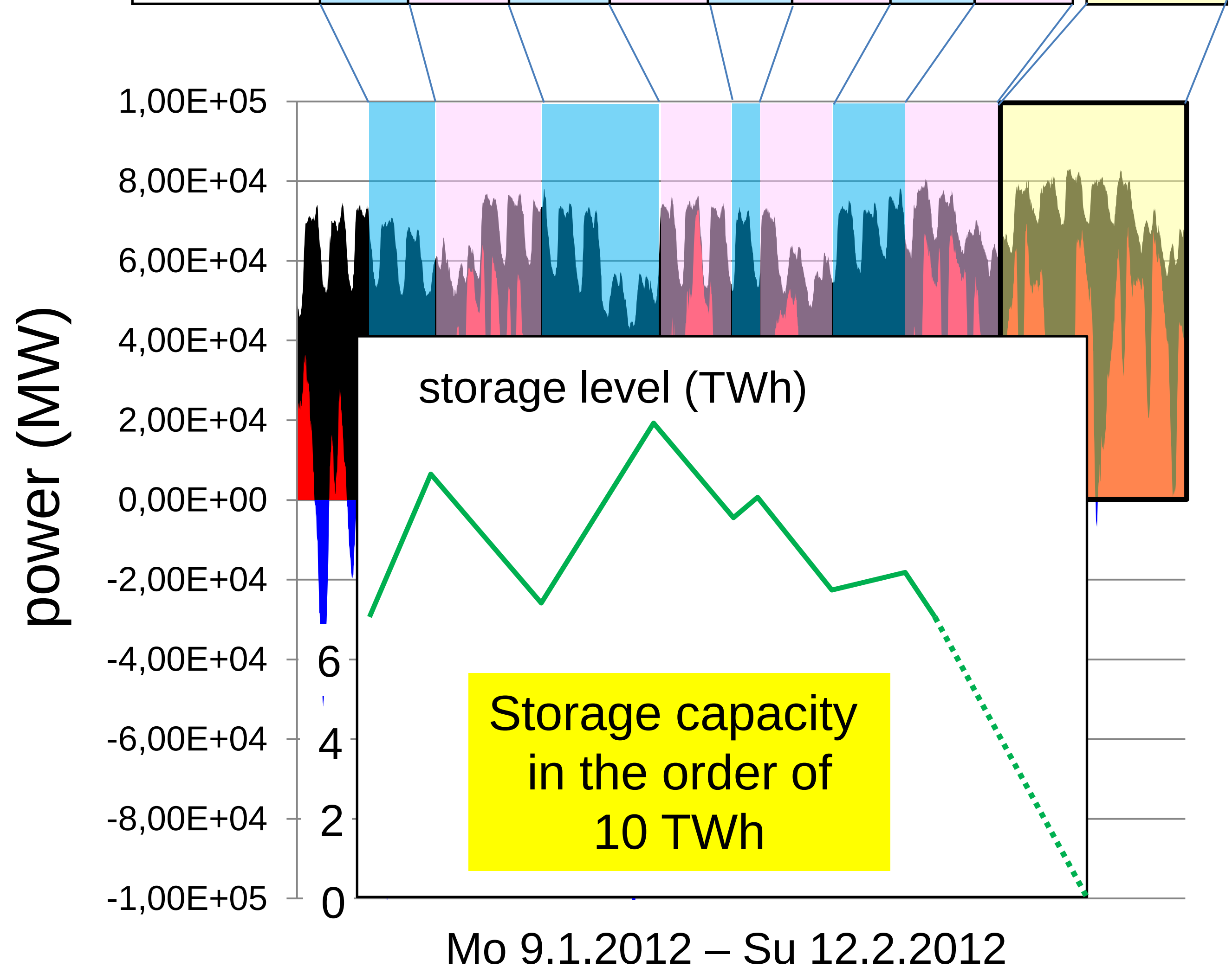
Storage

h	66	90	117	67	27	71	70	83	**181**
TWh	3.7	-3.5	4.5	-2.5	0.5	-2,4	0.8	-3.4	**-7.1**



