Can flexible power generation from biomass complement the fluctuating feed-in from wind and solar power?

Results from a case study in Germany

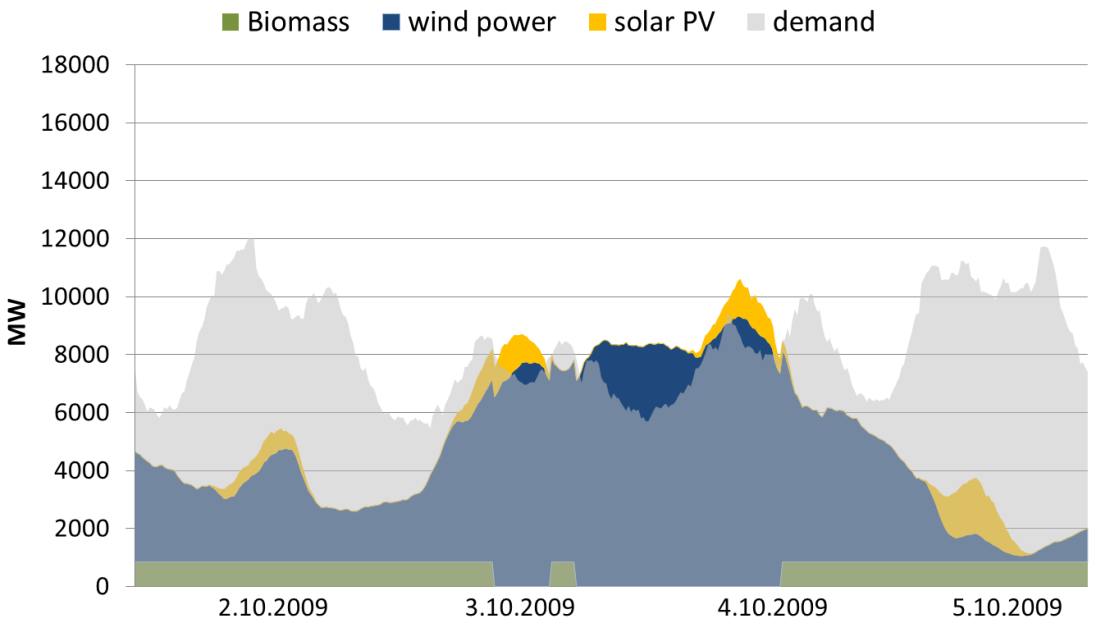
Philip Tafarte
Department Bioenergy (BEN)
Helmholtz Centre for Environmental Research – UFZ

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Introduction

Principal challenge in using renewables in power systems in Germany

<u>Temporal variability</u> of major renewable sources (wind/solar) (intermittent, stochastic, not fully predictable and dependable "variable Renewable Energy Sources (vRES)")



