GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

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MACROECONOMIC ASSESSMENT OF REMODELLED SCENARIOS – AN ANALYSIS WITH THE MACROECONOMETRIC MODEL PANTA RHEI

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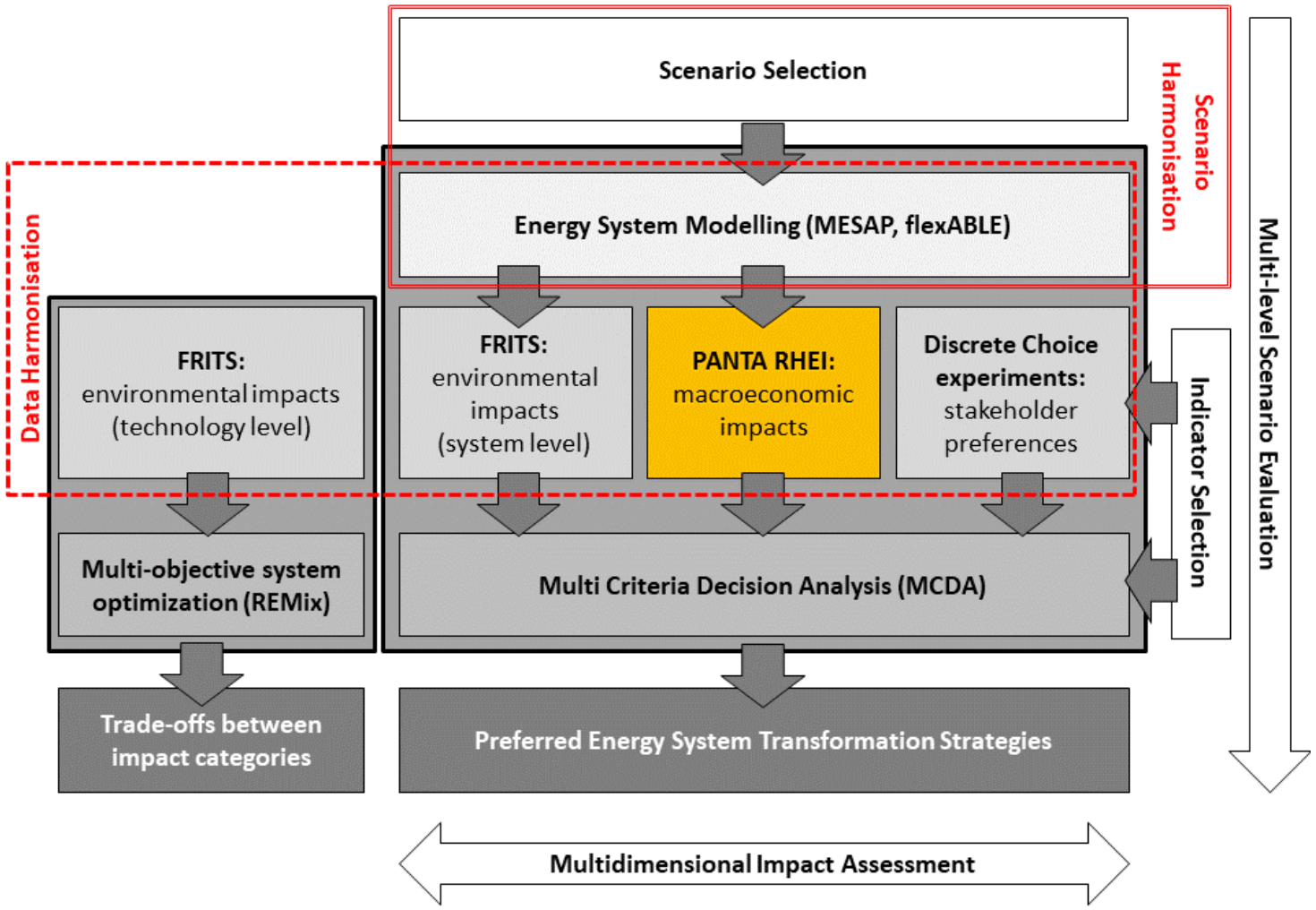
Project structure and workflow



Outline

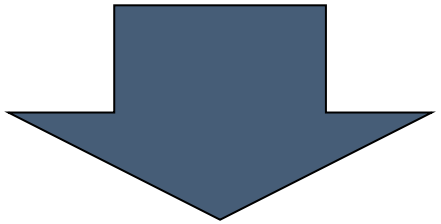
1. Introduction: Tasks and method (PANTA RHEI)
2. Input data: Coupling with MESAP and main economic drivers
3. Main results and socioeconomic indicators
4. Regional results
5. Conclusions

1. Introduction

- **Tasks and method**

Task: macroeconomic assessment

- Requirements for macroeconomic assessment of future energy scenarios
  - ⇨ consistent model framework with all relevant linkages between the energy system and the economy
  - ⇨ input-output structure and complete representation of GDP
  - ⇨ consideration of path dependencies in the economy