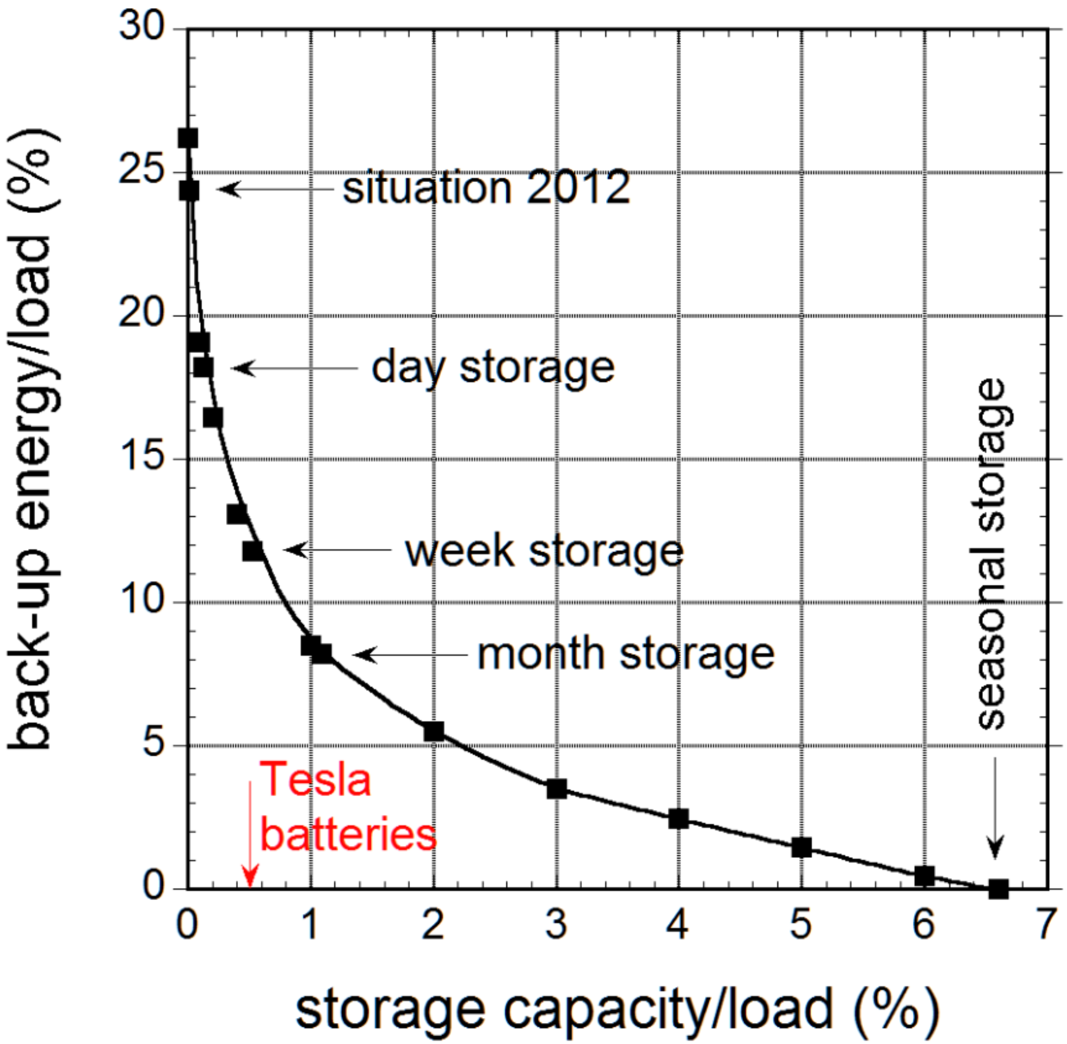
Storage

h	66	90	117	67	27	71	70	83	**181**
TWh	3.7	-3.5	4.5	-2.5	0.5	-2,4	0.8	-3.4	**-7.1**