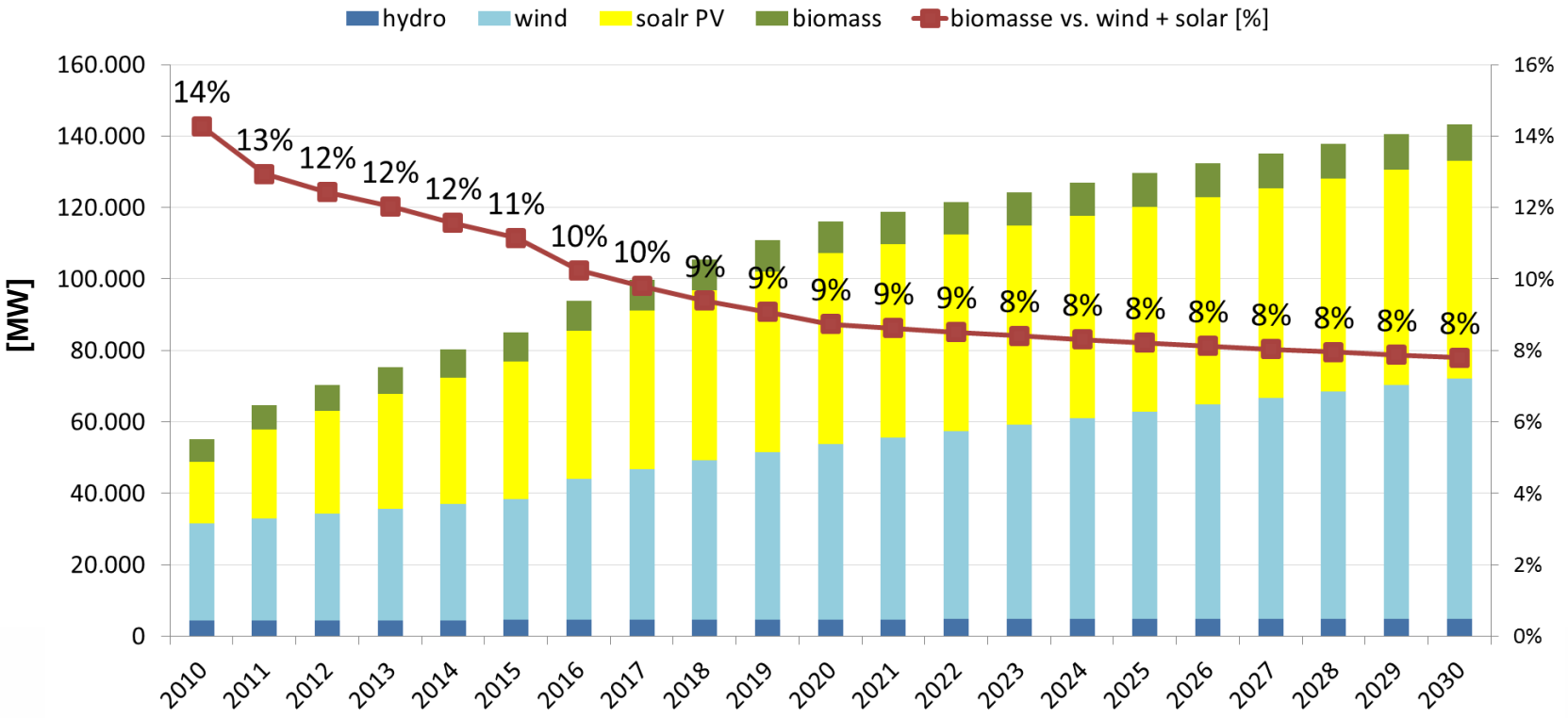
Tafarte, Philip, et. al. (2014): "Small adaptations, big impacts: Options for an optimized mix of variable renewable energy sources", Energy.

Figure modified after: Tafarte, Philip, et. al. (2014): "Small adaptations, big impacts: Options for an optimized mix of variable renewable energy sources", Energy