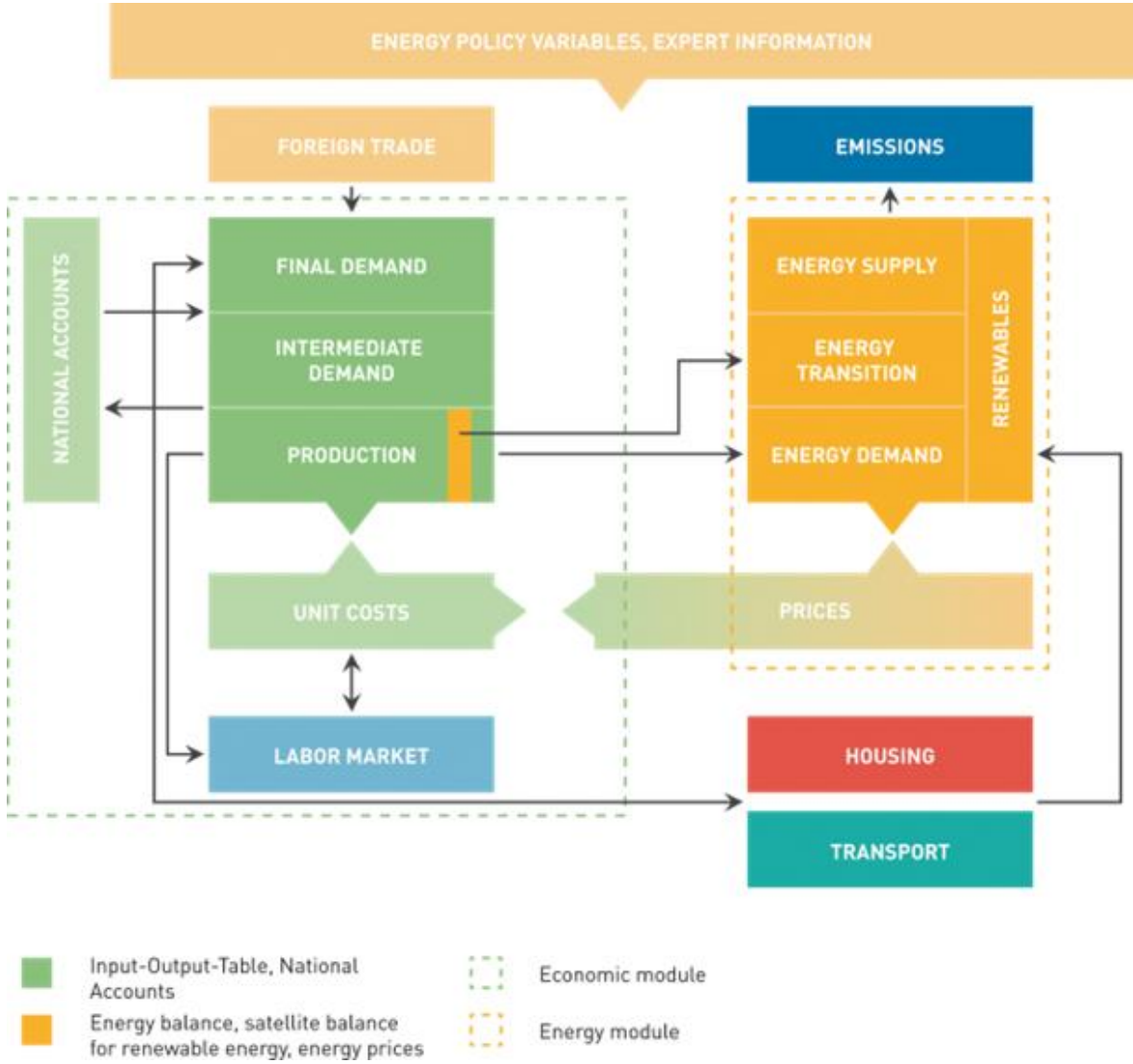
PANTA RHEI

Overview of the model PANTA RHEI (I)

- Environmentally extended version of macroeconometric simulation and forecasting model INFORGE
  - ⇨ developed for the macroeconomic evaluation of environmental protection measures and energy economic policy
- Contains a multitude of macroeconomic variables drawn from official statistics
- Fully integrated System of National Accounts
- Disaggregated to 72 product groups and 63 economic sectors
- Behavioural parameters are econometrically estimated based on time series data

Overview of the model PANTA RHEI (II)

