DEVELOPMENT AND APPLICATION OF SOCIO-ECONOMIC SCENARIOS

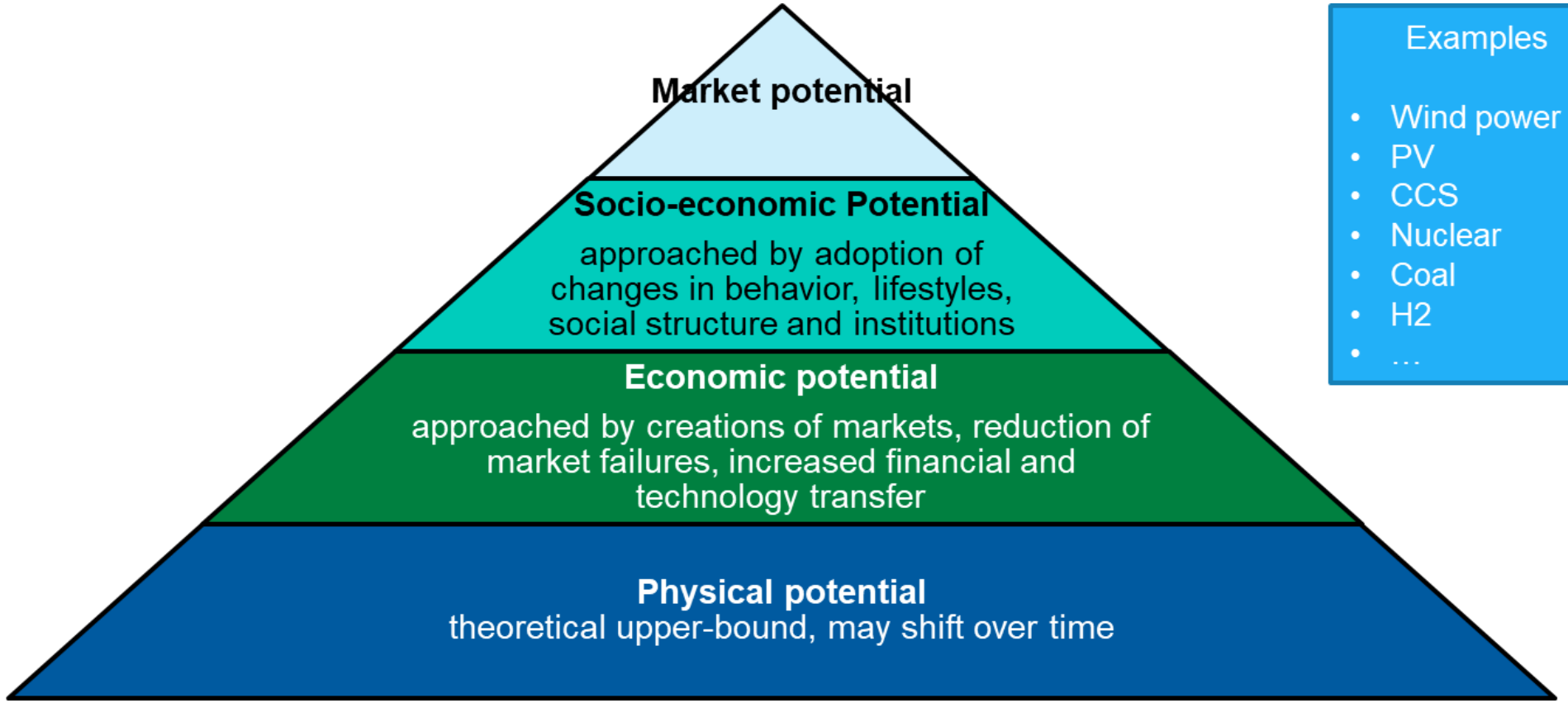
09.06.2022 I STEFAN VÖGELE

1. INTRODUCTION

- Does „socio-economics” count?
- Why do we need socio-economic scenarios?

1. INTRODUCTION

POTENTIALS AS LIMITING FACTORS



Examples

- Wind power
- PV
- CCS
- Nuclear
- Coal
- H2
- …

1. INTRODUCTION

SOCIO-ECONOMICS FACTORS FRAMING ENERGY DEMAND AND SUPPLY

	Determining factors (1st order)	Determining factors (2nd order)
Private households	Demand for living space	Individual preferences, prices, income
Mobility	Car purchases and use of cars	Individual preferences with respect to e.g., design, comfort, safety, environmental awareness, prestige/image, power, fuel prices
Industry	Investments in technologies, use of them	Preferences with respect to e.g., targeted profit rate, risk, expectations on development of markets

1. INTRODUCTION

SOCIO-ECONOMICS FACTORS FRAMING ENERGY DEMAND AND SUPPLY

- **Risk perception, attitudes toward risks**
  - Geopolitical risk
  - Financial risk
  - Technological risk

Perception and attitudes differ among stakeholders!