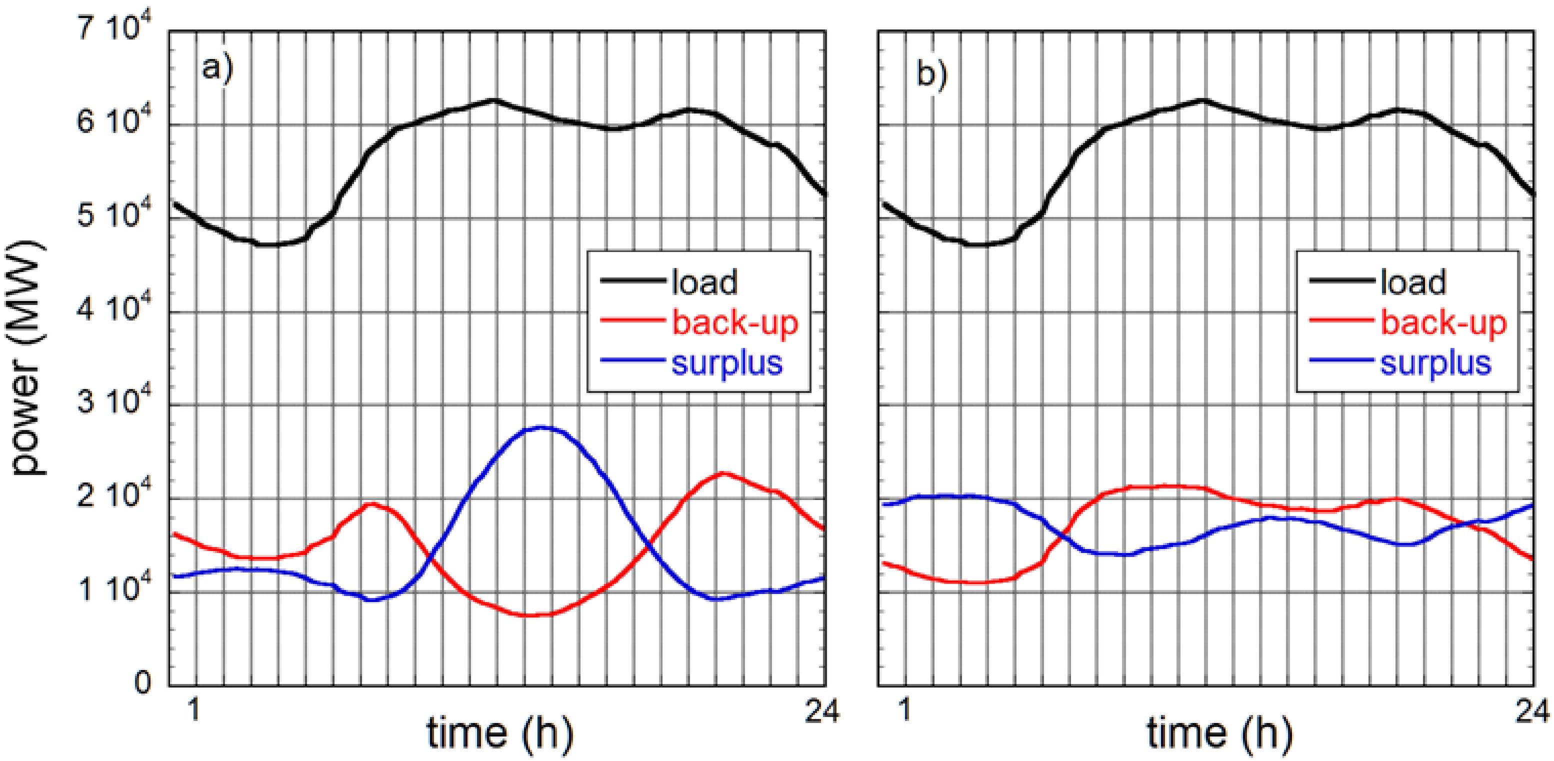
Storage

Need from back-up depending on storage capacity

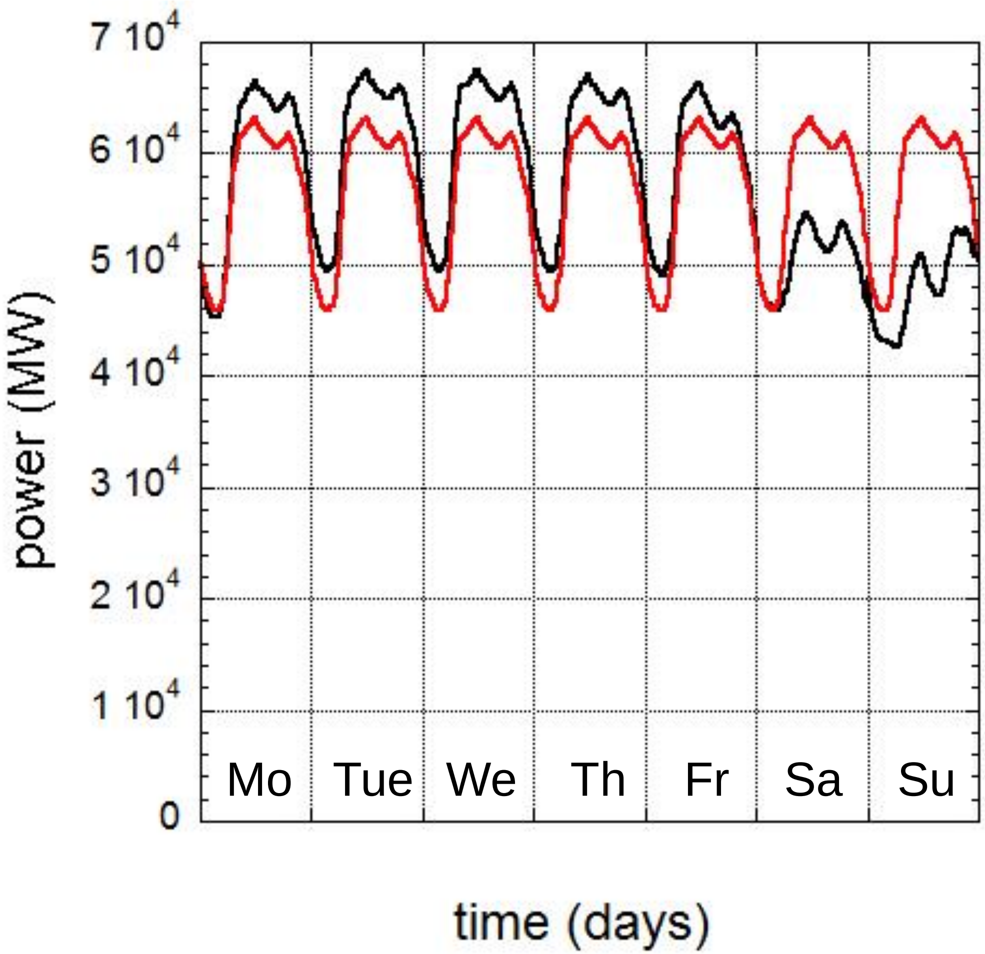


Demand-side-management

100%, optimal mix case



Demand-side-management: use of weekends



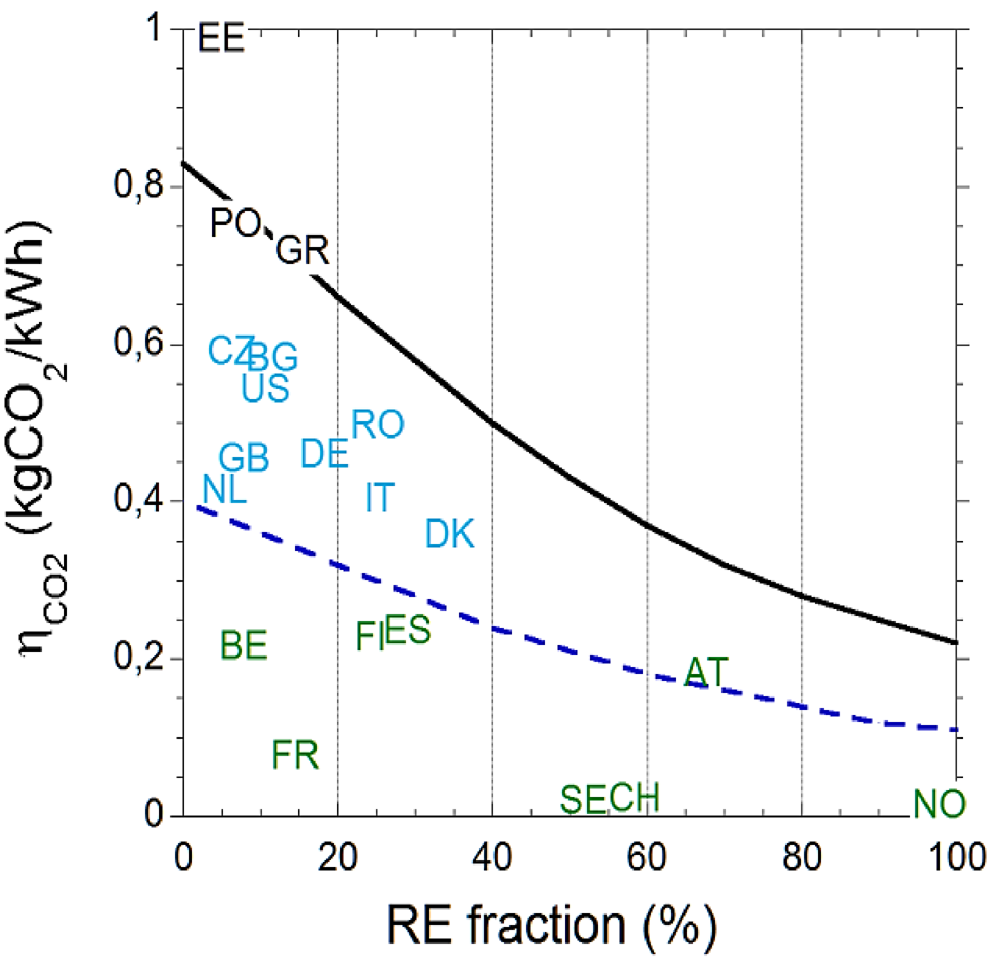
Full integration of weekends:

Additional use of RE: 7.9 TWh

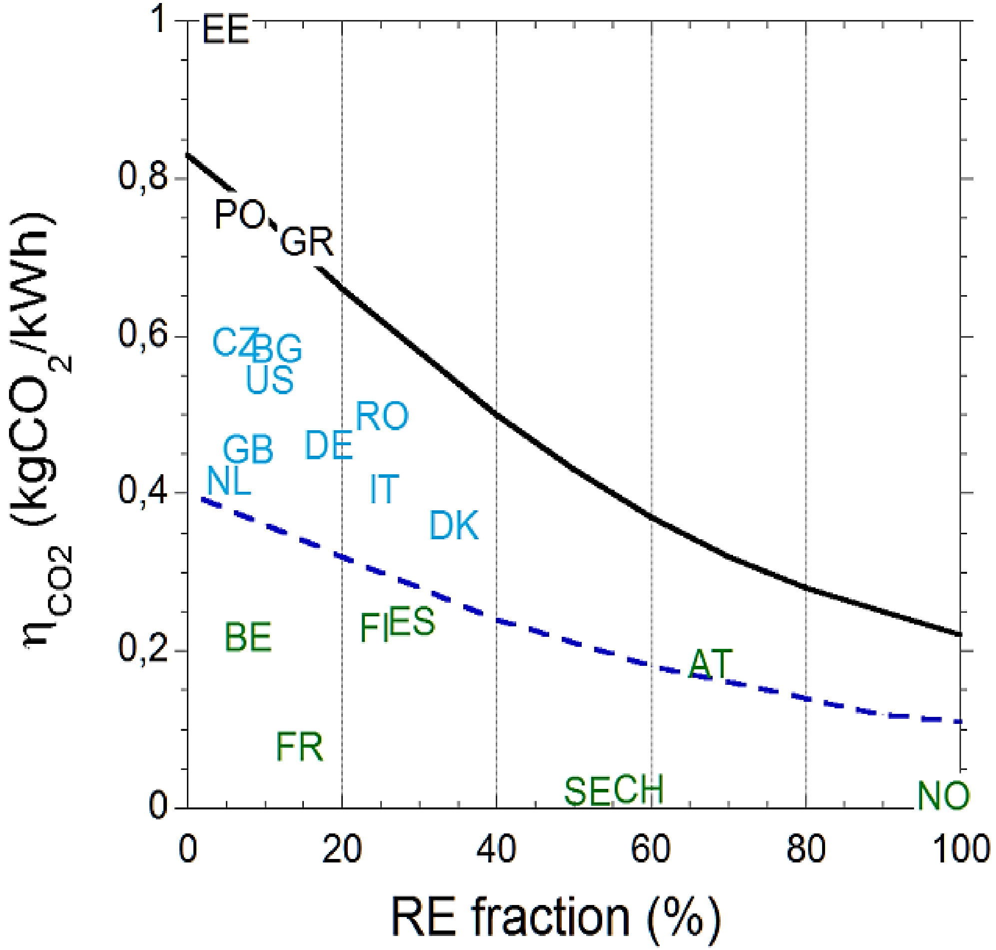
Peak-load: 83 → 63 GW

Reduction of back-up system:
131 → 123 TWh

Specific CO2 emission



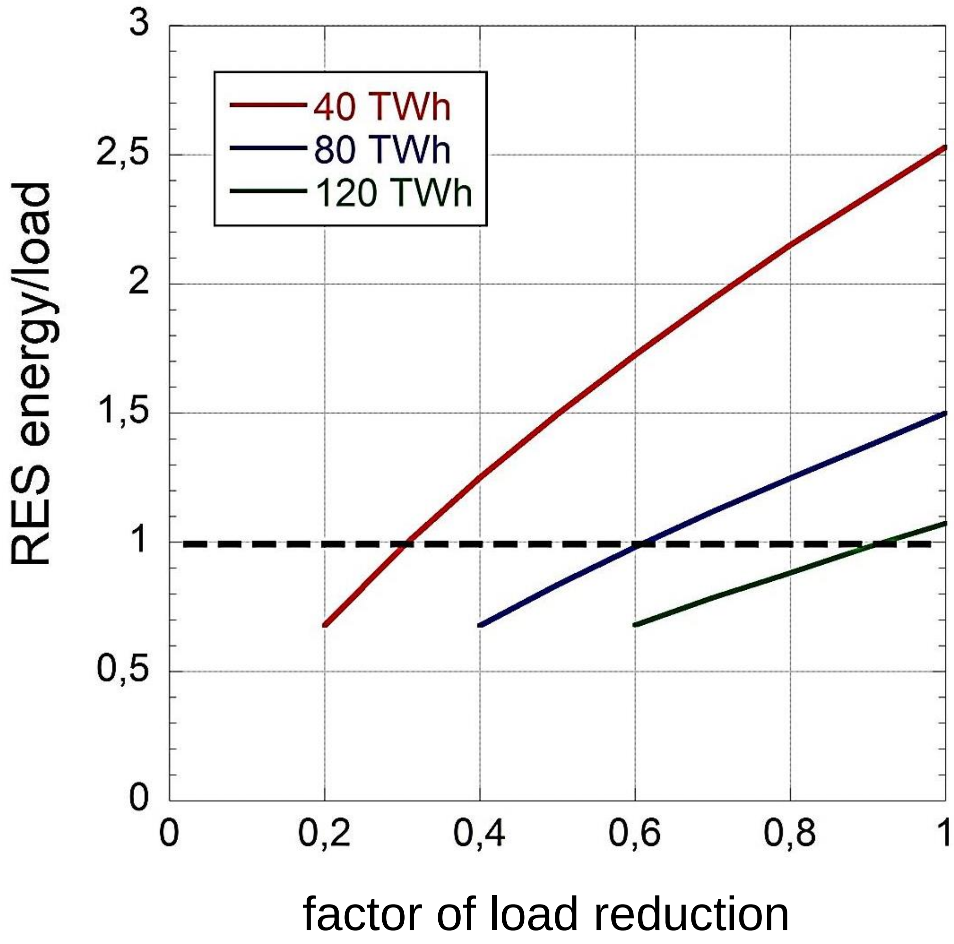
Specific CO2 emission



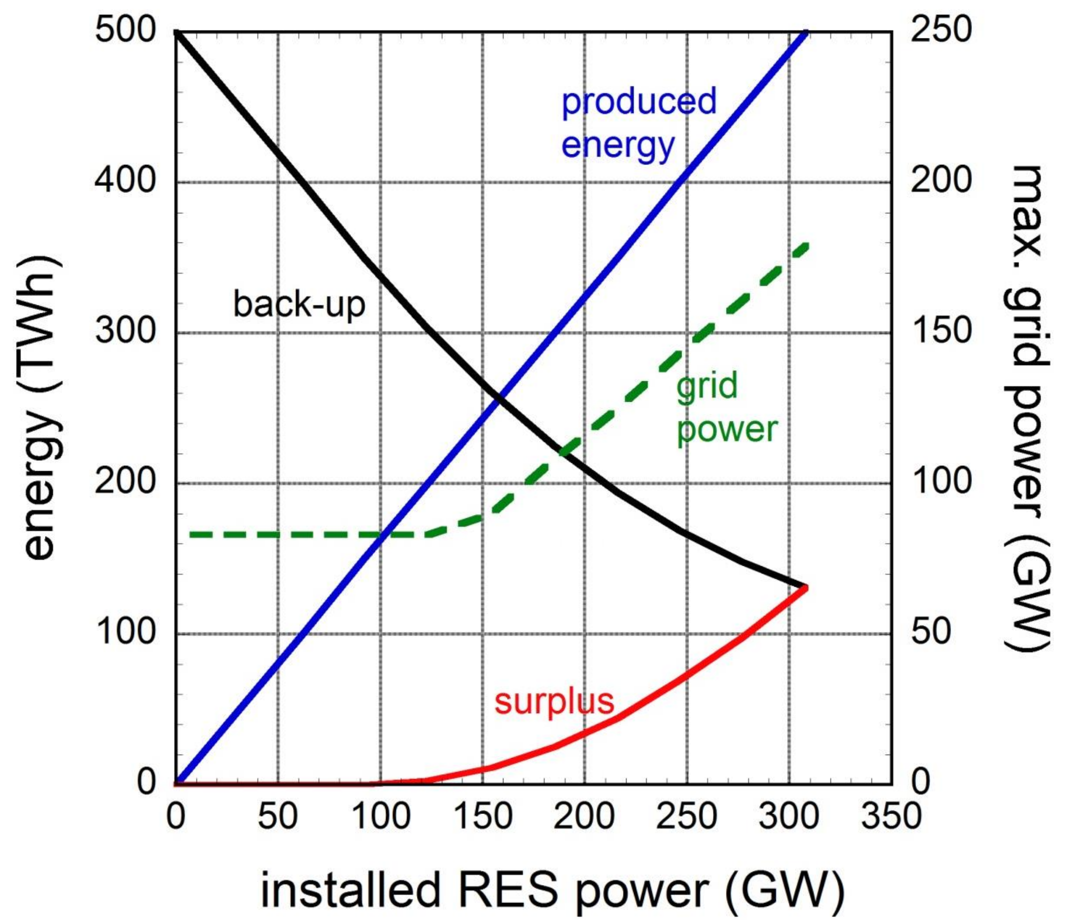