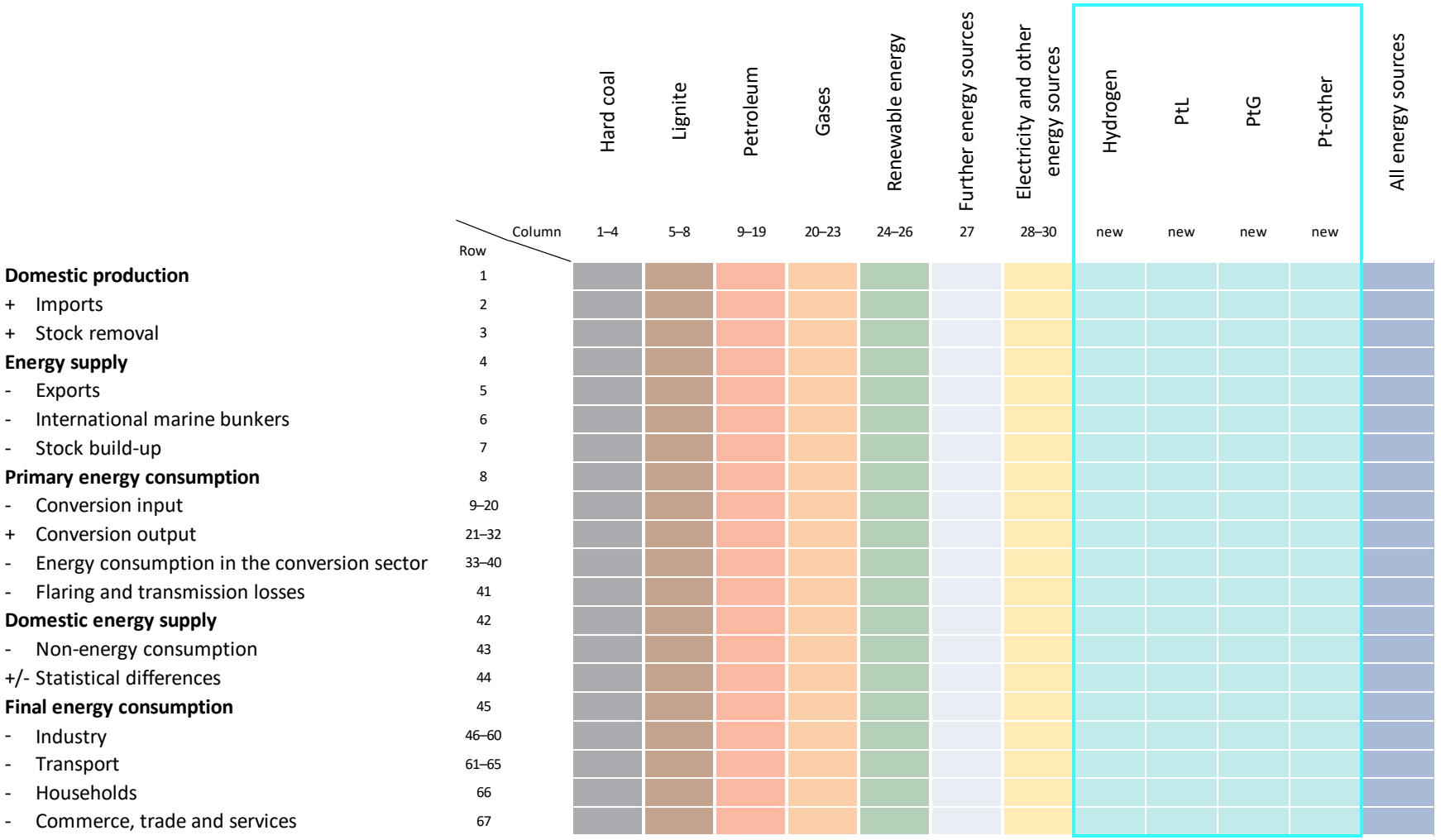
- In addition to the comprehensive economic modelling (INFORGE), there are modules for
  - ⇨ energy,
  - ⇨ emissions,
  - ⇨ transport, and
  - ⇨ housing



Extension of the energy balance (I)

- In PANTA RHEI, the energy system is modelled using the systematics of the German energy balance
  - ⇨ 30 energy source (groups), including 3 groups for renewable energies
  - ⇨ No “new” technologies like hydrogen, methane, PtX
- Those technologies may play a role in the future energy system and are therefore part in some of the scenarios
  - ⇨ Hence, the energy balance in PANTA RHEI was extended

Extension of the energy balance (II)



Source: Lehr, U., Becker, L. & Ulrich, P. (2020): Zur Integration strombasierter Energieträger in die Energiebilanz Deutschlands. Energiewirtschaftliche Tagesfragen 11/2020, S. 59-62.

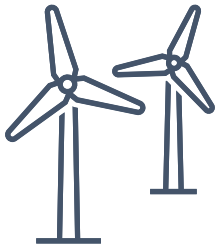
2. Input data

- **Coupling with MESAP and main economic drivers**

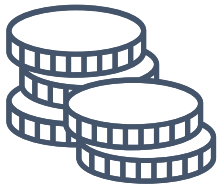
Coupling PANTA RHEI with MESAP

- Both models based on common framework data
  - ⇨ e.g. population development, economy-wide energy efficiency gains
  - ⇨ no consideration of COVID-19 effects
  - ⇨ assumed to be the same for all scenarios examined
    → economic effects resulting exclusively from the transformed energy system
- Coupling using an Excel-based interface
  - ⇨ data output from MESAP = data requirements from PANTA RHEI

Main economic drivers

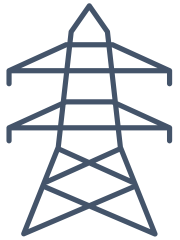


- Energy mix
  - ⇨ reproduces the energy system modelled in MESAP which is linked to the economic part in PANTA RHEI and causes feedback effects here



