Questionnaire and responses from the case studies. Additional

Table S1

Guiding questions
Knowledge integration in different methodological designs – CASE STUDY 1 (C1)

Case description (write properly – is direct part of the paper):

1) What is the central question of the project?

Analysis of future energy demand of private households in Germany

The objective of this first project was to analyze the future energy demands of private households. Taking different policies and frameworks into account, a technology-based simulation model (JEMS-BTS[1]) was therefore used to create different energy scenarios. This model is based on a scenario approach; using a comprehensive typology for residential buildings, heating, and hot water technologies in Germany (Hansen et al. 2015), it calculates the effects of various energy efficiency measures.

2) Definition of goals of the model instruments:
    a) What type of model is/are used? What can be "done" with the model(s)?

Technology based simulations model

Creating of scenarios taking different polices and frameworks into account

    b) What is the purpose of the CIB analysis in the project?

Creation of consistent storylines, consistency check for existing scenarios, extension of point of view

CIB was used for the purpose of i) creating internally consistent storylines, ii) checking the consistency of pre-existing energy scenarios, and iii) extending the general scope of the study towards (societal) issues beyond the modeled realm. Three CIB matrices were therefore constructed and linked to each other, serving the global, national, and sectoral levels (see Hansen et al. 2014).

3) Concerning the CIB:
    a) How many descriptors are "coupling descriptors" and how many descriptors describe societal factors (beyond energy)?

Coupling descriptors: 10 / overall: 43

[1] JEMS-BTS: Jülich Energy Modeling Suite - Building Stock and Technology Simulation Model for Space Heating and Hot Water Supply.

Factors on Global level	Factors on National level	Factors on Sectoral level
Oil price	Oil price	Oil price
Innovation dynamics	Innovation dynamics	Innovation dynamics
CO_2-reduction policy EU	CO_2-reduction policy EU	
Willingness to invest	Willingness to invest	
Energy resources: scarcity	Resource scarcity	
	Climate change/energy policy	Climate change/energy policy
	Growth of GDP	Growth of GDP
	Population	Population
	Expansion of electricity grid	Expansion of electricity grid
	Regional level of diversification	Regional level of diversification

b) Please add a list of descriptors and variants

Influencing factor		Possible outcomes	
Factor	**Remarks**	**Outcome**	**Indicative Values/Explanation**
Growth of GDP (global)	**Average growth rate**	• **slightly increasing**	**2010-2030: ~3%/year**
		• **strongly increasing**	**2010-2030: ~3.5%/year**
Oil price	**Price for one barrel of brent oil**	• **low**	**2030: ~100$/bbl**
		• **moderate**	**2030: ~125$/bbl**
		• **high**	**2030: ~175$/bbl**
Population (EU)	**Annual growth rate for population in EU 28**	• **increasing**	**~ 0.1%/year**
		• **decreasing**	**~ -0.4%/year**
International climate change policy		• coordinated and ambitious	
		• not coordinated, less ambitious	
CO_2-reduction EU	Reduction in Greenhouse gases measured as CO_2 (EU 28)	• CO_2 reduction targets are missed, no new targets	reduction of not more than 20% below 1990 levels by 2030
		• moderate CO_2 red. targets	reduction of 30% CO_2 below 1990 levels by 2030
		• ambitious CO_2 reduction targets	reduction of 40% CO_2 below 1990 levels by 2030 and 80% by 2050
Price for CO_2-allowances		• low	<30 Euro/ton CO_2
		• moderate	30-50 Euro/ton CO_2
		• high	50-75Euro/ton CO_2
		• very high	75-100Euro/ton CO_2
Environmental protection	Attitude to measures for environmental protection	• low rate	nearly the same level as today
		• high rate	
Willingness to invest		• low	nearly the same level as today
		• high	
Energy res.: scarcity	Scarcity of oil and gas	• new deposits	
		• increasing scarcity	
Energy res. trade	Limitations on the trade with oil and gas	• free	nearly the same level as today
		• restrained	new trade barriers
Other res.: scarcity	Scarcity of resources like	• new deposits	
		• increasing scarcity	
Other res.: trade		• free	nearly the same level as today

		• restrained	new trade barriers
Desertec and similar supranational energy projects	Supranational energy projects which are aimed for increasing energy trade within Europe and between Europe and other regions	• not put into action • put into action with delay • put into action as planned	
Electricity demand EU	Demand for electricity in EU-28	• decreasing • constant • increasing	~ -0.2 %/year ~ 0.2 %/year ~ 0.6 %/year
Energy cons. (World)		• slight increase • moderate increase • strong increase	~1.0%/year ~1.2%/year ~1.5%/year
Growth of GDP (Germany)	annual change in gross domestic product	• minor increase • strong increase	approx. 0.5% per year approx. 1% per year
Population	number of persons in Germany	• slight decrease • strong decrease	2030: 79 million 2030: 77 million
Climate and energy policy (national)	Focus of climate and energy policy in Germany	• focus on energy security • focus moderate greenhouse gas red. • focus ambit. greenhouse gas red.	reduction of energy demand and diversification of energy sources CO_2 reduction target: -40 % (2030) CO_2 reduction target: -60 % (2030)
Environmental awareness		• unchanged • increasing	situation as it is today more interest in “green” lifestyle and “green” economy
Knowledge generation		• slightly increasing • strongly increasing	continuation of current trends acceleration of the current development
Innovation dynamics	development and deployment of new techniques	• constant • increasing	continuation of current trends acceleration of the current development
Replacement of assets		• slightly accelerated • accelerated significantly	continuation of current trends acceleration of the current development
Climate change	Visibility of impacts of climate change in Germany	• slightly visible • clearly visible	only small changes in temperature higher temp. in winter, heat waves in summer
Space requirements	average space requirement person (private households)	• slight increase • strong increase	~ 46 m^2 per person ~ 50 m^2 per person
Equipment with electric devices (priv. househ.)	Number of electric application in the sector private households	• increasing • strong increase	continuation of current trends acceleration of the current development
Energy demand: Private households	Demand of the private households for electricity and heat	• gradual decline • strong decline	~ -1% per year ~ -1.5% per year
Energy demand: Industry	Demand of the industry for fuels	• slight increase • gradual decline • strong decline	~ 0.5% per year ~ -0.5% per year ~ -1% per year
Energy demand: Transport	Demand of fuels for transportation purposes	• gradual decline • strong decline	~ -0.5% per year ~ -1% per year
Energy demand: Others (Business, trade, …)		• gradual decline • strong decline	~ -0.5% per year ~ -1% per year
Expansion of electricity grid	Expansion of the high-voltage grid	• restrained • unrestrained	lower the proposed by [dena, 2010] as proposed by [dena, 2010]
Degree of centralization	Concentration of electricity production on selected sites	• low • high	less energy supply hotspots than today energy supply hotspots as today