Countries with hydro + nuclear are already there where others would like to be in 2050

Conditions of a 100% supply by RES

Main knobs: savings/efficiency + use of biomass
Minor knobs: decrease of population, import (depatchable power), geo-th-power



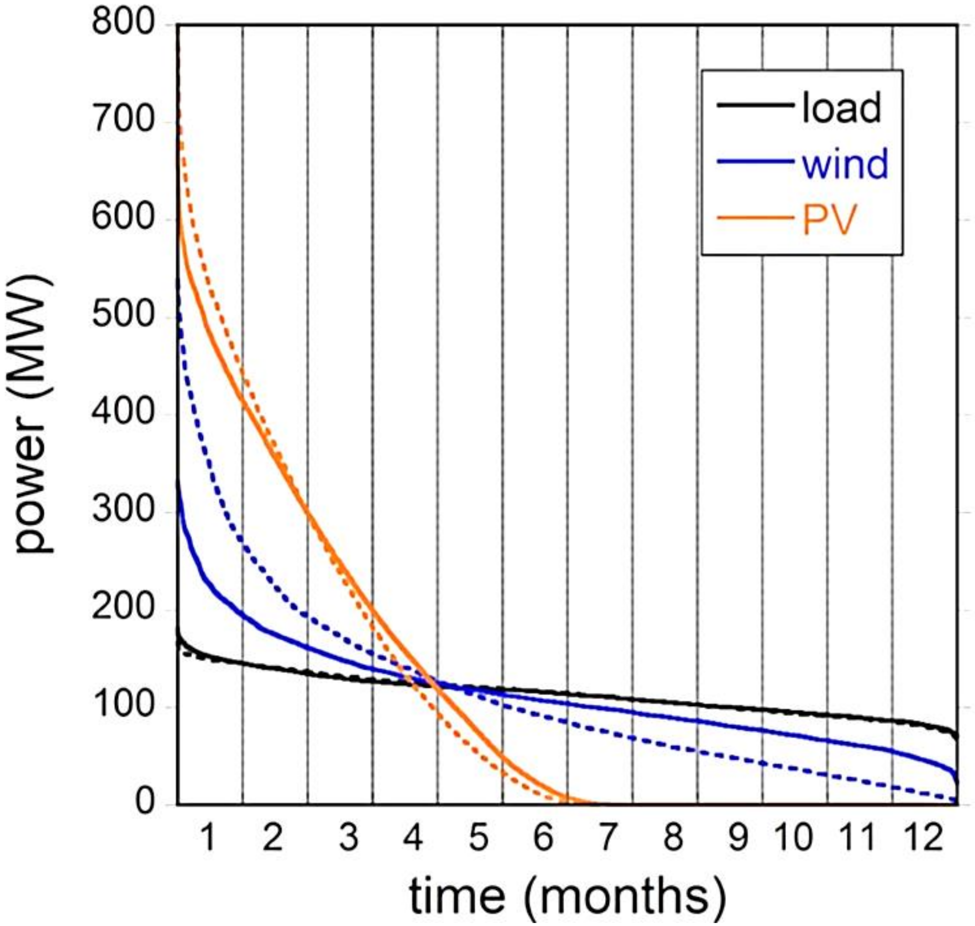
Possible contribution by intermittent sources



