EFFECTS OF INCREASING WIND ENERGY SHARE IN THE GERMAN ELECTRICITY SECTOR ON THE EUROPEAN STEEL MARKET

Interdisciplinary approach of material demand analysis and econometrics

Shivenes Shammugam[1], Estelle Gervais[1], Andreas Rathgeber[2], Thomas Schlegl[1]

[1]Fraunhofer-Institute for Solar Energy Systems ISE

[2]Institute of Materials Resource Management MRM, University of Augsburg

15th IAEE European Conference 2017 Vienna, 6th of September 2017

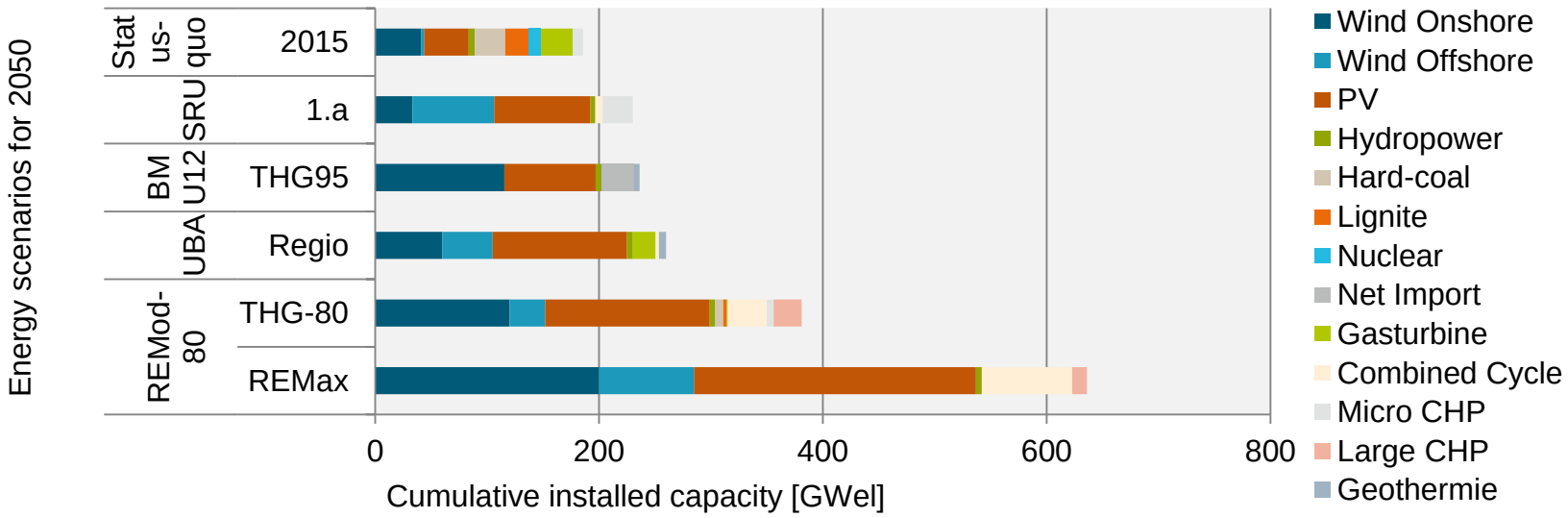
www.ise.fraunhofer.de

Materials Resource Management

Fraunhofer ISE

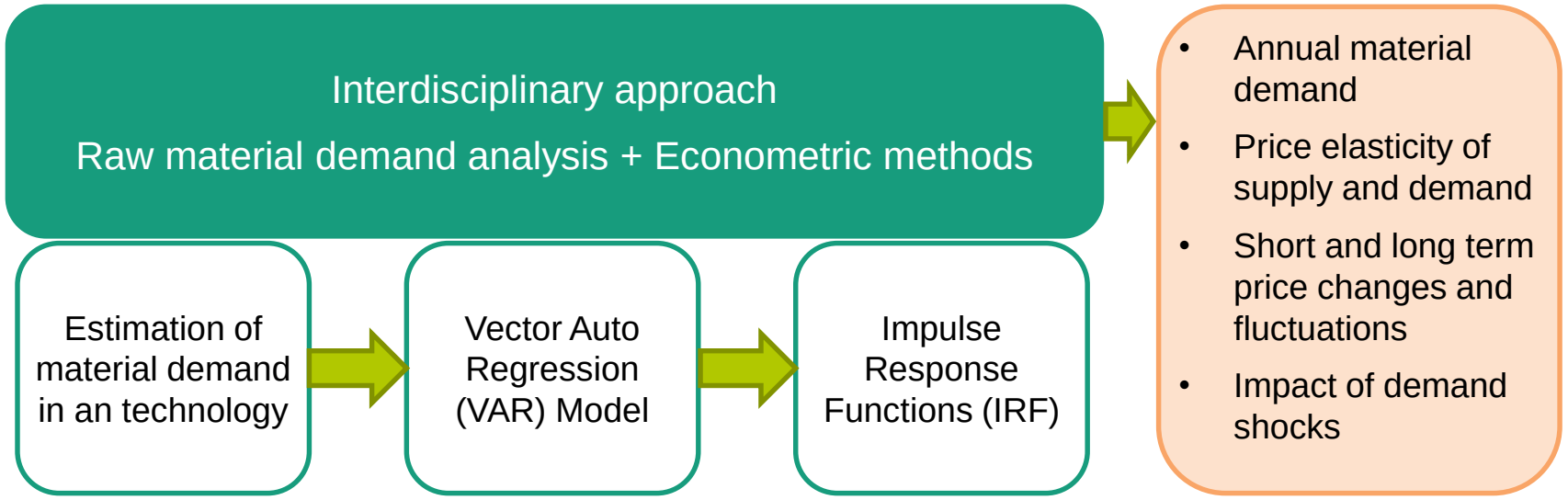
Introduction and Motivation
Increasing share of RE-Technologies

- German government set targets for CO_2-reduction and RE-share
  - 80% RE-share by 2050, 80-95% CO_2-reduction by 2050



- Increasing demand of raw materials due to deployment of RE-Technologies might lead to supply bottlenecks or price instabilities

Aim of the study
An interdisciplinary approach



- This approach is exemplarily tested on the steel demand due to deployment of wind turbines in Germany until 2050