Size of energy sup. Units	Average size of units producing electricity	• increased application of small units • dominant application of large units	significant more energy supply units with less than 1 MW
Regional level of diversification	Regional distribution of population	• constant • increased	situation as it is today increase in the differences between regions
Fuel prices	Prices for fuels the households have to pay	• strong increase • moderate increase • minor increase	3,0 %/year 1.5 %/year 1.0 %/year
Disposal income	income without expenditure for energy	• slight decrease • strong decrease	- 0.3 %/year - 0.7 %/year
Use of decentr. energy supply options	renewable energies for space heating and hot water (growth rate)	• strong increase • moderate increase • slight increase	12.5 %/year 10.0 %/year 7.5 %/year
Use of renewables	renewable energies for space heating and hot water (relative share)	• strong increase • moderate increase • slight increase	2030: 50 % 2030: 30 % 2030: < 30 %
Working population	number of the national working population	• increasing • constant • decreasing	2030: > 43 million 2030: 43 million 2030: 42 million
Relevance of households with elderly persons	change of number of households with elderly persons compared to today	• increasing • constant • decreasing	2030 + 20 % 2030: constant (compared to today) 2030: - 20 %
Energy performance of buildings	high means low energy demand and low corresponds to a high energy demand.	• high • medium • low	<100 kWh/(m²a) 100-140 kWh/(m²a) >140 kWh/(m²a)
Rental charge/price of buildings and flats		• strong increase • slight increase	2.5 %/year 1.5 %/year
Final energy demand	demand for energy of the end-users	• gradual decline • strong decline	~ -1% per year ~ -1.5% per year

black: descriptor can be coupled more or less immediately with models (if necessary after minor assumptions and re-calculations)

Dark grey: descriptor can be coupled with models after major interpretations/assumptions. Qualitative descriptors have to be interpreted plausibly in a quantitative manner.

Light grey: descriptor cannot be coupled to models

4) How many descriptors are qualitative (=defined by text only), how many are quantitative (=do include numerical definitions, too)?

Qualitative: 20 Quantitative: 23

Case characterization: How was the methodological procedure? (only informative – not necessary to write properly)

A. 1st central moment of knowledge integration during the construction of context scenarios

1) What is the societal context that has been chosen to be relevant with regard to the specific problem? (geographic scale and thematic scope)

Economic development and energy policies on international and national level, changes in population, income, … on national level

2) What type (and how many) actors have been included in which part of the CIB process and how has the process been implemented? (big table in the annex)

1st central moment of KI **during the construction of context scenarios**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Context descriptor selection 2. Coupling descriptor selection 3. Cross-Impact-Assessments (CI-Einschätzungen)	10 experts from IEK-STE with different backgrounds (engineers, economists, political scientist) Core team + 8 experts	Workshop	fastest way to get a CIB
4. Selection and assessment of scenarios	10	Interviews	at last the model experts decided how which scenarios should be analyzed in more detail

a) Definition experts:

i) Experts responsible for the model

1 modeler (business engineer)

ii) Experts responsible for the context scenario study

1 CIB expert (economist) plus modeler (business engineer)

iii) Domain experts (which domains?)

modeler (business engineer for private households), CIB expert (economist for developments on national and international level)

3) Did the structure and focus of the model influence the choice of the context?

Yes. As usually in the selection process the experts were asked which descriptor might be relevant for the assessment of the future of the energy consumption of the private households. The knowledge of the model user on relevant factors and their links helps to structure the search for and selection of descriptors

4) Handling with dissent and uncertainty
   a) Have there been any ambivalent results from the CIB scenario construction?

Yes. Some framework constellation used in earlier studies seem to be less consistent than expected. New constellations came up as option.

   b) If yes, how did you deal with it?

Based on different results we alternative scenarios were created and analyzed.

5) Have there been any recursive elements within the process?

No, because the model expert was involved in the specification of CIB

6) Which role did the experts responsible for the model play in the construction of the context scenarios?

The expert took part on the workshops.

B. 2nd central moment of knowledge integration: Effects from the CIB analysis on the numerical model (implicit or explicit on system borders, elements, interrelations,...)

1) Did the context scenarios (construction) with CIB method stimulate adaptation or rethinking of the model in any way? If yes, how?

Yes. CIB helps to understand links between factors (linking descriptors). "New" scenarios had been generated taking aspects on international level as well as indirect effects into account. Consistency of "old" scenarios had been checked. The input data for the model have changed, but model structure remained.

2) Was it implemented in a way? If yes, how?

see answer to (1)

3) If no, why was it not implemented?
4) Who (and how many) actors have been included in which part of the process and how has the process been implemented?
   a) Experts:
      i) Experts responsible for the model

1 business engineer

      ii) Experts responsible for the context scenario study

1 economist (CIB expert), supported by the modeler (business engineer)

      iii) Domain experts (which domains?)

2nd central moment of KI: **Effects from the CIB analysis on the numerical model**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Interpreting context scenarios concerning model premises on context	2	individually after discussion	
2. Possibly adapting or shaping the energy model or deciding not to do so	2	individually after discussion	
3. Others?			

5) Which role did the experts responsible for context scenarios play in the adaptation or rethinking of the model?

The CIB expert served as interpreter. He discussed with the model expert how to interpret the descriptors and how to transfer them into the model.

C. 3rd central moment: Translation of context scenarios into input data sets (and model parameter/bounds…)

1) In which specific phase did the quantification take place in the process?
   a) And how was the quantification put into practice?

Of course scenarios had been created by us without knowing results of the CIB. So, in a first step we compared the results of CIB with the framework assumed so far. Based on literature review missing links were closed and numbers specified.

2) How strictly did you stick to initially made quantifications during the process (e.g. in model runs)?

Only quantitative numbers can be used in the model. However, it is possible to make sensitivity analysis.

3) What type of (and how many) actors have been included in which part of the process and how has the process been implemented?
   a) Experts:
      i) Experts responsible for model

1 business engineer

      ii) Experts responsible for the context scenario study

1 economist (CIB expert), supported by the modeler (business engineer)

      iii) Domain experts (which domains?)

3rd central moment of KI: **Translation of context scenarios into input data sets (and model parameter/bounds…)**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Quantification of qualitative data	2	individually after discussion	
2. Possible revision of quantifications	2	individually after discussion	
3. Recommendations for further model restrictions (bounds)	2	individually after discussion	
4. Others?			