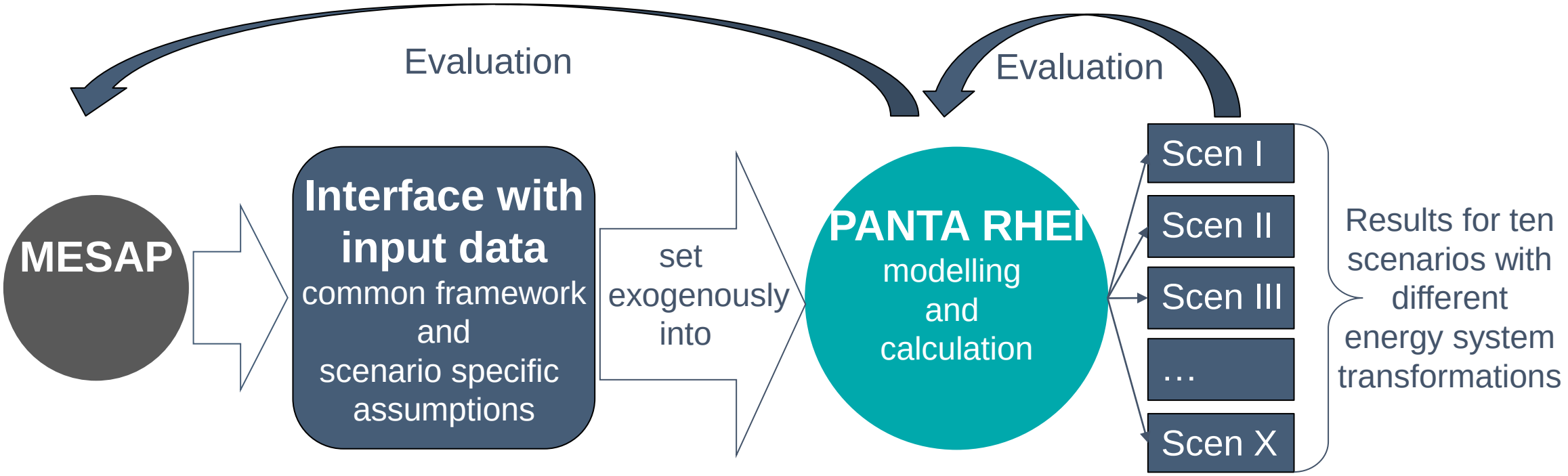
- Investment pathways and costs for operation and maintenance
  - ⇨ are allocated to the corresponding economic sectors and also have an impact on input sectors via input-output structure of the model

- Energy imports
  - ⇨ trade balance has effects on domestic production and cost structures



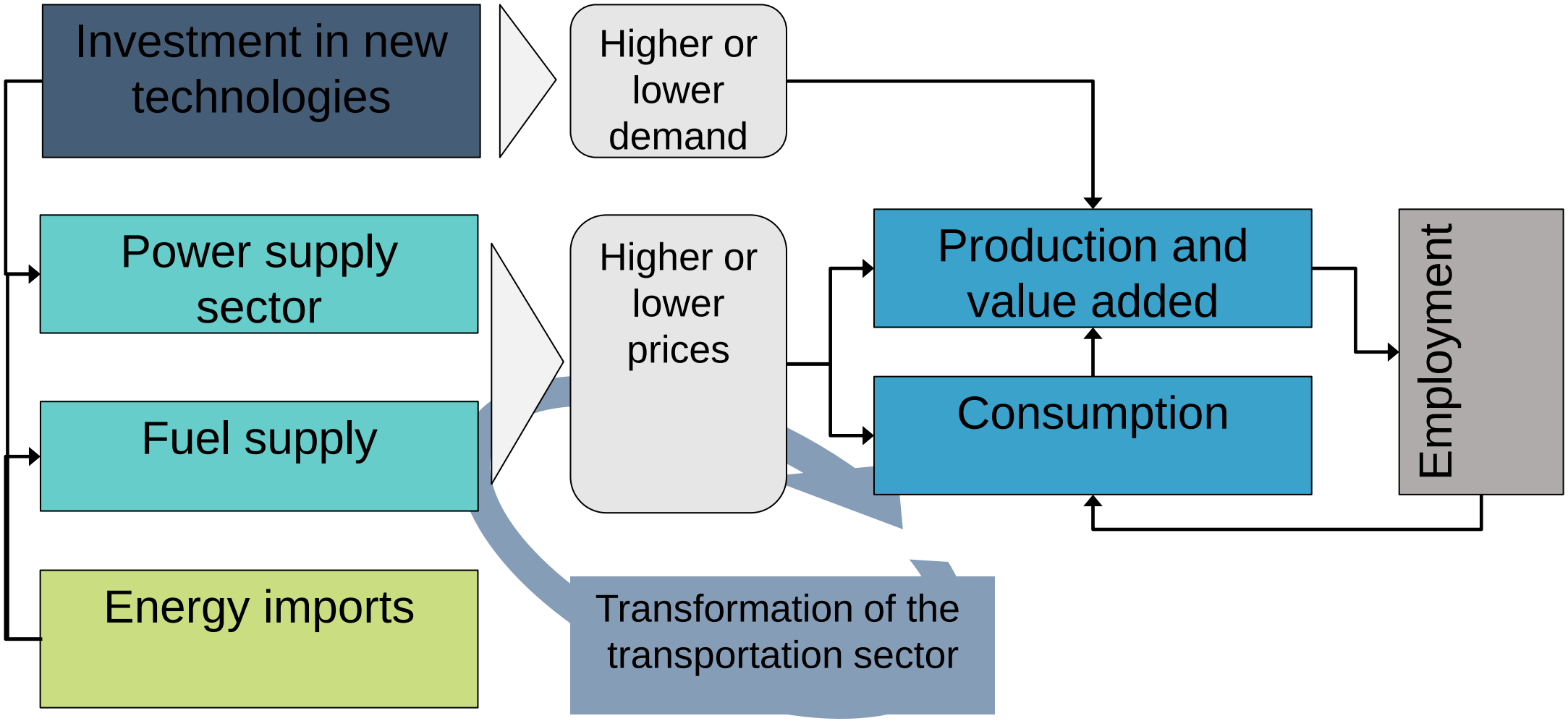
- Levelised costs of electricity (LCOE)
  - ⇨ affect the electricity price