possible limit

Benefit from an EU-wide RES field

Annual duration curves for German RES field (**dashed**) and EU-wide RES field



The benefit

the back-up energy is reduced by 24%,

the maximal back-up power by 9%,

the maximal surplus power by 15%,

the maximal grid power by 7%,

the typical grid fluctuation level by 35%

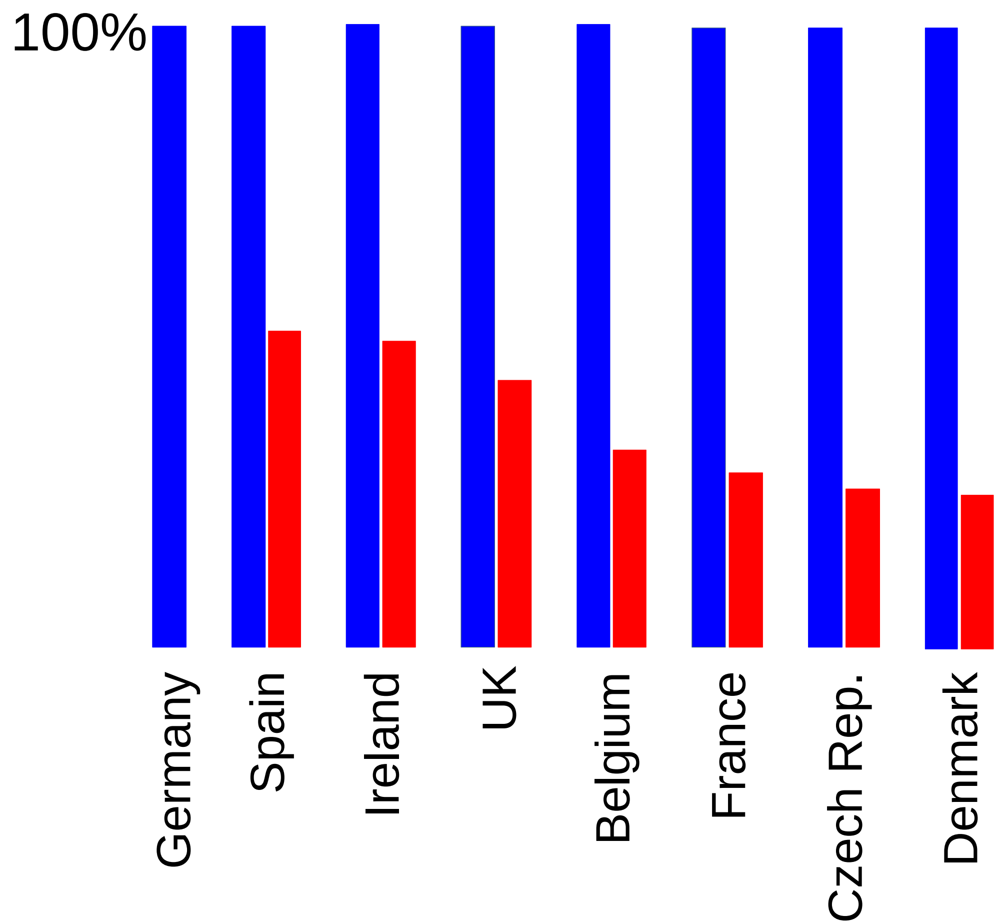
the maximal storage capacity by 28%

The structure of the EU-wind field

Correlation coefficients

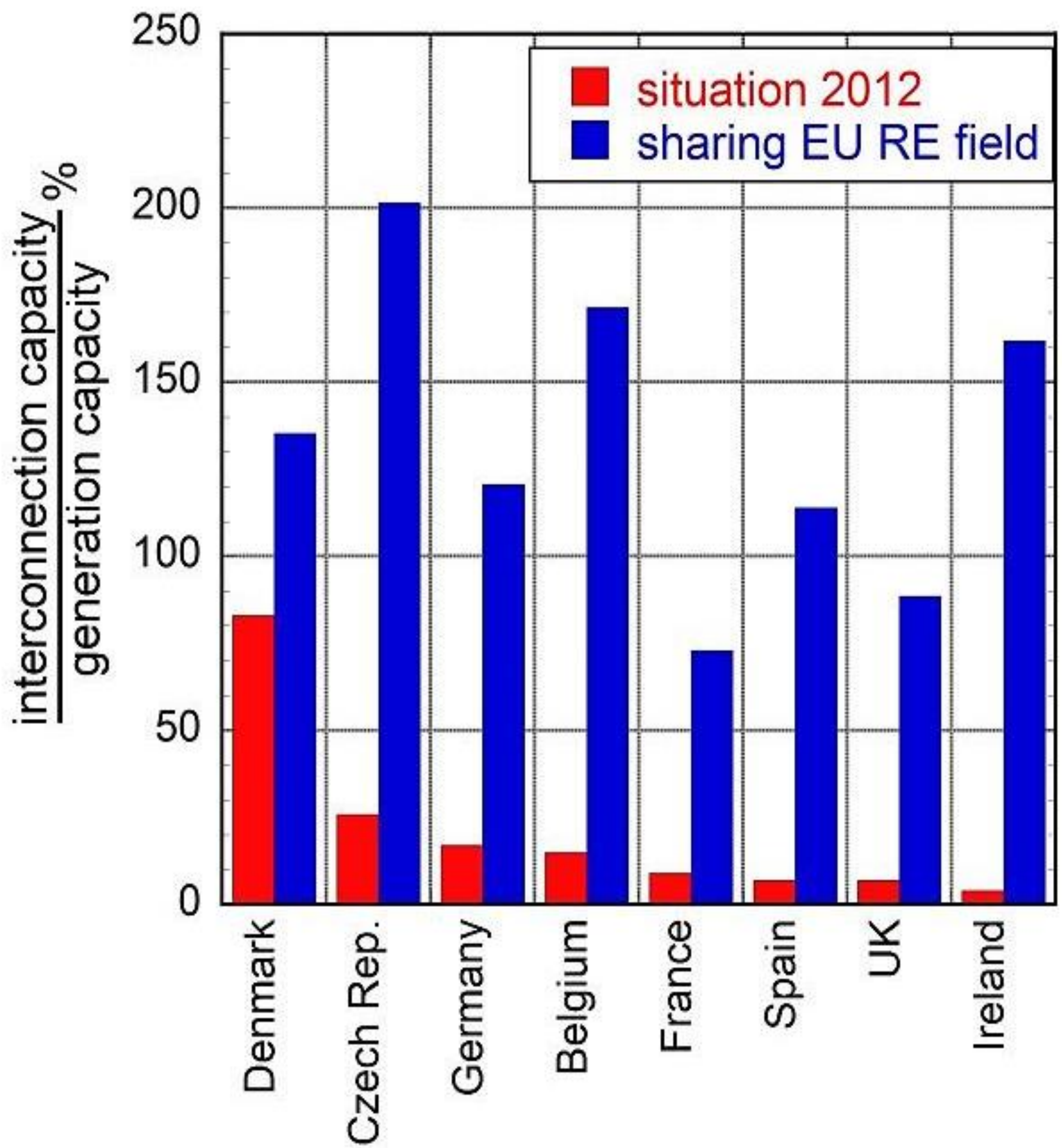
Pair of countries	R
Germany-Denmark	0.56
Germany-Czech Rep.	0.53
Germany-France	0.45
Germany-UK	0.40
Germany-Belgium	0.39
Germany-Sweden	0.37
Germany-Ireland	0.19
Germany-Spain	0.05