4) Which role did the experts responsible for context scenarios play in the translation and interpretation of the context scenarios into numerical sets of parameter?

Because the expert for the model was involved in the CI-Process, an intensive discussion of modeling aspect was possible. The quantification was done in close cooperation with the person responsible for context scenario (personal discussions).

D. Potentially 4th central moment: Iteration

5) Has there been iteration from the modeling process back to the CIB or is an iterative step planned?

Until now, no iteration is planned

6) If yes, what was the outcome and how did you deal with it?

E. Further remarks?

e.g.

1) Are there any other special outcomes you can share?
2) Do you already have any hypothesis you can share?
3) Would you rather change anything next time in the process, the compilation of actors,…

Guiding questions
Knowledge integration in different methodological designs – CASE STUDY 2 (C2)

I. Case description (write properly – is direct part of the paper):

1) What is the central question of the project?

The main objective of this project is to develop and apply a new methodology for integrated energy scenario building that combines the classic approach for energy system analysis with social-oriented context scenarios, and in doing this, to translate the motif of "socio-technical" scenarios into the field of national energy transition scenarios. In addition to this, the project aims at including a more comprehensive characterization of infrastructural needs in energy scenarios and to analyze the interrelationship between social drivers and the technological-structural development pathways required for the transformation of the energy system.

2) Definition of goals of the model instruments:
   a) What type of model is/are used? What can be "done" with the model(s)?

MESAP + REMix

The energy system model primarily applied for the project is an accounting framework which is used for years for the building of target-oriented scenarios for Germany (see Pregger et al. 2013). The model represents the energy system with a detailed and transparent data structure. Science-based premises are the most essential part of the methodology applied for defining and modelling development paths in all sectors of the energy system in a consistent and traceable way. Comparing the present situation and targets for the future and taking into account economic, political and social realities, interests, and the resulting barriers and incentives results in consistent development paths which point out required measures for each sector of the energy system to get to this future state. In addition to the scenario model, a high resolution multi-sectoral energy system model is applied for scenario validation in the power sector using a linear optimization approach. This leads to insights into infrastructural needs such as long-term and short-term storages or grid expansions which are usually not covered by scenarios on annual energy supply and at national level.

   b) What is the purpose of the CIB analysis in the project?

The energy model used in the project (like any energy model) requires a set of framework assumptions, e.g. future assumptions about the population, the economic development, the development of technological data and others. Such data implicitly refer to the underlying ideas of the modellers about the overall future of the embedding society. The challenge to ensure analytic quality in the model exercise despite of this unavoidable recourse on societal hypotheses is twofold: i) the set of "socio-technical" assumptions driving the model has to be internal consistent (avoiding explicit and implicit contradictions between the several assumptions); ii) the future uncertainty of such socio-technical assumptions has to represented by developing and applying several different "storylines" about the future of the embedding society and matching socio-technical assumptions. CIB has the role to ensure internal consistency and uncertainty representation in the socio-technical framework assumptions by providing “context scenarios” (Weimer-Jehle et al. 2016). Context scenarios and model-based energy scenarios shall be merged to “socio-technical energy scenarios”).

3) Concerning the CIB:
   a) How many descriptors are “coupling descriptors” and how many descriptors describe societal factors (beyond energy)?

In the project A2, five active and ten passive quantitative descriptors can be coupled more or less directly to the scenario models (including minor assumptions and calculations to adjust descriptors to model parameters). Furthermore, seven qualitative descriptors can be coupled to the scenario models after assumptions on how to quantify the qualitative descriptors. The remaining sixteen descriptors – mainly qualitative – cannot plausibly be translated to model parameters. However, as they affect (via the CI matrix) other descriptors, they act indirectly on the model output. The list of descriptors can be found below.

   b) Please add a list of descriptors and variants

Colour code:

black: descriptor can be coupled more or less immediately with models (if necessary after minor assumptions and re-calculations)
Dark grey: descriptor can be coupled with models after major interpretations/assumptions. Qualitative descriptors have to be interpreted plausibly in a quantitative manner.
Light grey: descriptor cannot be coupled to models

	type	development 1	development 2	development 3	development 4
Overall global development	i	market forces	policy reform	fortress world	eco-communalism
global fossil price pathway ($/bbl oil)	d	100	166	210	
global interest rate (%)	s	0.0%	2.5%	4.0%	
EU integration	i	EU renaissance	nobody cares	EU under threat	
population in 2050 (millions)	d	67.4	72.4	78.7	
GDP growth (% per year)	i	0.6	01. Feb	01. Aug	
employment market development	i	low unemployment, strong transition to flexible working hours	high unemployment, strong transition to flexible working hours	employment market bifurcation	
tertiarization of the economy	s	70%	80%		
innovative capacities of the economy	i	decreasing	stable	increasing	
transnational flows of trade	i	European Germany	European Germany - focus on services	global Germany	re-nationalization
international integration of electricity grids	i	trend towards national self-reliance (regarding capacities)	stronger European transmission network with European self-reliance	trans-European optimization of power supplies (incl. imports)	
development of infrastructures of power transmission and distribution grids	i	undelayed	delayed	strongly delayed	
expansion of renewable energies in the electricity sector (TWh/yr electricity produced in 2050)	d	300	450	700	

Trends of central/decentralized electricity generation and storage	s	trend towards integrating decentralized units into a centralized system	trend towards mixed structures	trend towards the transition to a decentralized system	
regulation electricity market	i	modifications of existing markets (security of supplies via the market)	transition of existing markets (security of supplies via suppliers)	introduction of new markets (security of supplies via the state)	
policy stability in the energy field	i	decreasing	constant	increasing	
governance in the energy field	i	preference for administrative regulations	preference for technology-specific economic instruments	preference for non-technology-specific economic instruments	
governance of infrastructure expansion	i	trend towards coordinated expansion	trend towards non-coordinated expansion		
planning legislation/public infrastructure planning	i	focus on acceleration	focus on legitimation and acceptance	predominance of partial interests	compromise
political guidelines	i	heavier focus on state/public governance	heavier focus on public participation and transparency	heavier focus on market mechanisms	no change
welfare state development	i	heavier emphasis on liberal welfare elements	heavier emphasis on corporatist-statist welfare elements	heavier emphasis on social democratic welfare elements	
income distribution	i	increasing inequality, continuing weak or absent growth of average income	constant/decreasing inequality, continuing weak or absent growth of average income	increasing inequality and increasing average income	constant or decreasing inequality and increasing average income
technology acceptance (energy technologies)	i	decreasing	constant	slightly increasing	heavily increasing
individual energy consumption behaviour[2]	i	trend towards non-involvement	trend towards sufficiency	trend towards technophilia	trend towards sustainability
educational development	i	heavy focus on MINT/low limitations on access	heavy focus on MINT/strong limitation on access	strong focus on general education/low limitation on access	
public attitudes towards the energy transition / NIMBY	i	trend towards positive attitudes	no trend visible	trend towards negative attitudes	
value orientation and objectives of economic development	i	trend towards materialism	trend towards sustainable materialism	trend towards post-materialism	trend towards differentiation