From input data to macroeconomic results



3. Main results and socioeconomic indicators

Drivers and interdependencies



Overview over scenario results

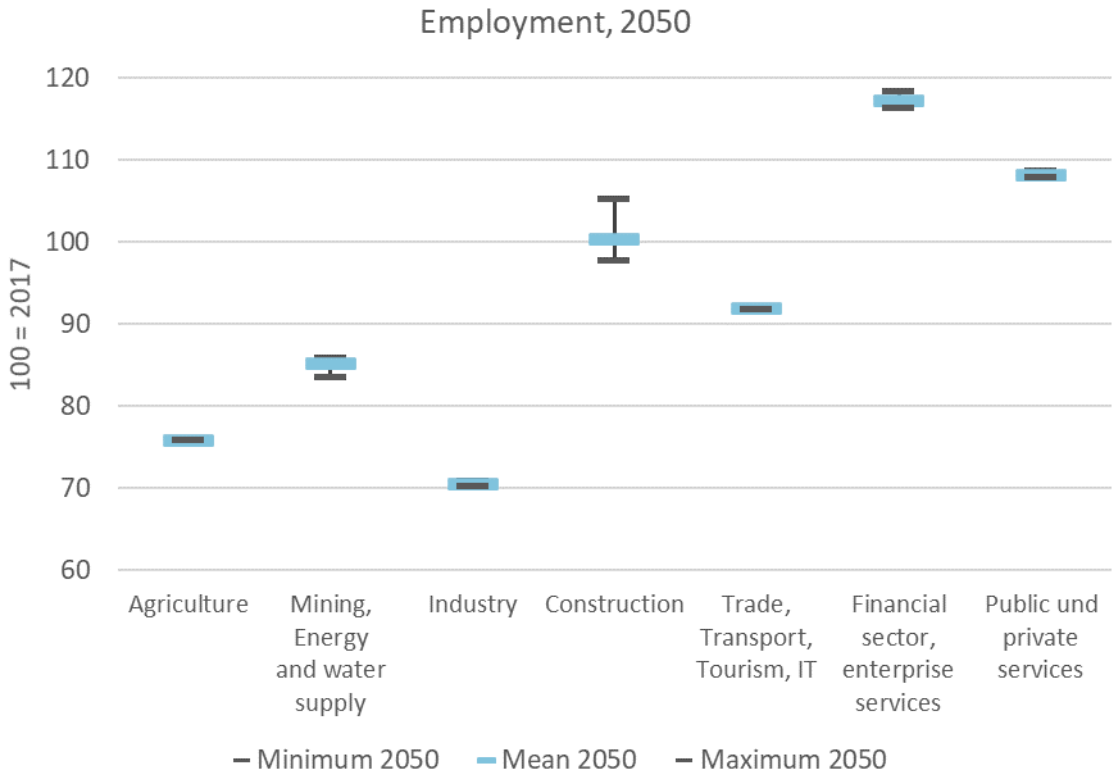
- Development of four central indicators:
  - ⇨ Gross Domestic Product (GDP) → prosperity growth
  - ⇨ Total investment (in construction and in equipment) → forward looking economic activities
  - ⇨ Employment → household incomes, leading to further demand and value added.
  - ⇨ indicator for the unemployment rate → social importance of employment, more accentuated
- More ambitious scenarios (bottom rows) predominantly exhibit on average larger positive effects on GDP and employment than the scenarios aiming at 80% GHG reduction compared to 1990 (top five rows).
- Overall, the differences between future development of the economy in the scenarios are very low
- Essentially, the total investment over the projection period is responsible for the differences in the macroeconomic results
- Differences in detail
  - ⇨ RE-Technology mix
  - ⇨ Energy imports