normalised surplus
and
„useful“ surplus

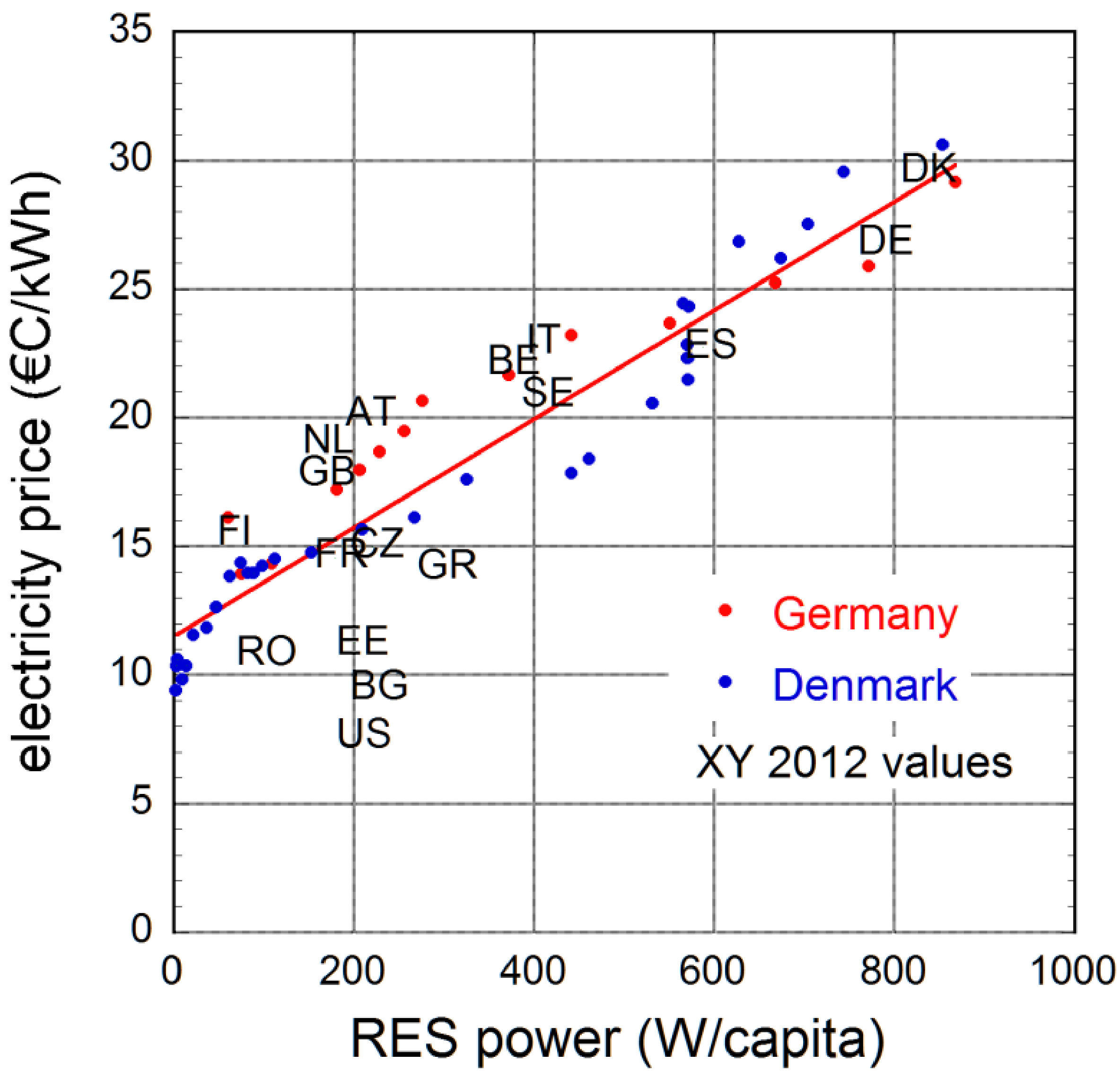


In case of surplus – simultaneously also By the neighbours

Interconnector capacity

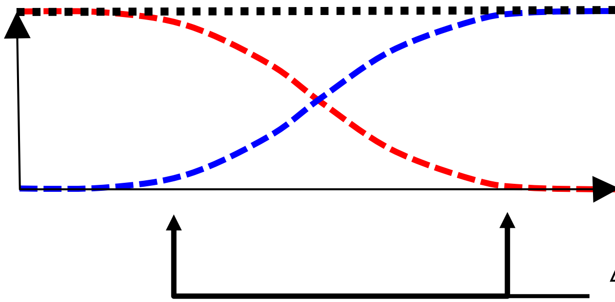


Development costs



Source: F. Wagner Finadvice

The German „Energiewende“



Δt: costs

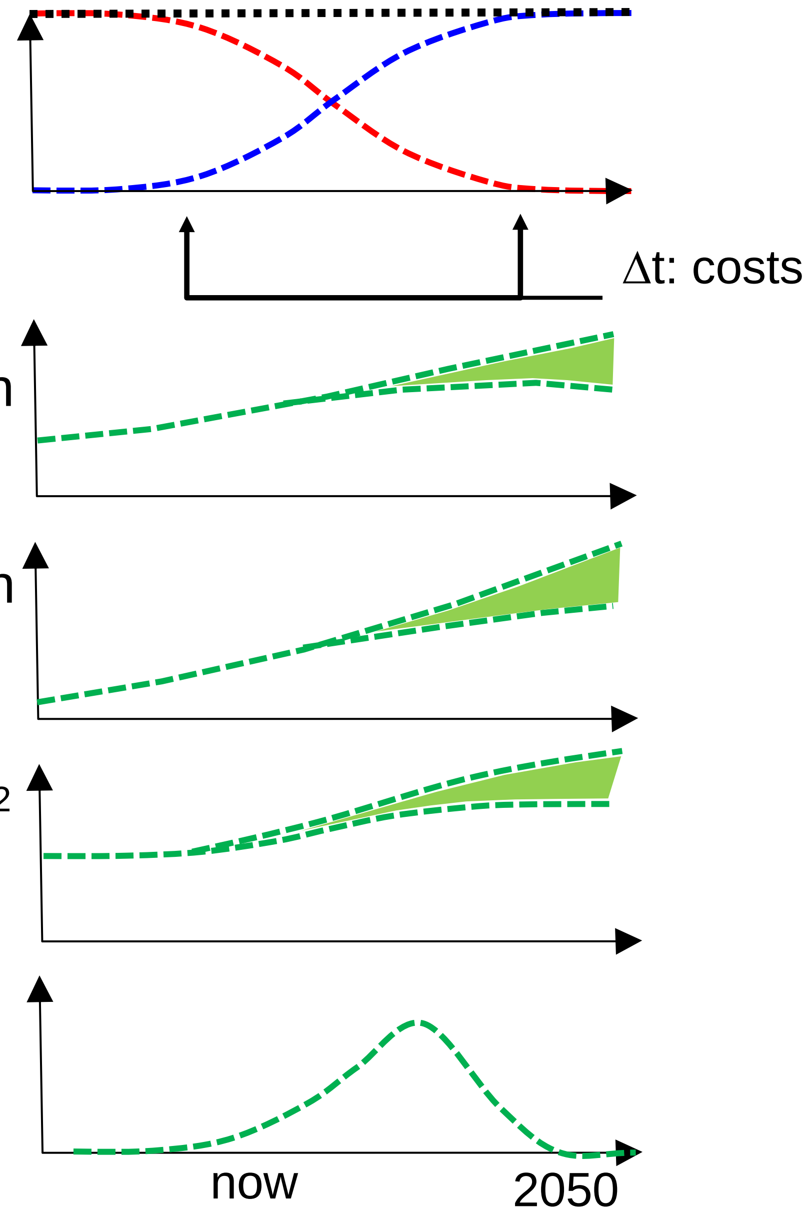
One has to discriminate between

the aims

and the selected route

The German „Energiewende“

from red: fossil, nuclear
to blue: wind, PV