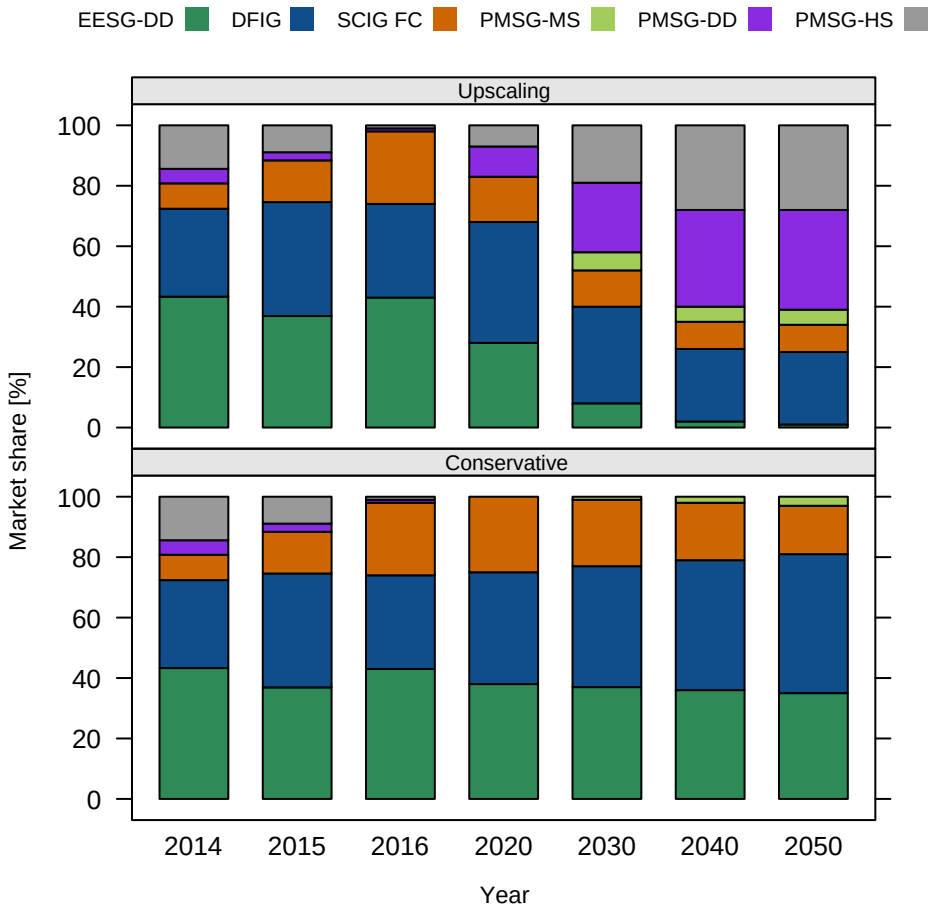
Methodology I

Estimation of steel demand in wind turbines

As-built material requirements			Additional material consumptions		
Composition current WT	Roadmaps	Composition future WT	Production losses	Maintenance	Repowerings
• LCA • Reports and sheets from Manufacturers	• Installed capacity • Average rotor diameter • Average rated power • Towers market shares • Foundations market shares • Drive trains market shares	• Empirical models (upscaling methods) • Techno-economical optimized models	• Metal scrap rates	• Statistical failure rates • Weibull distribution	• Weibull distribution

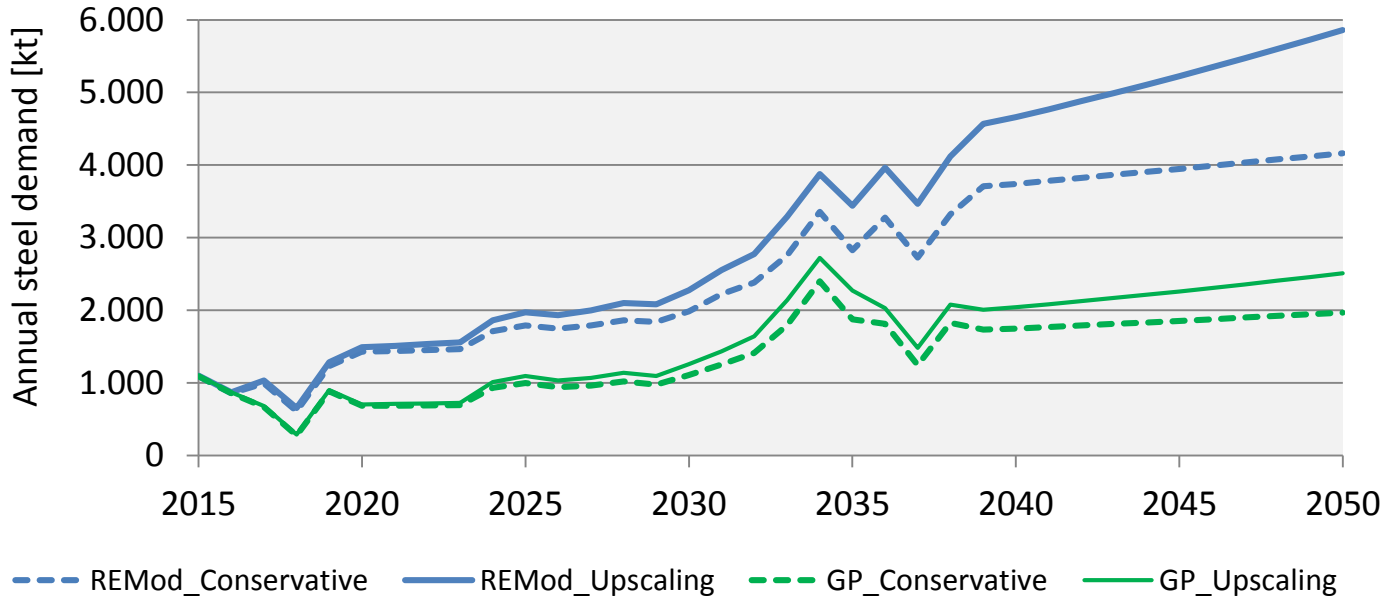
Methodology I
Scenarios for generator market shares

- Upscaling scenario (On- and Offshore)
  - Continuous trend towards larger plants
  - Increased share of PM generators
- Conservative scenario (Onshore)
  - Stagnant trend towards larger turbines
  - Low dynamics in technology market shares



Materials Resource Management
Fraunhofer ISE

Results I
Estimation of steel demand



- Largest steel demand in 2050: 5,900 kt in 2050
- Steel production in Germany in 2015: 42,000 kt
- Bottleneck in steel supply is highly unlikely

Methodology II
Vector Auto Regression (VAR) Model

- Annual data from 1968 to 2013
- Unit root tests: ADF-test and KPSS-test
- Optimal lag length via Akaike and Bayesian information criteria

$$Y_t = a_0 + \sum_{i=1}^{lag} b_i Y_{t-i} + +\varepsilon_t$$

Y_t	vector of length n
a_0	[n ×1] vector of constants
b_i	[n × n] coefficient matrices
i	order of the model
ε_t	matrix of residuals