Scenario	GDP	Total investment	Employment	Unemployment-rate indicator
	Real, Bn Euro$_{2015}$		1 000	Percent
	Average of the years 2030 to 2050			
Scen I	3751,9	820,7	43879,5	4,39
Scen II	3748,8	815,5	43869,9	4,41
Scen III	3755,8	825,4	43888,1	4,37
Scen IV	3749,0	817,3	43889,8	4,37
Scen V	3757,0	836,3	43936,3	4,27
Scen VI	3775,1	842,8	43982,8	4,17
Scen VII	3788,4	862,8	44009,1	4,11
Scen VIII	3762,2	834,2	43946,5	4,25
Scen IX	3783,7	870,3	44047,7	4,03
Scen X	3743,9	822,1	43875,0	4,40

Impact by sector in employment

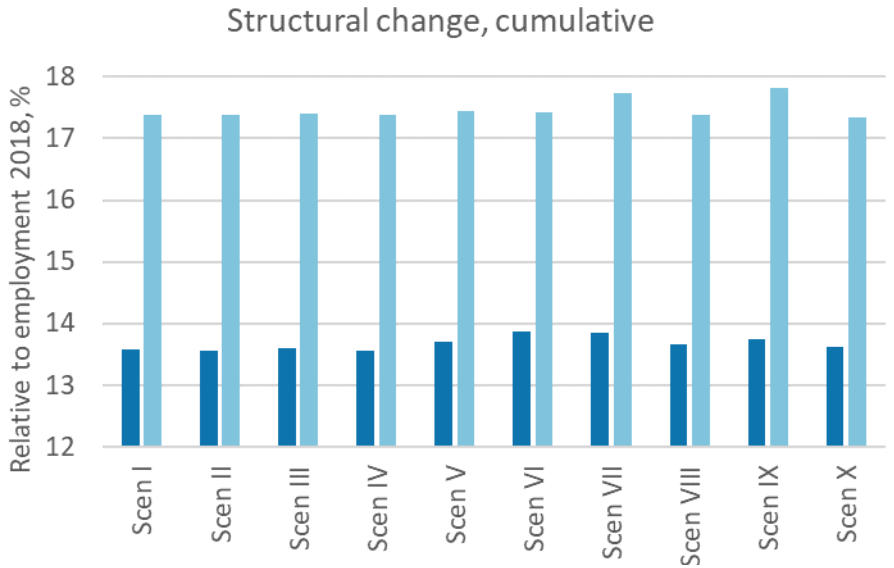
- Structural change within the whole economy is quite the same in all scenarios
- Construction and enterprise services respond to additional demand
- Rather high impact in energy sector

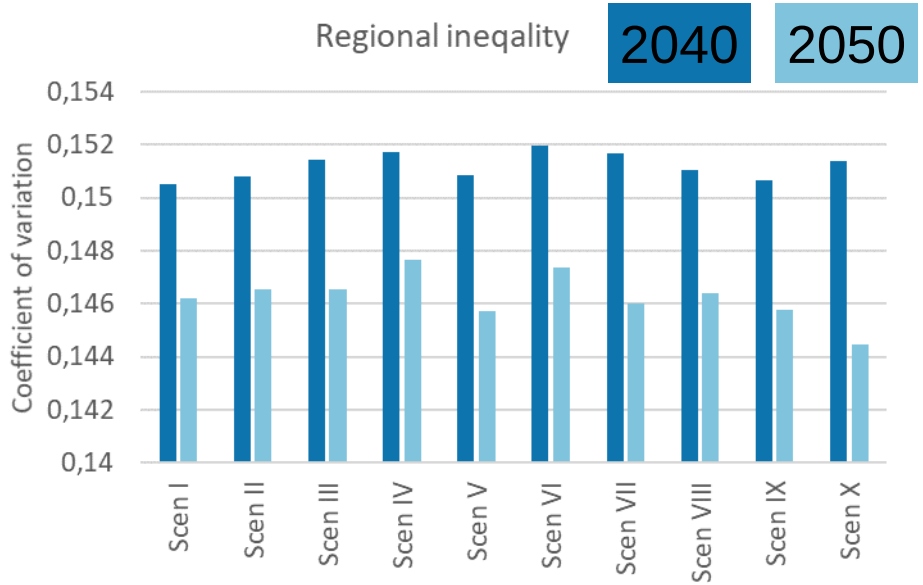
- PANTA RHEI represents the whole economy
- Energy system is only a (rather small) part of it
- All scenarios represent a transformation
- Transformation costs of the transportation sector are not fully included
- Energy efficiency measurements: additional costs are not included



Socioeconomic indicators for MCDA

- GDP
- Employment
- Unemployment rate indicator
- Structural change indicator
  - ⇨ Absolute number of created and lost jobs across 63 sectors (7 to 8 Mio Jobs until 2050 → 17 %)
  - ⇨ Similar patterns as for employment
- Regional inequality
  - ⇨ Variation coefficient: GDP and population across 16 regions