- **Prioritization of policies**
  - Focus economic stability, employment
  - Focus environment protection
  - Focus international cooperation

Government on national and local level as well parties have different interests.

CHALLENGES FOR DEVELOPMENT OF SOCIO-ECONOMIC SCENARIOS

Need to deal with multiple factors on different scales:

- **Policies:** How to assess future priority settings? Priority to reduction of GHG emissions, economic growth, increase in welfare, fairness? R&D activities?
- **Prices:** More than „cost“, end user prices as relevant factor, internalization of technological and geopolitical risks
- **Preferences of stakeholders:** Acceptance of technologies and policy measures, Greta-Effect? CCS?

Challenges

- Identification of relevant factors (quantitative and qualitative factors)
- Assessment of meaning of qualitative factors
- Specification of interactions between factors
- Transformation into quantitative figures

Approaches

- Workshops, consulting processes (e.g. „Netzentwicklungsplan“)
- Cross-Impact-Balance (approach for systematic construction of qualitative scenarios)
- …

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Basics of CIB

- Identification of “descriptors” reflecting elements of the system under consideration
- Specification of 2 to 4 possible “states” (manifestations) for each descriptor
- Adjustment of interlinkages between states
- Balancing of impacts promoting or hindering mantifestations

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Descriptors

- Qualitative and quantitative factors
- E.g., political framework, acceptance of technologies, environmental engagement, fuel prices, economic growth, cost

Example for descriptors

Growth of GDP (global)

International climate change policy

Trade restrictions

Innovation dynamics

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Descriptor states

- Usually limited to 2 to 4 manifestations showing different possible outcomes for descriptor
- E.g. low, medium, high, „Incremental“, „Increasing“, constant, increasing, 5%, $150

Example for descriptor states

Growth of GDP (global)
slightly increasing
strongly increas.

International climate change policy
ambitious
less ambitious

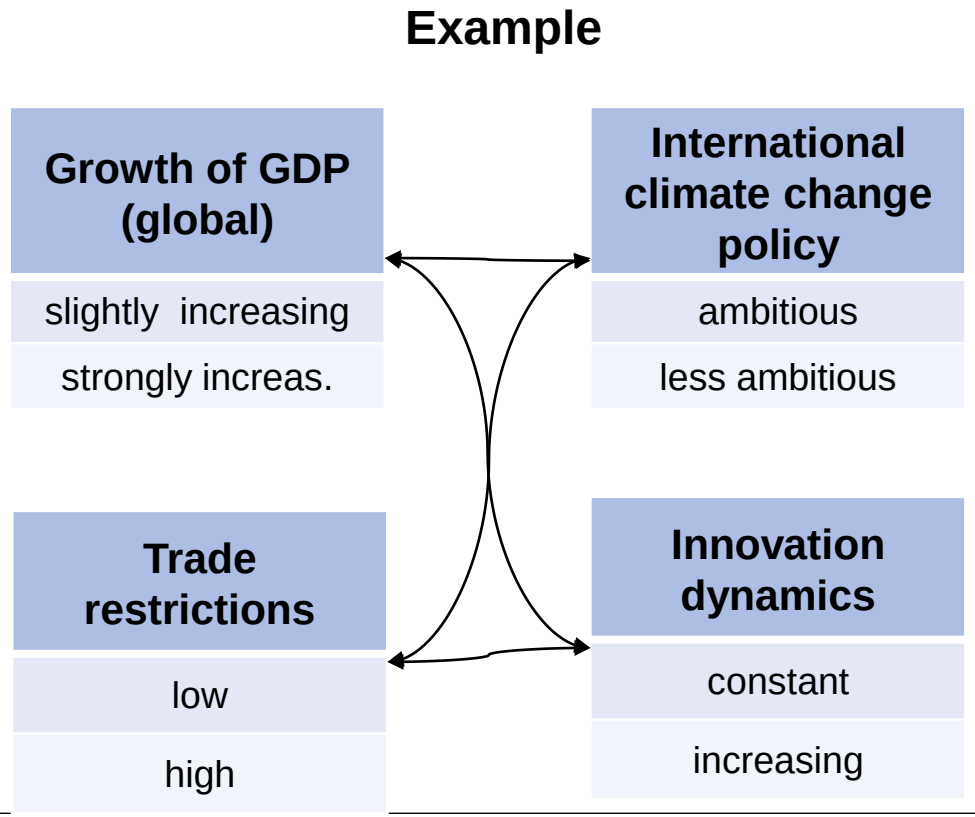
Trade restrictions
low
high

Innovation dynamics
constant
increasing

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Interdependencies among descriptors‘ states