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ in cooperation with DBFZ

Bioenergy in the energy matrix

Projected REN capacity development in Germany 2010-30

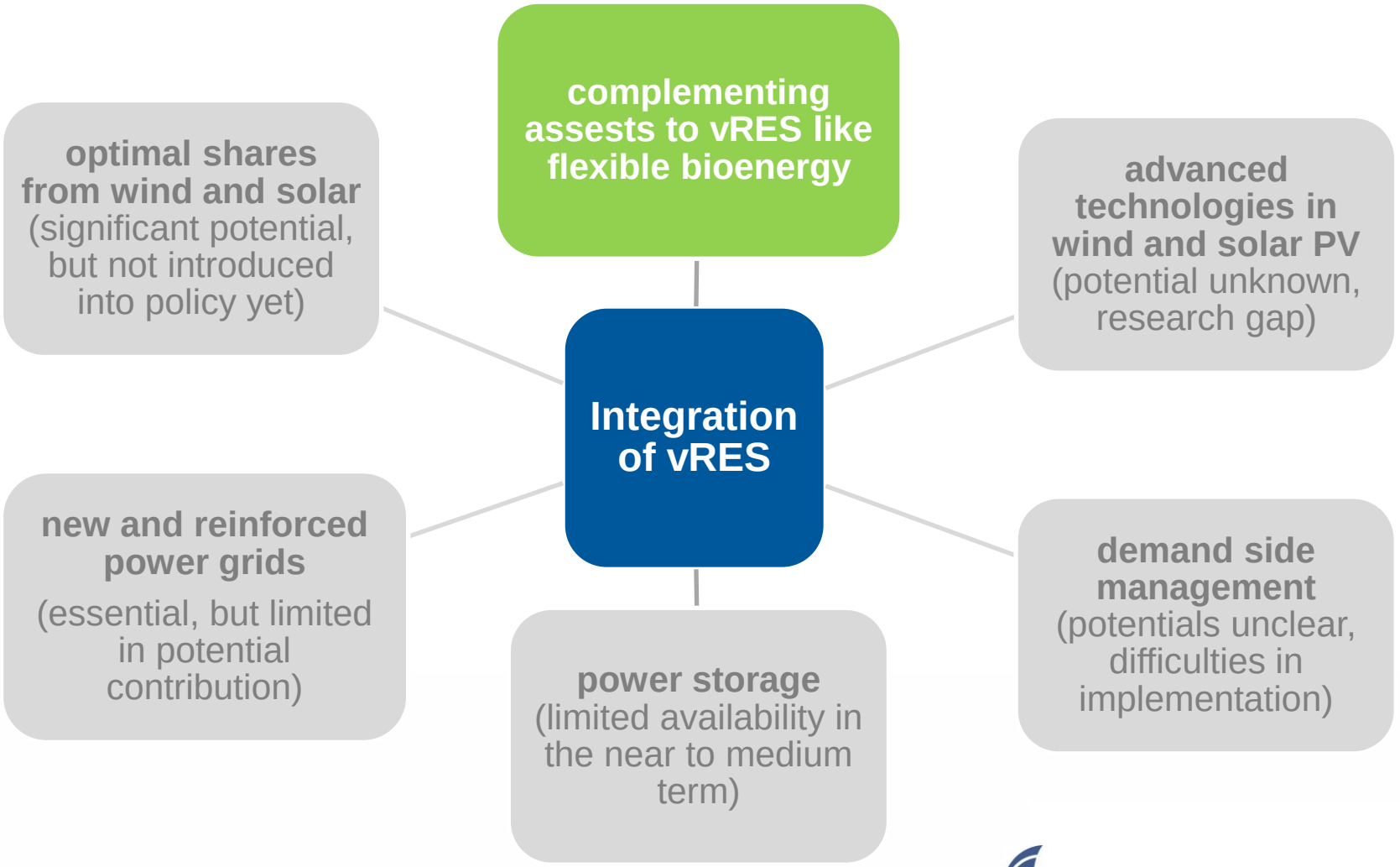


Data source: Nitsch J, Pregger T, Scholz Y, Naegler T, Sterner M, Gerhardt N, et al. Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global - „Leitstudie 2010“ . Stuttgart, Kassel, Teltow: Deutsches Zentrum für luft und Raumfahrt (DLR), Fraunhofer Institut für Windenergie und Energiesystemtechnik (IWES), Ingenieurbüro für neue Energien (IFNE); 2010. p. 186 ff.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Options for the integration of vRES



HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

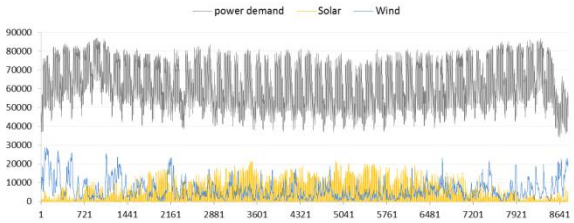
Case study region and data source

- **Case study region: 50Hertz Transmission grid area**
  equivalent to Eastern Germany + Hamburg

- **Data source**

  registered or recalculated time series data
  (15min time steps, 5 years from 2009-13)

  for
  - power consumption
  - power production from wind
  - power production from solar PV



- **Future feed-in and demand data is derived by scaling of historic time series in order to cover temporal variability**

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Modelling flexible bioenergy

- Modelling is performed on an aggregated level for the study area (not plant specific).