4. Regional results

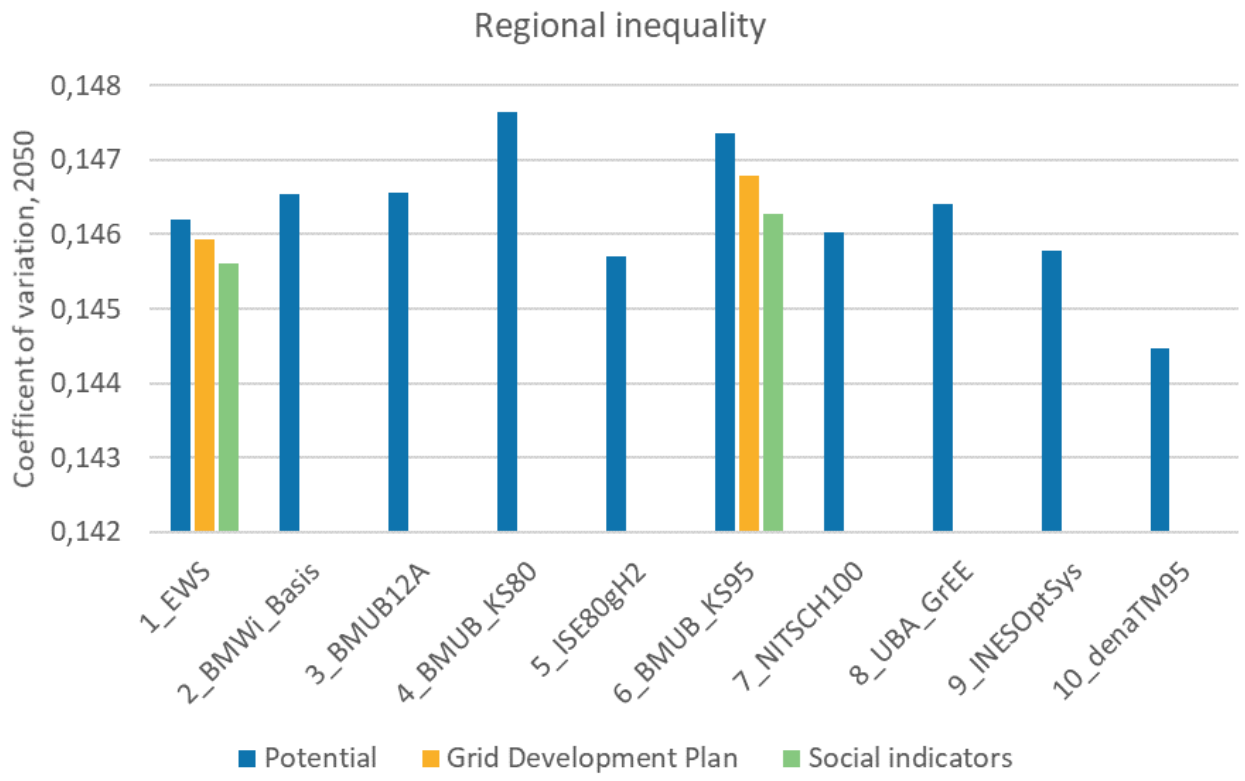
Regional changes in the transformation scenarios

- Top-down estimation of regional impacts subject to
  1. Economic structure and regional changes
  2. Structure of regional energy mix, now and in the future (new installation in MW)
  3. Regional distribution of investment in renewable energies (new installation in EUR) as well as regional additional demand versus regional interdependencies and spillovers
- Scenario input data for 13 Regions, modelling 16 federal states
- Method is a composite of two regional models, both integrated or united in one framework (PANTA RHEI)
  - ⇨ LAENDER as part of PANTA RHEI
  - ⇨ Regional Input-Output-Model hyBRID, coupled with PANTA RHEI-LAENDER
- Our example here: Inputs 1 & 2 and sensitivity analysis in PANTA-RHEI-LAENDER