Along the way:

Increase in world population

Increase in energy consumption

Increase of CO_2

Other issues:

- Oil-peak
- Economic disparities
- Politically caused shortages
- Destruction of supply infrastructure
- Breakthroughs in new technologies

The German „Energiewende“

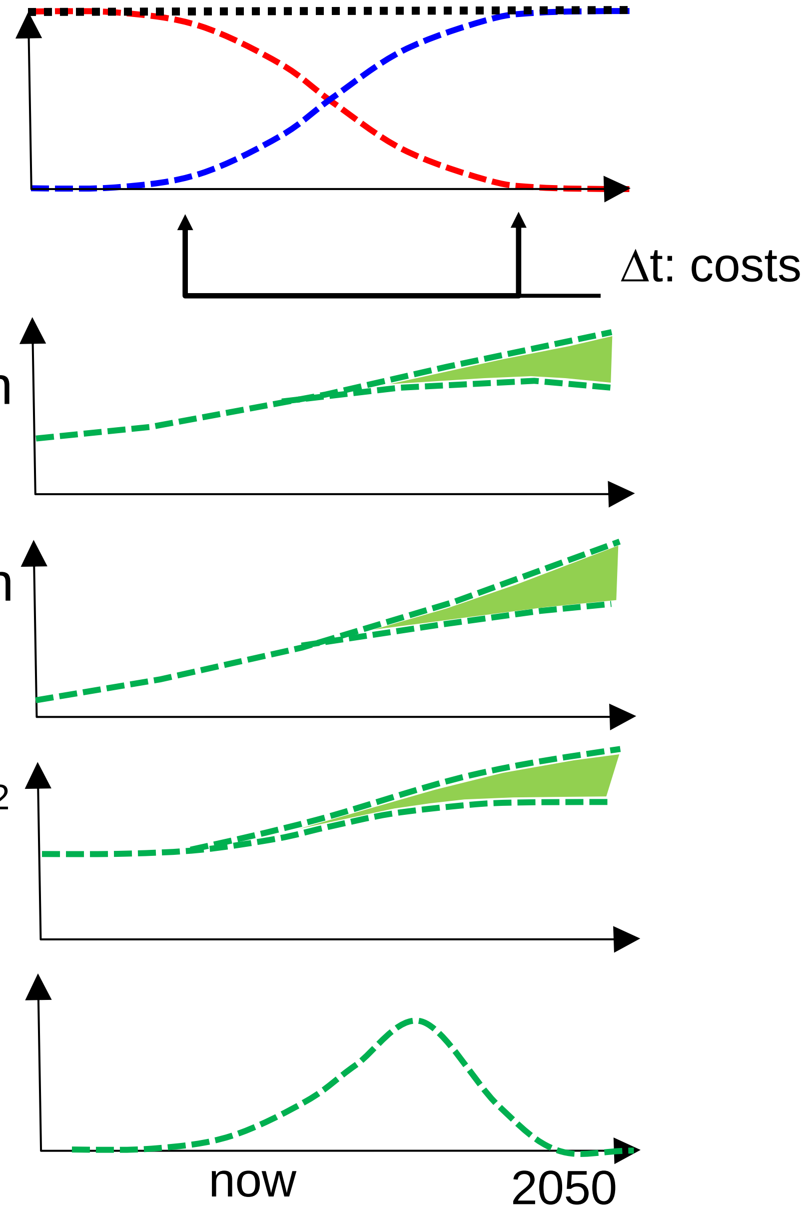
from red: fossil, nuclear
to blue: wind, PV

Along the way:

Increase in world population

Increase in energy consumption

Increase of CO_2



Keep all options open !