- Descriptor states promote or hinder each other
- Relationship between descriptor states varies from strongly restricting to strongly promoting another state
- Usually scale from -3 (strongly hindering) to 3 (strongly supporting) with 0 as neutral



2. DEVELOPMENT SOCIO-ECONOMIC SCENARIOS

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

	Growth			GHG Poll			Trade			Inno	
	sl	str		amb	less		low	high		con	inc
Growth of GDP (global)											
slightly increasing				2	-2		1	-1		1	-1
strongly increase				3	-3		-1	1		-2	2
International climate change policy											
ambitious	1	-1					0	0		-2	2
less ambitious	-1	1					0	0		0	0
Trade restrictions											
low	-2	2		0	0					-1	1
high	3	-3		0	0					1	-1
Innovation dynamics											
constant	2	-2		-2	2		-1	1			
increasing	-2	2		2	-2		1	-1			
Balance	-3	3		2	-2		1	-1		-3	3

Balance: Scenario consistent when no other variant‘s impact sum > impact sum of selected variant: this scenario is consistent!

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Typical outcome of CIB analysis using the CIB software ScenarioWizard

Scenario No. 1	Scenario No. 2	Scenario No. 3
Growth of GDP (global): slightly increasing		Growth of GDP (global): strongly increas
International climate change policy: ambitious	International climate change policy: less ambitious	International climate change policy: ambitious
Trade restrictions: high		Trade restrictions: low
Innovation dynamics : constant		Innovation dynamics : increasing

2. DEVELOPMENT SOCIO-ECONOMIC SCENARIOS

EXAMPLE: CROSS-IMPACT-BALANCE ANALYSIS

Strength	Weakness
• Able to integrate qualitative and quantitative knowledge • Reduces risks of inconsistencies and incompleteness compared with intuitive scenario construction. • More traceable, objective, and reproducible than intuitive approaches • Learning effects resulting from discussions on (inter)disciplinary scenario teams	• Restricted number of descriptors (typical size 10-20) => high aggregation level • Conditioned influences are difficult to represent by pair wise impact assessments • Coding by experts or by interpreting literature is not free of subjectivity and uncertainty. • CIB storylines usually cannot completely define a model run: additional reasoning and interpretation required

Examples for applications:

I. Provision of consistent framework data for e.g., techno-economic models (context scenarios)

II. Development of socio-techno-economic scenarios

III. Consistency check of storylines

3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS
I. PROVISION OF CONSISTENT FRAMEWORK DATA

Research topic:

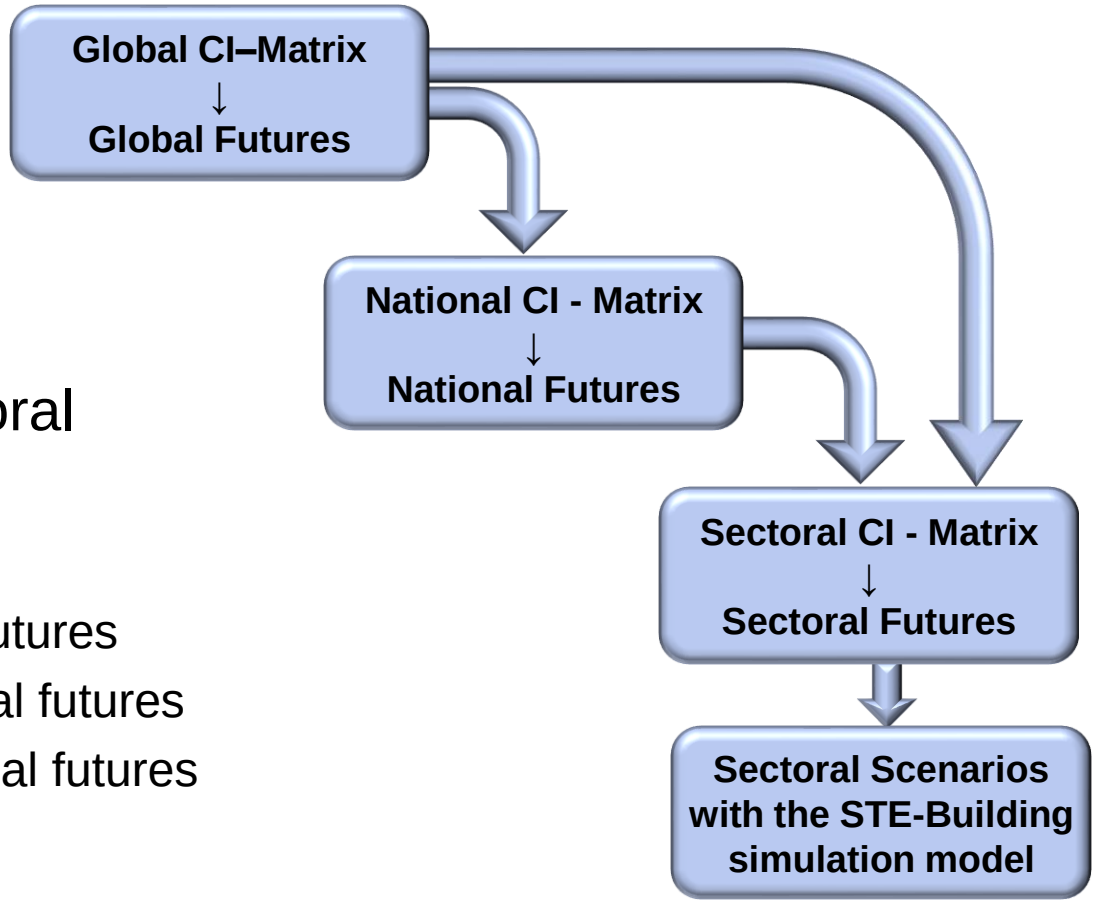
Futures of energy consumption of private households