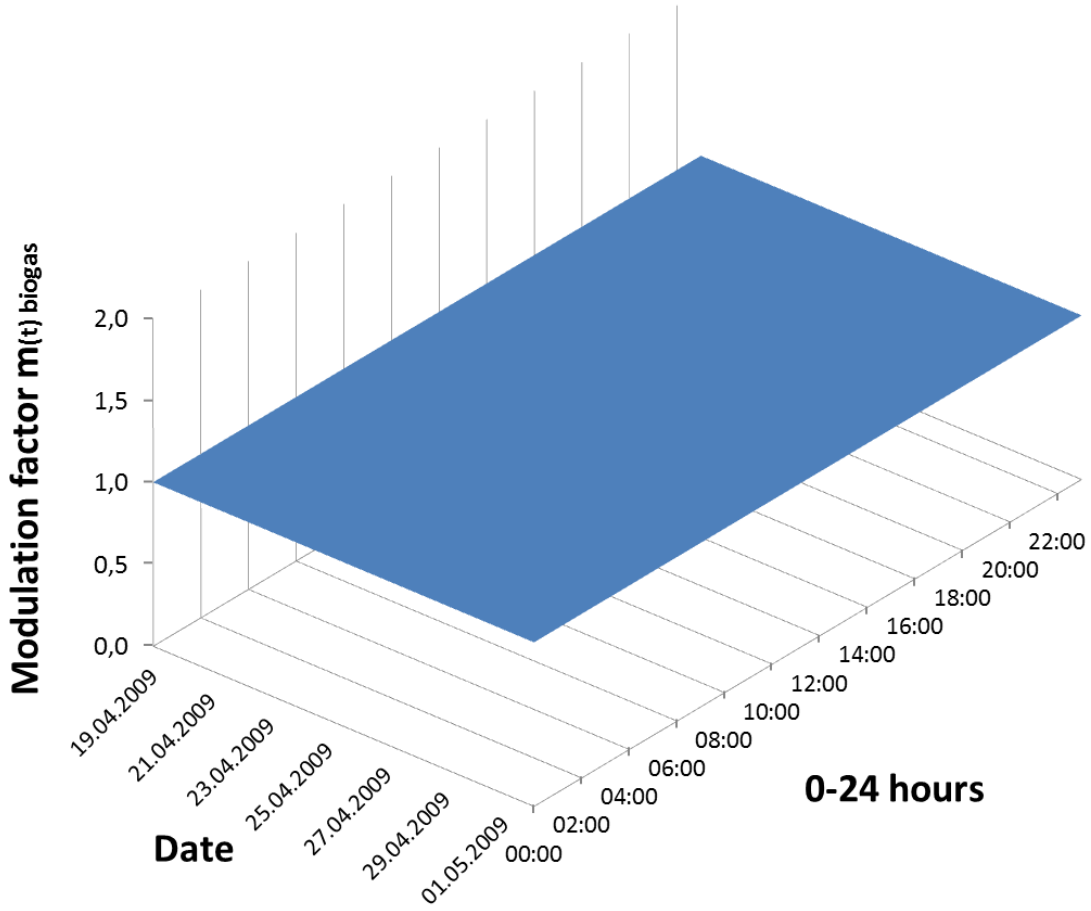
- Daily (24h) optimization in 1h time steps using time series data based on 2009-11 with projected capacities for wind and solar in 2030.

- Modelling state of the art flexibility concepts with modulation of power production for the aggregated bioenergy production ranging from
  - 0 - 2.0 for biogas plants (→doubling of generator set capacity and a maximum biogas storage of up to 24h)
  - 0 - 1.2 for solid biomass plants.

- Modulation is performed in order to reduce fluctuation in residual load in the study area, at the same time reducing excess / surplus power generation from renewables.

Flexible bioenergy to offset fluctuations

Modelling impact of demand driven and flexible biomass to offset residual load fluctuations