Micro Variables	Macro Variables
Steel price	Gross domestic product GDP
Apparent consumption	Consumer price index CPI
Steel production	Yields on debt securities outstanding
Export of iron ore	Oil price: West Texas Intermediate (WTI)

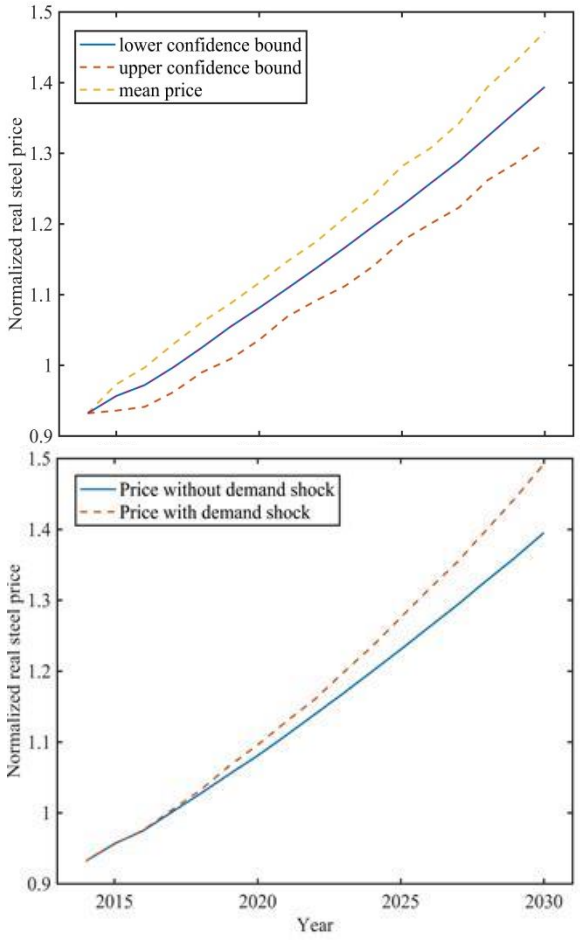
Methodology II
Impulse Response Functions (IRF)

- IRF shows how the system reacts to specific isolated shocks

- Two cases are tested
  - Case 1: No additional demand shocks
  - Case 2: Annual steel demand as annual shocks in in IRF

- Confidence bands constructed via Monte Carlo method of 1000 simulation runs for a period of 17 years until 2030

Results II
Development of steel price



- CAGR of steel price in the past 30a: 2.5% p.a.
- In the first case, CAGR of steel price: 2.4 % p.a.
- In the second case, CAGR of steel price increases by 0.4 %
- Steel production remains at 0.1 % in both cases
- Total steel demand increases at 2.9 % p.a.

Total steel demand increases at a much higher rate than the additional steel demand due to wind turbine

Conclusions and further works

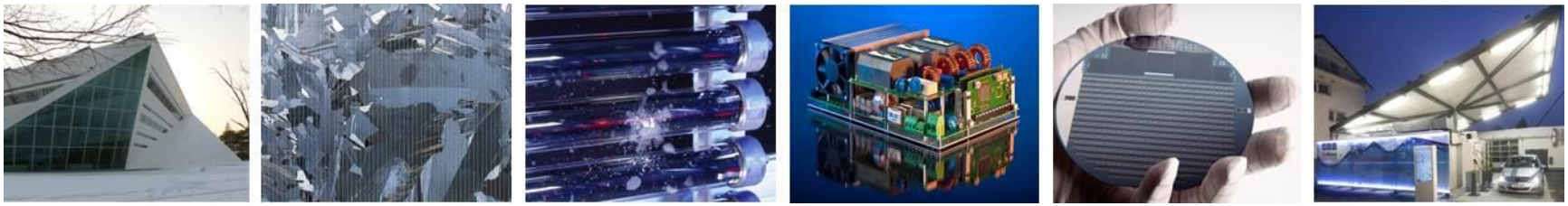
- Conclusions
  - Approach to combine raw material demand analysis of an energy technology and econometric methods in order to analyze the effects of an increasing share of renewable energies on the raw material price is successfully tested
  - The additional steel demand from wind turbine are absorbed by the model, thus limiting the impact on the price.

- Further works
  - Expansion of the VAR-Model and selection of variables via Granger-Causality test
  - Application of method on demand of other materials and technology / energy system

References

- SRU 1.a - Wege zur 100 % erneuerbaren Stromversorgung, Sondergutachten; Sachverständigenrat für Umweltfragen; 2011
- REMod – Energiesystem Deutschland 2050; Fraunhofer ISE; 2013
- BMU12 - Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global; DLR, Fraunhofer IWES, ifne; 2012

Thank you for your attention!