1st-level assessment

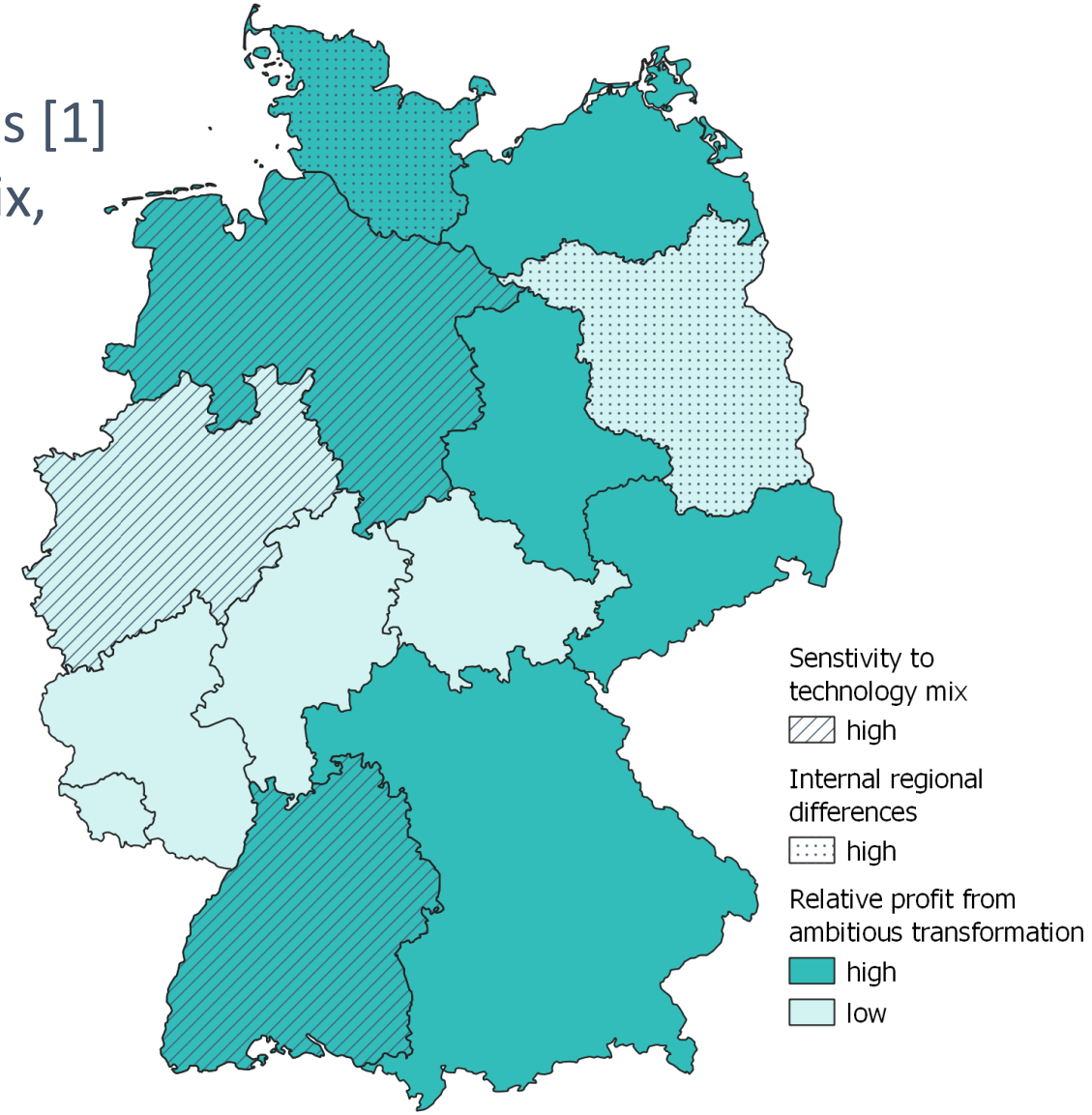
Varying the distribution key of new installations

- Three **distribution assumptions** for RE new installations: “Potential”, “Grid development plan” and “Social indicators”
- Small variation of regional inequality among scenarios and distribution assumptions
- More ambitious scenarios show lower inequality
- Distribution along social indicators yield lowest inequality over federal states
- “Potential” distribution for RE leads to least balanced distribution of economic output
- Regional distribution of new capacities not more important than technological aspects in the overall economic context



Regional impacts

- Summary of regional impacts until 2050 (Economic structure and regional changes [1] as well as structure of regional energy mix, now and in the future [2])
  - ⇨ Winners and losers of very ambitious transformation in relative terms
  - ⇨ Higher profits near-coast north , in the south as well as majority of east
  - ⇨ In some states/regions impacts vary much upon the scenarios, as they are more sensitive to technology mix, independent of the ambitiousness



5. Conclusions

Conclusions

- Relative differences in **macroeconomic effects** between the scenarios are very small
  - ⇨ all scenarios represent a transformation path, who share a strong ambition to strong reduction of GHG emissions
  - ⇨ energy industry represents only a comparatively small section of the overall economy, while the results of macroeconomic modeling refer to the whole economy with all its interconnections
  - ⇨ the restriction to the supply side of the energy system also implies only a subset of macroeconomically relevant costs of the transformation (e.g., for efficiency measures or carbon taxes)
- From a macroeconomic perspective the decision on the strategy for the transformation of the energy system is **not very important for the overall economy compared to a decision whether to transform or not**
- Scenarios with comparatively **high investments for the transformation of the energy system** tend to have a higher positive impact on most selected macroeconomic indicators than scenarios with comparatively low investments. There are some minor – not decisive – differences in price developments and energy imports.
- Our results confirm that one can expect effects to vary stronger at the **regional level**. Both present structure and regional investment patterns in the future contribute to different outcomes.

Method and its limitations

- **Coupling energy system models with macroeconomic models** makes it possible to determine macroeconomic consequences of different transformation pathways.
- Necessary but challenging: Describing not only a future state of the economy with few variables but describing the **evolution of the economy within the context of energy system transformation**
- Assumptions for the long-run structure of the economy and their interrelations with the energy systems are not elaborated in underlying scenario studies. **How does the future business model of energy supply look like?** Especially when it comes to synthetic fuels?
- For an integrated assessment with both ecological and economical indicators **system boundaries** of different models must be considered

Thank you for your attention.

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