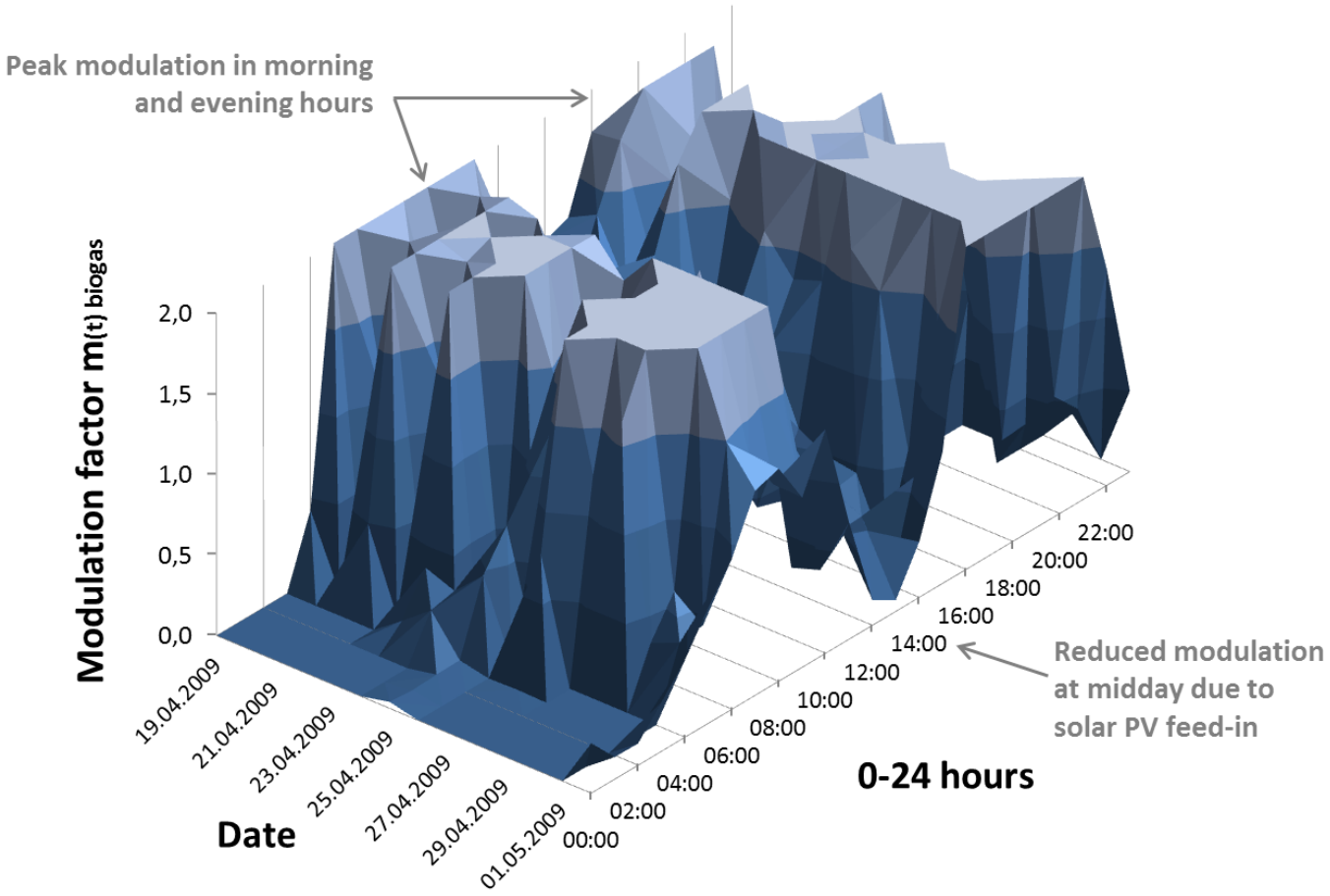
Figures taken from: Smart Bioenergy, Technologies and concepts for a more flexible bioenergy provision in future energy systems, expected for publication in 2015

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Flexible bioenergy to offset fluctuations

Modelling impact of demand driven and flexible biomass to offset residual load fluctuations