[2] Wir haben im Modell nicht zwischen Nutzerverhalten und Geräteeffizienz unterschieden, sondern arbeiten derzeit (noch) mit dem aggregierten Indikator „Pro-Kopf-Verbrauch". Eine Trennung von Nutzung und Gerät wäre schön. Ansätze dazu gibt's auch schon – eine Praktikantin hat bei uns dazu mal ein Modell entwickelt. Allerdings haben wir das noch nie konkret eingesetzt und getestet. Ob wir das im Rahmen der Energy-Trans-Szenarien einsetzen können, ist fraglich.

Ich habe den Deskriptor jetzt aber mal dunkelgrau hinterlegt, weil es mit Modellerweiterungen und einer Quantifizierung der Ausprägungen durchaus möglich wäre, den Deskriptor ans Modell zu koppeln.

media discourse	**i**	and performance high plurality of opinions/strong trends of tabloidization	high plurality of opinions/weak trends of tabloidization	slight plurality of opinions/strong trends of tabloidization
reduction in energy demand - household appliances (% per year)	**d**	**0.6**	**1.3**	
reduction in energy demand - PC electric vehicles (% per year)	**d**	**0.8**	**1.7**	**2.1**
reduction in energy demand - PC engines (% per year)	**d**	**0.8**	**1.55**	
renovation rate / depth - buildings (private) (% per year / %)	**s**	1.0 / 30	1.5 / 50	2.0 / 70
reduction in energy demand - industry (% per year)	**d**	**1.0**	**2.3**	
reduction in energy demand - commercial sector (% per year)	**d**	**1.5**	**2.5**	**3.4**
expansion of district heating	**s**	no change	strong expansion	
investments in new vehicle concepts and infrastructures	**s**	small (20% of the vehicle market)	moderate (50% of the vehicle market)	high (~100% of the vehicle market)
living trends (m^2 space per head)	**d**	**50**	**55**	**60**
expansion of renewable energy use for heating (TWh per year)	**d**	**250**	**400**	**500**
rebound effects of individual energy demand[3]	**s**	small	moderate	strong

4) How many descriptors are qualitative (=defined by text only), how many are quantitative (=do include numerical definitions, too)?

See question 3

Case characterization: How was the methodological procedure? (only informative – not necessary to write properly)

A. 1st central moment of knowledge integration during the construction of context scenarios

1) What is the societal context that has been chosen to be relevant with regard to the specific problem? (geographic scale and thematic scope)

Geographic: International / European / National (Germany)

Thematic: International - Politics and (Resource)Economy
European - Politics and Energy
National - Economy, Politics, Society, Culture (each including energy and non-energy descriptors). Descriptors address macro, meso and (average) micro-level

[3] Im Prinzip gilt hier ähnliches wie oben – und zusätzlich muss man sich noch überlegen, wie man Rebound in unseren Szenarien abbilden könnte. Im Prinzip haben wir dazu schon einige Ideen, aber sicherlich nicht die Zeit, innerhalb von EnergyTrans viel davon umzusetzen.

2) What type (and how many) actors have been included in which part of the CIB process and how has the process been implemented? (big table in the annex)

Table 1. First central moment of knowledge integration.

1st central moment of KI **during the construction of context scenarios**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Context descriptor selection	3 ZIRIUS staff members (steering) Ca. 80 ET members invited to state their priorities. 28 replies.	Survey	Broad participation opportunity intended
2. Coupling descriptor selection	Nomination by 2 DLR staff members (modelers)	DLR was asked to deliver a proposal	Operability of context scenario / model interface has to be ensured
3. Cross-Impact-Assessments (CI-Einschätzungen)	5 ZIRIUS staff members (interviewers) 67 domain experts from inside and outside of the Alliance	(Mostly) individual interviews	Matrix too large for workshops. Limitation of effort for the experts. Avoidance of group thinking. Better and more comprehensive explanations about CI judgments expected.
4. Selection and assessment of scenarios	3 ZIRIUS staff members (analysis, preparation) 2 DLR staff members (modelers) 2 ITAS staff members (sustainability experts) 67 domain experts (validation)	Scenario pool constructed by software based evaluation. Criteria for scenario selection (out of the pool) found by Internal group discussions and discussions with modelers. Collateral usage of systematic methods (e.g. correspondence analysis) to control diversity coverage. Validation by domain experts (written feedback and workshop) Application of a sustainability indicator system to the scenarios	First draft has to be prepared by method experts (method training required). However, scenarios should "work" for modeling => modelers involved. Third, CIB aims at constructing scenarios which express the views of the experts giving the input => success control via expert feedback required.

    a) Definition experts:
        i) Experts responsible for the model
        ii) Experts responsible for the context scenario study
        iii) Domain experts (which domains?)

3) Did the structure and focus of the model influence the choice of the context?

In a limited extend: yes. The (national) geographical focus of the model leaded us to address the European scale only highly aggregated. The macro level of the model parameters guided us to design the descriptors also on a macro level (and, for instance, not on an actor focused level). Knowing that the core of the model is not optimizing, this gave us more freedom for conceptualizing energy-related factors as context scenario factors (i.e. model input). However, it was not the goal to tailor the context analysis in a very strict sense for the specific model type used in the project - the context scenarios should be able to make some sense also for other models.

4) Handling with dissent and uncertainty
    a) Have there been any ambivalent results from the CIB scenario construction?

Yes - in most cases more than one domain expert were interviewed about a descriptor. In a number of cases we got contradicting statements

    b) If yes, how did you deal with it?

All domain experts contributing to the same descriptor got all interview results. In a Delphi style way they were asked to comment on judgments and explanations showing significant dissent.

5) Have there been any recursive elements within the process?

Descriptor essays were iteratively developed together with respective domain experts

All results of cross-impact interviews were send to the respective domain experts, asking for commendation (Delphi approach).

Scenario results will be send to the domain experts, asking for comments and a scenario validation workshop with domain experts will be conducted.

6) Which role did the experts responsible for the model play in the construction of the context scenarios?