Fraunhofer-Institut für Solare Energiesysteme ISE

Institute of Materials Resource Management MRM, University of Augsburg

Shivenes Shammugam, Estelle Gervais, Andreas Rathgeber, Thomas Schlegl

www.ise.fraunhofer.de

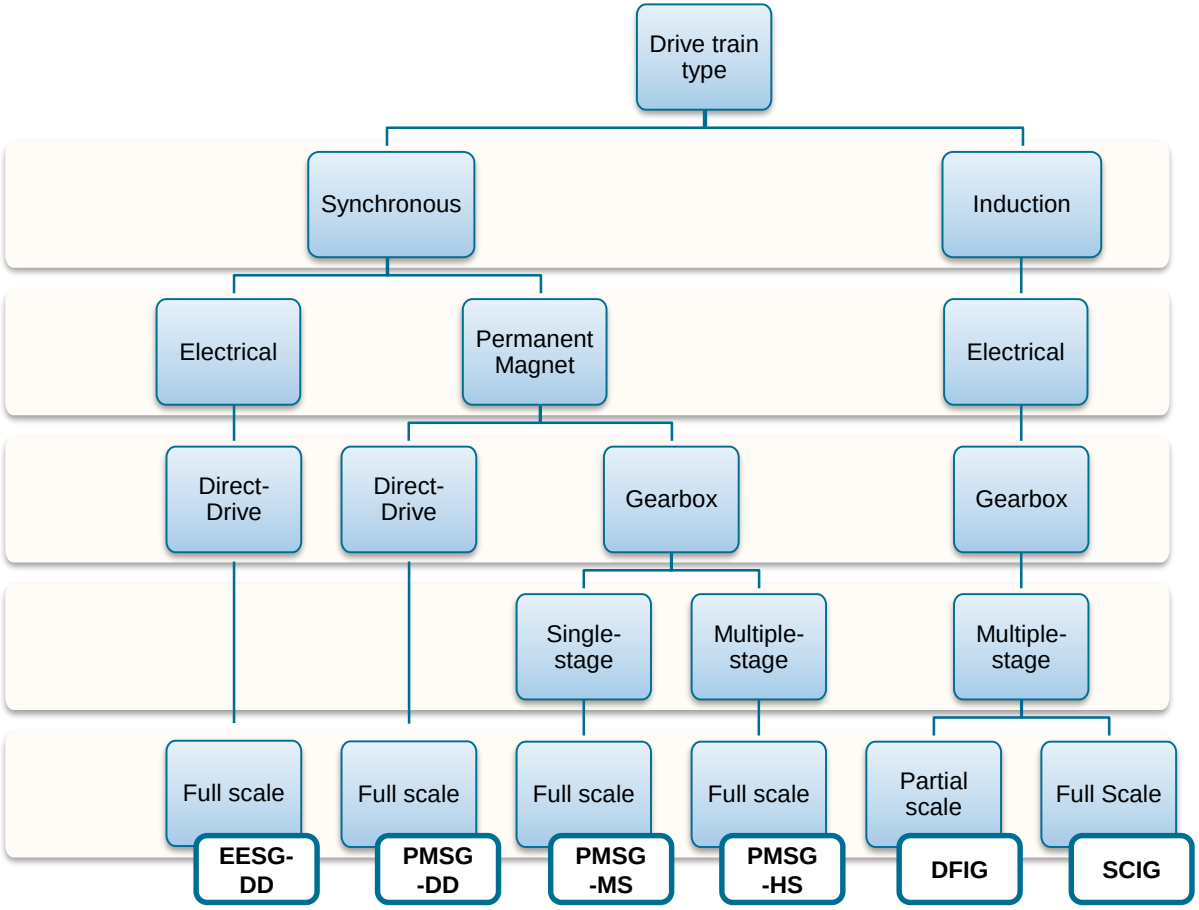
shivenes.shammugam@ise.fraunhofer.de

*this work was supported by the Reiner Lemoine Stiftung

Methodology I

Component of wind turbines and drive train systems

- Rotor
- Tower
  - Steel
  - Hybrid
- Foundation
  - Jacket
  - Monopile
  - Tripod
  - Floating
  - Onshore
- Nacelle
  - Drive train system



Fraunhofer ISE