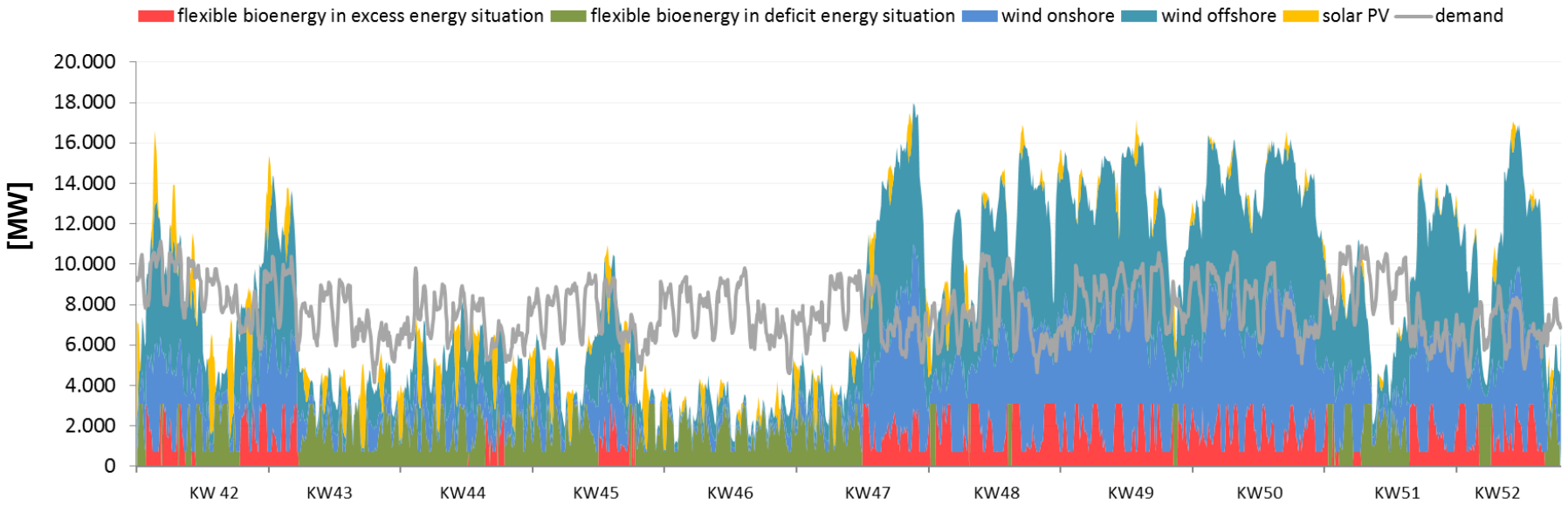


Figures taken from: Smart Bioenergy, Technologies and concepts for a more flexible bioenergy provision in future energy systems, expected for publication in 2015

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Flexible bioenergy to offset fluctuations