A joint pretest exercise comprising the whole analysis cycle was conducted ("Demonstrator")

Model experts were part of the general descriptor selection process. In particular, they were responsible for defining the direct coupling descriptors.

Descriptor quantification was conducted in close cooperation of DLR and ZIRIUS.

Model experts served as domain experts for a number of (model-related) descriptors.

Model experts advised ZIRIUS in selecting context scenarios for the model exercise.

B. 2nd central moment of knowledge integration: Effects from the CIB analysis on the numerical model (implicit or explicit on system borders, elements, interrelations,…)

1) Did the context scenarios (construction) with CIB method stimulate adaptation or rethinking of the model in any way? If yes, how?

No methodological and structural adaptation of the models themselves

Participation in CIB analysis allows scenario experts to clearer define (a) premises of the scenario development and (b) plausible and consistent definition of the range of possible future transformation pathways.

More explicit consideration of societal factors and context

CIB stimulated more explorative scenario building than before, when we developed scenario variants based on a single set of assumptions for energy demand drivers in order to show how targets could be met (normative scenario approaches), but did not analyse scenarios which fail to meet the targets e.g. due to alternative developments of energy demand drivers.

Participation in CIB process and choice of descriptors could inspire future model developments (e.g. explicit consideration of rebound effect in the models)

Enquiry (E) 1: Do you really mean i) the participation in the process has helped you or do you mean ii) the context scenarios (as a result)? Or is it i) for a) and ii) for b)?

Here at this point it's mostly (i) – participation in the process: Through participation in the CIB exercise we had to reflect much more on previously implicit qualitative premises in our scenario development approach. We also had to reflect on the possible range of quantitative and qualitative descriptors. The context scenario as a result goes one step further and provides a set of consistent socio boundary conditions – urging us to reflect on the interdependency of the context descriptors.

E 2: Do you also mean that you analyze different pathways to meet the goals, some which meet the targets nearly (depending on the story) and some which fail? "Fail" sounds like scenarios are quite far off the targets – some might be close, too.

In the past, we generally developed scenarios which met the targets. However, usually there are many technical solutions which can lead to a reduction of e.g. CO_2 emissions – that's why we refer to normative scenarios (in the plural). The context scenario exercise, however, will result in plausible context scenarios which not necessarily lead to target fulfilment. That's why this approach is more "explorative" (we explore the outcome of different context on the energy system) and less "normative".

2) Was/Is it implemented in a way? If yes, how?

Yes, new and enhanced definition of premises (like EU integration, tertiarization of the economy, international integration of electricity grids, development of infrastructures of power transmission and distribution grids, trends of central/decentralized electricity generation and storage, technology acceptance (energy technologies, ….) and explicit socio-technical path descriptions (Context scenarios + consistent technical storylines, as preliminary stage to the actual modelling results for the socio-technical scenarios) for the “Integrated Scenario Building” project of HGF Alliance ENERGY-TRANS

Explorative approach for scenario building: Analysis of scenarios without target compliance

3) If no, why was it not implemented?

Context scenarios and their descriptors were not implemented completely and directly because descriptor scope is much broader than scope of parameters needed/implementable in the DLR energy scenario models

Difficulties in plausible quantitative interpretation of qualitative (in particular social) descriptors

Only limited set of indicators (coupling descriptors) that could be linked with quantified model parameters.

4) Who (and how many) actors have been included in which part of the process and how has the process been implemented?

Implementation was discussed between DLR and ZIRIUS, 2 to 3 persons of each institute.

a) Experts:
    i) Experts responsible for the model: 2
    ii) Experts responsible for the context scenario study: 2-3
    iii) Domain experts (which domains?)

energy scenario construction and assessment (DLR): engineer + physicist

context scenario construction and assessment (ZIRIUS): geographer + social scientist + physicist

domain experts - descriptor selection: 28 (economics, energy, jurisprudence, political science, psychology, social science)

domain experts – 50 (culture, demography, economics, energy, jurisprudence, political science, psychology, social science)

Table 2. Second central moment of knowledge integration.

2nd central moment of KI: **Effects from the CIB analysis on the numerical model**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Interpreting context scenarios concerning model premises on context	2 model experts plus feedback from CIB experts	Individually plus discussion/review (reflection of the actors)	Practicability, specific insights into scenario building process needed
2. Possibly adapting or shaping the energy model or deciding not to do so	2 model experts	Individually plus discussion/review	Practicability, specific insights into scenario building process needed

3. Others?	Review by senior scientist/scenario expert (DLR)	individually	

5) Which role did the experts responsible for context scenarios play in the adaptation or rethinking of the model?

With respect to premises: Discussion if conclusions derived from CIB and adaptation for new premises is consistent and robust/supported by CIB results and background knowledge.

With respect to model adaptation: no role

C. 3rd central moment: Translation of context scenarios into input data sets (and model parameter/bounds…)

1) In which specific phase did the quantification take place in the process?
   a) And how was the quantification put into practice?

At the stage of descriptor and variant choice: discussion of descriptors and variants between CIB experts and scenario modellers, if possible: choice and quantitative description of variants according to model requirements (central model parameters should be included in a quantitative manner in the descriptor/variant list).

At the stage of (energy) scenario development: Some quantitative descriptors/variants refer directly to model parameters and can be implemented without (or with only minor) additional assumptions. Some (mostly) qualitative parameters can be translated to quantitative model parameters using plausibility arguments. Plausibility arguments include background knowledge of scenario modellers.

2) How strictly did you stick to initially made quantifications during the process (e.g. in model runs)?

Some slight modifications were done in order to integrate current background knowledge and after discussions/reviews

3) What type of (and how many) actors have been included in which part of the process and how has the process been implemented?

2-3 energy modelling experts for translation of context scenarios into input data sets plus evaluation of external literature/studies and previous energy scenarios.

External reviews: 2-3 experts from ENERGY-TRANS

E 3: What do you mean? Was is about the already made quantifications, which we found in the energy study research or was it about qualitative descriptors, which might be quantified under specific circumstances (grey descriptors in the list above)?

Here, the possible range of values/ range of possible assumptions for single parameter respectively the implementation of single technical-structural solutions. That means, the black as well as the dark grey descriptors from the list as well as further differentiated assumptions in the energy system, which are not directly described with the descriptors (e.g. expansion of wind power onshore in Southern Germany)

a) Experts:
   i) Experts responsible for model
   ii) Experts responsible for the context scenario study
   iii) Domain experts (which domains?)

Table 3. Third central moment of knowledge integration.

3rd central moment of KI: **Translation of context scenarios into input data sets (and model parameter/bounds…)**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Quantification of quantitative data	3 experts for context scenarios 2-3 model experts	Energy scenario study evaluation, discussions with model experts	To get an image of the “range of uncertainty/ possibility” of different parameter which is assumed in the energy community
2. Quantification of qualitative data	2-3 model experts	Discussions/reviews and evaluation of literature/studies/previous scenarios	In order to include and reflect the current thinking about the range of possible futures for each quantifiable parameter
3. Possible revision of quantifications	2-3 model experts within EnergyTrans, possibly external reviews for selected parameters	Individual reviews	Practicability, no expert can assess all quantifications
4. Recommendations for further model restrictions (bounds)	2-3 model experts	individually	You mean quantitative limits in the energy scenario on the basis of the interpretation of the context scenarios? This I could imagine at one point or another in the scenarios, especially if they reflect specific technical options very unilaterally.
4. Others?			

4) Which role did the experts responsible for context scenarios play in the translation and interpretation of the context scenarios into numerical sets of parameter?

Initial proposal and integration of quantifications (see box 3rd moment of knowledge integration: quantification of quantitative data) for central parameters into the descriptor/variant descriptions in CIB.

Discussions during the demonstrator test phase

Contribution to the final review process (informal discussion/workshop to discuss procedure and results of interpretations/quantifications)

D. Potentially 4th central moment: Iteration

1) Has there been iteration from the modeling process back to the CIB or is an iterative step planned?

Demonstrator to test interfaces, possibilities and challenges to link CIB and the energy model → subsequently a "full" version was operationalized.

2) If yes, what was the outcome and how did you deal with it?

A (limited) iteration of the process was implemented by conducting a pretest ("Demonstrator") in prior to the full-scale analysis. All expert judgements were made by the project group during the pretest and a simplified model was used. The aim of the pretest was to exercise the cooperation between the two involved scenario methods and to identify potential problems of the hybrid analysis approach.

Iteration before modeling and CIB process for selecting, substantiating and describing relevant descriptors and variants in order to identify coupling descriptors and suitable interfaces between CIB and the energy model.

An iteration would be helpful in the case that a certain variant does not appear in any of the consistent context scenarios, but has been identified as potentially important aspect of a future energy supply. This has been e.g. the case for the CSP import variant in I3. In cases like this the CI matrix has to be closely analysed which factor/sensitivity is responsible for this outcome and WHY this option seems not to be consistent/realistic in order to draw robust conclusions from the absence of this option in any consistent context scenario.

No further iterations after modelling process intended (lack of time, requires probably complex adaptations…).

E. Further remarks?

e.g.

4) Are there any other special outcomes you can share?
5) Do you already have any hypothesis you can share?
6) Would you rather change anything next time in the process, the compilation of actors,…?

For some descriptors/variants a common understanding or unambiguous interpretation seemed to be not ensured. Could be solved/improved in a next study by workshops rather than by individual interviews?

Guiding questions
Knowledge integration in different methodological designs – CASE STUDY 3 (C3)

I. Case description (write properly – is direct part of the paper):

1) What is the central question of the project?

The project regional modeling concentrates on shedding some light onto the regional idiosyncrasies of the German energy transition, particularly at the level of the regional planning region (DE: "Raumordnungsregion") that normally consists of several municipalities. It does so by modeling scenarios for selected regional planning regions, from the current state to possible future states (up to 2030 as well as an outlook on further development) of the electricity, heat and mobility demand and supply. By this we seek to support regional and national decision makers (e.g. industry, NGO, policy, administration).

2) Definition of goals of the model instruments:
   a) What type of model is/are used? What can be "done" with the model(s)?

Multiple sub-models (economic Input-Output, logit car ownership model, mathematical optimization of electricity and heat supply, life cycle assessment) are combined in this project in order to quantify the regional impact of the energy transition on the environment, economy and mobility and vice versa. In the following the main outcomes are pointed out:

- gross value-added, employment, wages and revenues as well as regional spill over and feedback effects
- demand on electricity and heat of different economic sectors
- final energy demand of the passenger transportation in passenger kilometers (pkm) based on vehicle fleet composition and specific data on fuel consumption
- infrastructure investments in electricity and heat supply systems
- environmental burdens in 13 different environmental categories based on a material flow model of electricity, heat and mobility supply

   b) What is the purpose of the CIB analysis in the project?

We applied a two stage scenario approach. First we utilized the national and international scenario exercises of the project groups C1 and C2 to gain insights in possible future developments of the international and national framework assumptions. Out of these scenarios we selected one scenario ("grüne Welt") and conducted for this a scenario assessment for the selected regions. The regional scenario descriptors were compiled in order to allow for the consideration of regional developments that could differ from the national average (e.g. population growth), as well as to consider developments that are decisive mainly at the regional level (e.g. social infrastructure). The CIB facilitates an enhanced understanding of the regional socio-technical system behavior and achieves a harmonization of the individual sub-models at the end.

3) Concerning the CIB:
   a) How many descriptors are "coupling descriptors" and how many descriptors describe societal factors (beyond energy)?

The model uses 6 coupling descriptors (population, economic growth, share of wind and solar energy, biomass production for energetic use, building retrofit) directly as input factors. Two descriptors describe societal factors (regional political structure and societal infrastructure)

b) Please add a list of descriptors and variants

Descriptors	Variants		
Population	pessimistic	neutral	optimistic
Economic growth	pessimistic	neutral	optimistic
Regional structure of politics	cooperative	parallel	
Wind energy	weak	strong	
Biomass production for energetic use	weak	strong	
Solar energy	weak	strong	
District Heating	weak	strong	
Building retrofit	none	low	high
Social infrastructure	insufficient	abundant	

4) How many descriptors are qualitative (=defined by text only), how many are quantitative (=do include numerical definitions, too)?

See Question 3a)

Case characterization: How was the methodological procedure? (only informative – not necessary to write properly)

A. 1st central moment of knowledge integration during the construction of context scenarios

1) What is the societal context that has been chosen to be relevant with regard to the specific problem? (geographic scale and thematic scope)

Regional scale (regional planning region (DE: “Raumordnungsregion”))

With the CIB we attempt to get a total overview of regional development related to all energy services and their actors (i.e. electricity, heat and mobility regarding demand and supply, structure of politics)

At the moment we investigated only scenarios consistent with the “Green World” scenario on national level, because a) in this future the Energiewende is successful and b) – a practical reason – most of the scenarios on national level need a different CIB on regional level (descriptors as well as CI assessments)

Enquiry (E) 1: Have expectations been fulfilled?