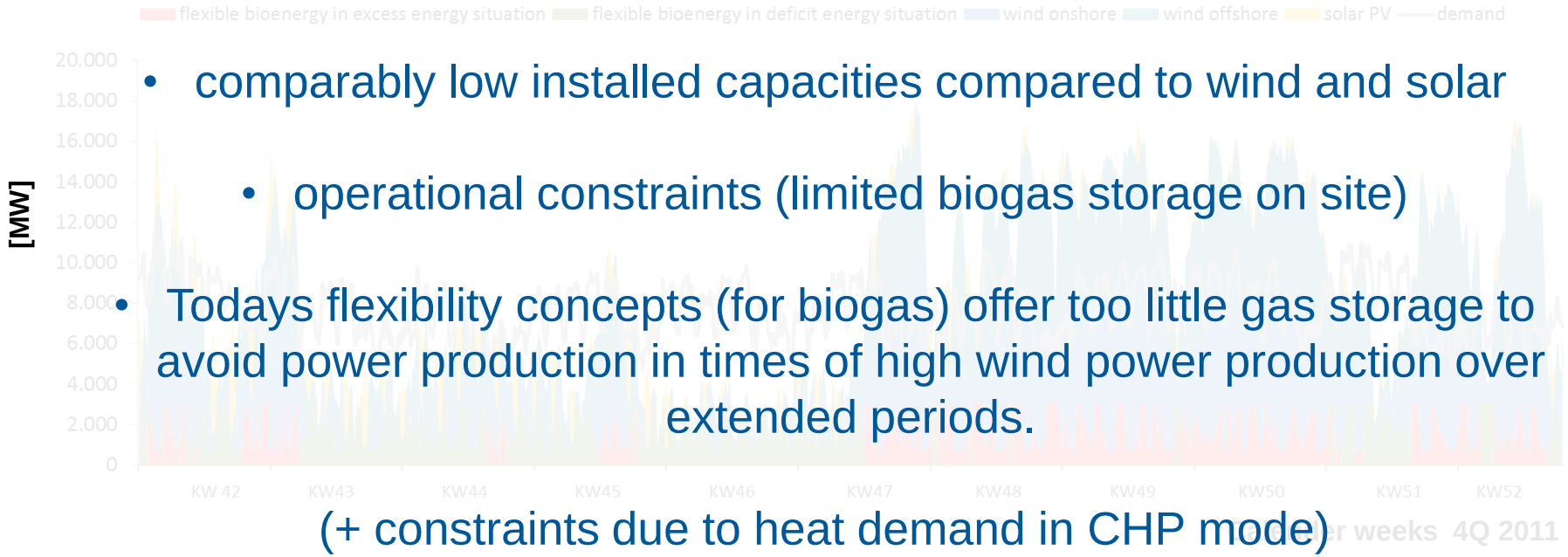


Data: time series data for demand and feed-in within the 50Hertz grid area; feed-in from wind and solar PV scaled to installed capacities expected for 2030 according to Leitstudie 2011 Flexible power generation from biomass modelled to minimize variances in residual load.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Flexible bioenergy to offset fluctuations



- comparably low installed capacities compared to wind and solar
  - operational constraints (limited biogas storage on site)
- Todays flexibility concepts (for biogas) offer too little gas storage to avoid power production in times of high wind power production over extended periods.

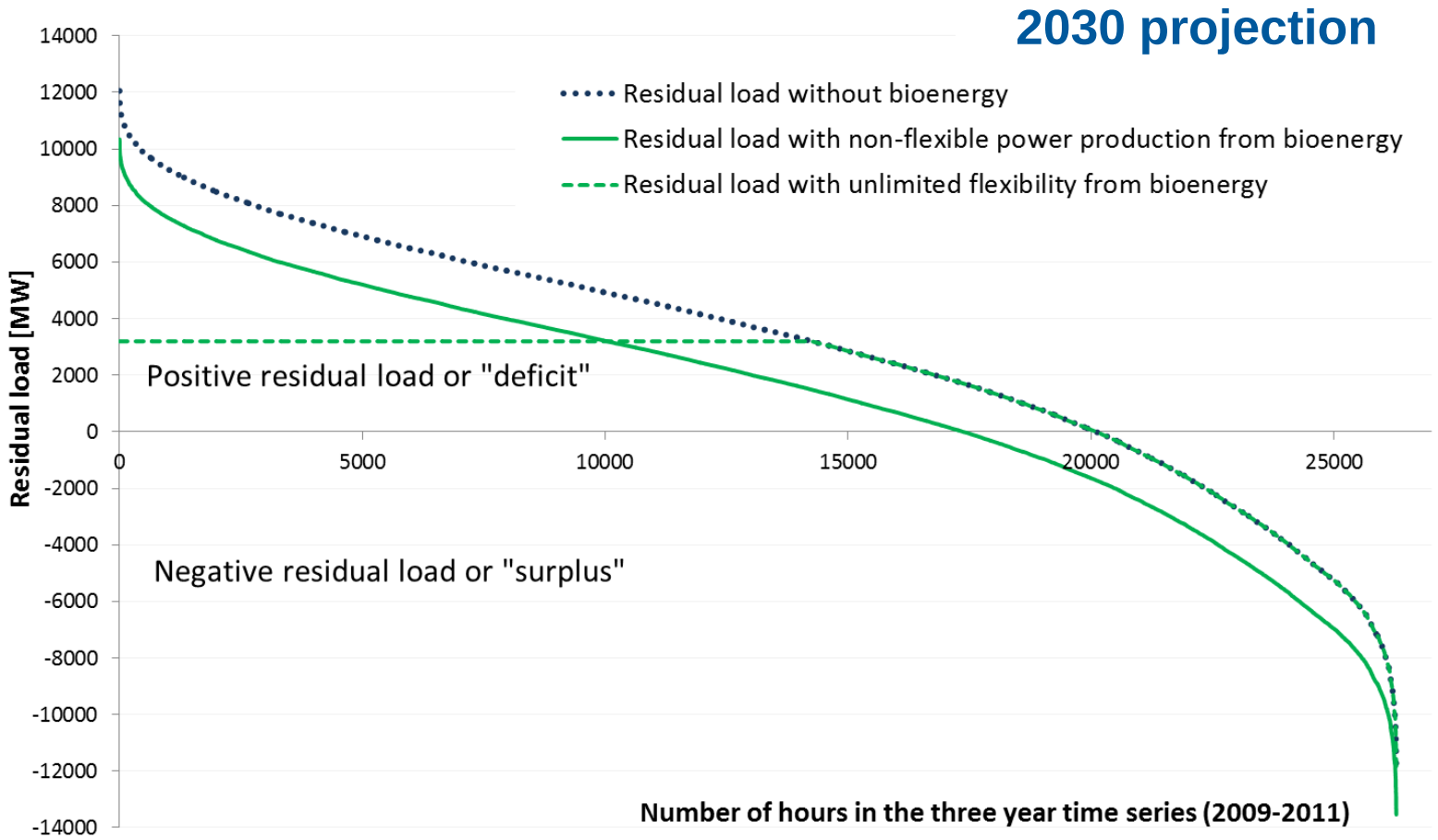
(+ constraints due to heat demand in CHP mode)