This cannot be finally answered at this time, because there are no complete modelling results available yet and reflection has not taken place yet. However, the application of CIB has led to a structured procedure, sensitization for the methodology of scenario analysis and modelling as well as for regional development. On a critical note, it has to be pointed out, that not all process participants have contributed to the CIB, that there has been no contact to external experts or stakeholders of the regions. Furthermore, there have been planned to little resources for this process step in the project description from the outset.

2) What type (and how many) actors have been included in which part of the CIB process and how has the process been implemented? (big table in the annex)

1st central moment of KI **during the construction of context scenarios**	How many and which actors?	How was it implemented (workshop, individually, combinations,...)?	Reasons?
1. Context descriptor selection	The actors consisted mainly of the project group (5 persons*)[4], everybody is in some kind involved in modeling	~ 3 workshops, several audio conferences and individual expert interviews	At the beginning of the project a scenario analysis was scheduled, but yet no specific method was selected. As the CIB analysis seems to support a reproducible and transparent approach, we decided during the scenario development to employ this method.
2. Coupling descriptor selection	Individual modelers* in discussion with the overall project group	3 workshops, several audio conferences	These direct input factors affect mainly the results. So it is important to know the interdependencies to the other descriptors.
3. Cross-Impact-Assessments (CI-Assessments)	Just the core group (3 persons*), but with exhaustive communication with the other group members and ENERGY-TRANS partners	Literature review, expert interviews within ENERGY-TRANS members. Especially 2 CIB experts* and regional planners (2 experts*), but also experts from the own institution working on specific topics (e.g. Biomass) (2 experts*)	Create a scientific basis for validation of the arguments; to handle the CI assessment values from -3 to +3 experience from CIB experts are needed

[4] The names of the persons are known the authors, but are not listed here due to anonymity reasons. This applies also for other the rest of the document, when actors/persons/experts/modelers/colleagues are mentioned and is marked with *.

4. Selection and assessment of scenarios	Project group (5 persons*)	Workshop of the project group (5 persons*)	Practical reasons; Decision of the project group to select one consistent scenario

a) Definition experts:
   i) Experts responsible for the model
   ii) Experts responsible for the context scenario study
   iii) Domain experts (which domains?)

3) Did the structure and focus of the model influence the choice of the context?

Since we try to capture a broad range of aspects with a bunch of models, the CIB also needs to have a very broad view. This broad view with regard to different context aspects, however, is limited by not investigating qualitative extreme different futures (just "Green World", no collapse of the region, no economic system changes)

4) Handling with dissent (between experts) and uncertainty
   a) Have there been any ambivalent results from the CIB scenario construction?

Due to the small scenario group and only a few expert interviews we did not have dissent or ambivalent results, but we got knowledge about the relevance of different descriptors. For example, the consistent scenarios show that a story of a shrinking region (negative population and GDP development) nonetheless can fulfill the goals of the "Energiewende".

So far there has been just a very small tableau of fully consistent scenarios. These scenarios were very plausible.

> E 2: Do I remember right, that modeler 1* and modeler 2* had a different opinion concerning one impact assessment? I think the question was, if a shrinking regional population has a fostering impact on the expansion of renewables (people could see this as economic opportunity) or a hindering impact (it´s not worth it any more to invest).

Actually you are right. But the result of the discussion was that the descriptor „expansion of renewables" was split into the different energy sources (wind, energetic use of biomass and PV) and was defined more specific.

> E 3: With „relevance of different descriptors" do you mean relevance for e.g. the interpretation of path dependencies? Like, a shrinking population is not determining the success or failure of the energy transition?

Yes, but also the relevance of different descriptors. E.g. to balance a shrinking population development and therefore to ensure the expansion of RE to a certain degree (successful energy transition) the descriptor „political structure" needs to be „cooperative" to other actors, too.

> E 4: But you calculated only ONE scenario out of the tableau. If I remember right, this was because the logic of CIB conflicted with the logic of other applied models (e.g. the Input-Output model)?

Yes, but also because we didn´t find an adequate database for all descriptor variants. E.g. there exists only one variant of the population development which describes population loss until 2030. If the actual migration flows have influence on the prognosis is answered only qualitatively and is not implemented in the population prognosis through a parameter.

b) If yes, how did you deal with it?

By making our CI assessments we mainly depend on literature review, but for the estimation of cross impacts where we presumed a connection, but couldn't find a citation, we made nonetheless a judgment. For a few cross impact estimations different values (from 1 to 3) are used in a kind of sensitivity analysis.

5) Have there been any recursive elements within the process?

Yes, we divided the descriptor "Development of Renewable Energy" up into three descriptors representing the different energy carriers (wind, solar, biomass), because we investigated different interplays.

There will be iteration between CIB (not only CI assessment but also descriptor selection) and model building and vice versa.

6) Which role did the experts responsible for the model play in the construction of the context scenarios?

The experts* responsible for the optimization model (electricity and heat supply pathways) and for the overall regional model (coupling of different sub-models). They were the main drivers to employ the CIB method. Also they were the main moderators of this process.

B. 2nd central moment of knowledge integration: Effects from the CIB analysis on the numerical model (implicit or explicit on system borders, elements, interrelations,…)

1) Did the context scenarios (construction) with CIB method stimulate adaptation or rethinking of the model(s) in any way? If yes, how?

Yes, in general with regard to the significance of the results (not concerning the context analysis, but concerning the results of the individual sub-models and their integration in the entire modell) for the entire model and each sub-model.

E 5: Did the CIB stimulate the integration of even further model(s) or was this planned from the outset? Has the combination of these very models been planned from the outset or was it a different combination initially?

The variety of models and also specific models (coupled with project partners) have been planned already from the outset and described in the project description: to get a joint scenario framework we then applied CIB. Over the course of the project a system-dynamics model was newly integrated for the analysis of the dynamics of energetic building retrofit of private households.

E 6: Did the results stimulate the rethinking of the set of models or rather the process of contstructing the scenarios, meaning for example the discussions, the research etc.

I think, mostly it was the construction of the trends and the research on the impact assessments.

E 7: Same question for the next point:

Yes, modeler 1* tries to rethink the framing of his optimization model.

E 8: Does this mean that the structure of the model was NOT adapted, but the "interpretation" of the model results is a different one, right?

Yes, the interpretation is a different one as meant at first. But I´m still reflecting, if I need to adapt input variables, too (like taxes, requirements of reserve capacity of RR) to really serve the adapted interpretations.

The results of the optimization model are not interpreted as realistically possible future developments (to this it would be necessary to illustrate the investment behaviour of different actors), but as an analysis of techno-economic system connections of individual technologies

2) Was it implemented in a way? If yes, how?

Behavior of residential homeowners as decision makers on energetic building retrofitting is included as a separate sub-model.

3) If no, why was it not implemented?

For the other modelers it was more difficult to implement changes as these models were already established (meant is a fleet model and a regional economic input-output model) and - maybe more important - they had not the freedom (institutional and/or individual) to scrutinize their own approach.

4) Who (and how many) actors have been included in which part of the process and how has the process been implemented?
   a) Experts:
      i) Experts responsible for the specific model

Yes

      ii) Experts responsible for the context scenario study

Yes, because they are the same as in i)

      iii) Domain experts (which domains?)

We got in touch (meaning that we had recurring discussions) with two colleagues* - philosophers - of our institute to get the epistemology of our models and the connection thereof right, but it is still in work.

2nd central moment of KI: **Effects from the CIB analysis on the numerical model**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?

1. Interpreting context scenarios concerning model premises on context	2 Persons* which are modelers; they are responsible for the project	Individually	Practical reasons, because we have yet no results of the entire model.
2. Possibly adapting or shaping the energy model or deciding not to do so			
3. Others?	-	-	-

5) Which role did the experts responsible for context scenarios play in the adaptation or rethinking of the model?

The experts initiating and leading the context scenario analysis are also modelers (as mentioned above) and therefore could directly make changes in their understanding of their own sub-models.

E 8: How do the changes look like? Did the changes also affect the data level or did they lead to a better „explicit" understanding of the model (explicit confrontation of model assumptions), but not to a change on the data level (e.g. through new, adapted model assumptions)

Herewith, the new interpretation of the optimizing energy system model is meant, as mentioned above, but also discussions about data sources as input data for the models, which finally lead to the new modelling activities of our colleague* (energetic building retrofit of private residential buildings).

Regarding the other models (fleet model and input-output model) applied in this project they started a discussion (by now there are no changes apparent) on model inherent assumptions (= making implicit model assumptions explicit)

C. 3rd central moment: Translation of context scenarios into input data sets (and model parameter/bounds...)

1) In which specific phase did the quantification[5] take place in the process?

We directly quantified (through literature research and for economic growth we made an own regression analysis with historic values of the last 10 years) the quantitative descriptor variants, while we were evolving these. This decision depends on the background that all involved actors are modelers.

Since for now all coupling descriptors are quantitative, we have no problem with translating qualitative in quantitative future developments -> that is one of the initial motives of the CIB exercise: connecting qualitative and quantitative factors (model parameters)
More specific, the integration of qualitative statements is meant e.g. for the political structure (cooperative vs. uncooperative) and its effects e.g. on the expansion of RE, which is easier to quantify and as parameter can be integrated in the energy system model in the first place.

[5] Assigning quantitative numbers to qualitatively formulated future perspectives, e.g. 0,6% economic growth to "low economic growth"; 1,2% to "moderate economic growth" and 1,8% to "high economic growth"

a) And how was the quantification put into practice[6]?

2) How strictly did you stick to initially made quantifications during the process (e.g. in model runs)?

For now, we stick strictly to made quantifications, but modeler 1 thinks of making traditional parameter variations/sensitivity analysis

Each descriptor variant has a bandwidth for itself, maybe even overlapping with the other variants, so we need to investigate the sensitivity of our sub-models (classic sensitivity analysis for each single input parameter)

E 9: This „bandwidth" was it intended from the start and included so to say in the „stick strictly to made quantifications" – do I understand right that "strict" means "within this bandwidth" and not tied to a single number?

Sorry for the misleading formulation: this is only my own view (modeler 1). We have assigned to all of the variants an exact value! But we are of the opinion that a bandwidth would be better. The sensitivity of the models concerning this assumed bandwidth of a variant would then have to be reviewed, however.

3) What type of (and how many) actors have been included in which part of the process and how has the process been implemented?
   a) Experts:
      i) Experts responsible for model

Yes, all modelers are included

      ii) Experts responsible for the context scenario study

Yes, because JB and AR are also modelers

      iii) Domain experts (which domains?)

3rd central moment of KI: **Translation of context scenarios into input data sets (and model parameter/bounds…)**	How many and which actors?	How was it implemented (workshop, individually, combinations,…)?	Reasons?
1. Quantification of quantitative data	Done by modeler 1 and modeler 2 with support by the others		
2. Quantification of qualitative data	project group (5 persons*), nearly everybody has model responsibility	Workshop, Mail	Practical reasons
3. Possible revision of quantifications			

[6] Description how you did it e.g. were numbers already included in the descriptor description or have they been defined after the finalization of context scenarios…

4. Recommendations for further model restrictions (bounds)			
5. Others?			

4) Which role did the experts responsible for context scenarios play in the translation and interpretation of the context scenarios into numerical sets of parameter?

See above 1)

D. Potentially 4th central moment: Iteration

5) Has there been iteration from the modeling process back to the CIB or is an iterative step planned?

It is a co-evolution of CIB and models -> i.e. the descriptor set (especially with regards to coupling descriptors) is not finished yet, since we still develop our models further on.

6) If yes, what was the outcome and how did you deal with it[7]?

Currently we found not an inconsistency, because we selected only one consistent scenario on national level ("grüne Welt") for modeling.

E 10: Did you find any inconsistencies? If yes, did you refine the context scenarios and repeated the model runs? Or… whatever?

To be more precisely: the input data processing for the optimization program

Further remarks?

Different SAS approach then in the other project groups: First we open up the future space by employing the CIB method and constructing context scenarios, so we investigated/showed the variety of future states, then we choose ONE context scenario for modeling

This was done due to

- practical reasons: time, data availability (e.g. prognosis of population development)
- methodological reasons: the rationale of the individual sub-models does not fit to every context scenario (e.g. in an Input-Output Model extrapolation of today's interrelationship of economic sectors for the scenario of a shrinking region)

Stakeholder workshops are planned when first results of the entire model are calculated

Lessons learned: Time consuming -> separation of the tasks context scenario development and computer modeling

[7] Did you find any inconsistencies? If yes, did you refine the context scenarios and repeated the model runs? Or… whatever?

Further research:

To model all other consistent scenarios of future regional development within the “Green World” (Case study 1) scenario on national level.

To investigate other framework assumptions (other context for possible future developments) of the “Grey World” or “convergence” with the entire constructed model.

e.g.

7) Are there any other special outcomes you can share?

8) Do you already have any hypothesis you can share?

9) Would you rather change anything next time in the process, the compilation of actors