Data: time series data for demand and feed-in within the 50Hertz grid area; feed-in from wind and solar PV scaled to installed capacities expected for 2030 according to Leitstudie 2011 Flexible power generation from biomass modelled to minimize variances in residual load.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ
in cooperation with
DBFZ

Flexible bioenergy to offset fluctuations

duration curves for residual load in the case study region



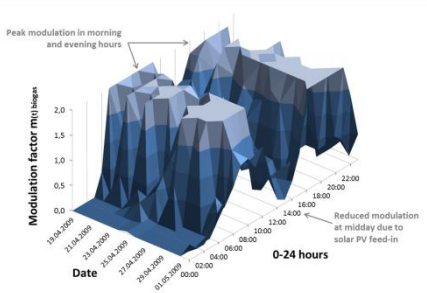
Data: time series data for demand and feed-in within the 50Hertz grid area; feed-in from wind and solar PV scaled to installed capacities expected for 2030 according to Leitstudie 2011. Flexible power generation from biomass modelled to minimize variances in residual load.

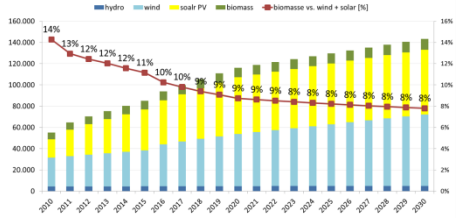
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Summary and conclusion

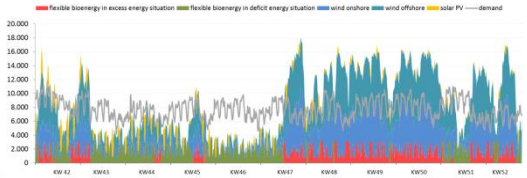
1. Today's concepts for flexible power production with limited infrastructure modification for existing plants enable already some potential to partly offset fluctuations from wind and solar at the level of transmission grids. Biogas ideally complement daily solar production profiles, whereas wind profiles require more storage volume/grid connection.





2. Demand for flexibility will increase as wind and solar will develop more dynamically. → Bioenergy will not be able to fully offset residual load fluctuations from wind and solar.

3. Future requirements until 2030 would entail further boosting of installed power production capacity from biogas plants as wells as higher gas storage volume/grid connection. Solid biomass plants likewise would have to modulate power production more dynamically.



- 4. Additional efforts are necessary to maintain high energy efficiency using flexible biomass in CHP operation (heat demand profiles → heat storage).

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ

Thank you for your attention

please feel free to comment and discuss

Philip Tafarte
philip.tafarte@ufz.de
phone +49 341 2434 594

- Tafarte, Philip, et. al. (2014): “Small adaptations, big impacts: Options for an optimized mix of variable renewable energy sources”, Energy.
- Smart Bioenergy, Technologies and concepts for a more flexible bioenergy provision in future energy systems, expected for publication in 2015

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

in cooperation with DBFZ