II. PROVISION OF CONSISTENT FRAMEWORK DATA

CIB Multilevel approach

Use of information on drivers, interactions and resulting impacts on global, national and sectoral

19 descriptors on global level ➔ 13 scenarios/5 global futures
23 descriptors on national level➔ 51 scenarios/5 national futures
16 descriptors on sectoral level ➔ 10 scenarios/7 sectoral futures



3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS

II. PROVISION OF CONSISTENT FRAMEWORK DATA

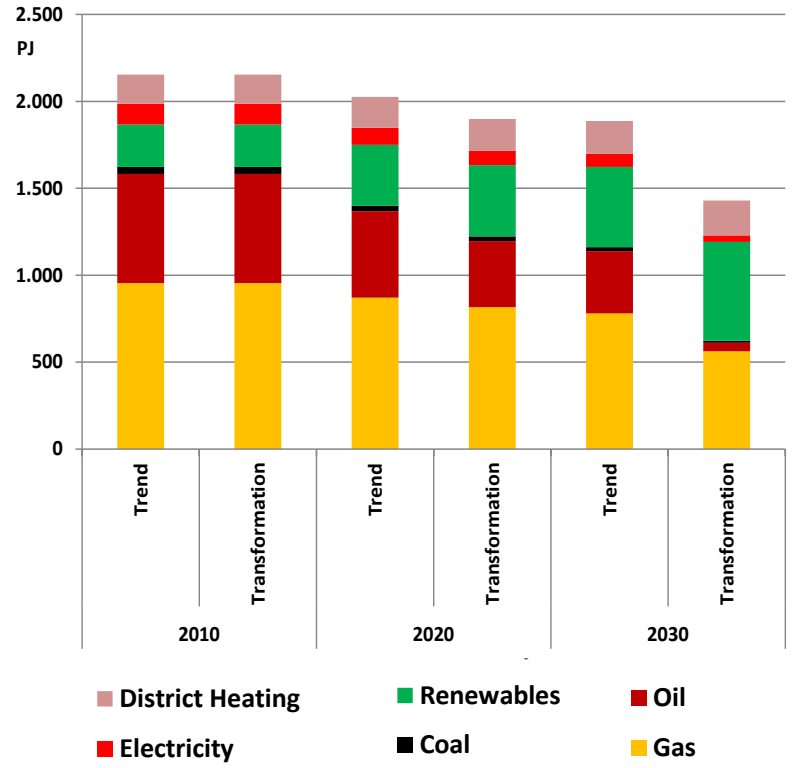
	Future I “Dark Green”	Future II “light grey”	Future III “Green”	Future IV “Green mod”	Future V “Black”
Set of futures	**[Global Future I, National Future II Sectoral Future IV]**	**[Global Future II, National Future I Sectoral Future I]**	**[Global Future III, National Future III Sectoral Future V]**	**[Global Future III, National Future IV Sectoral Future VI]**	**[Global Future IV, National Future V Sectoral Future VII]**
Growth of GDP (global)	str. incr.	strong increase	str. incr.	str. incr.	str. incr.
Growth of GDP (Ger.)	str. incr.	strong increase	str. incr.	str. incr.	str. incr.
Population	slight dec.	slight decline	slight decline	slight decline	slight dec.
International climate policy	EU as Forerunner	EU as Forerunner	EU as Forerunner	EU as Forerunner	EU as Forerunner
CO_2-reduction policy EU	new amb. targets	new mod. targets	new amb. targets	new amb. targets	new mod. targets
Climate change/energy policy (national)	focus ambitious CO_2 reduction	focus moderate CO_2 reduction	focus ambitious CO_2 reduction	focus ambitious CO_2 reduction	focus mod. CO_2 red.
Expansion of electr. grid	restrained	unrestrained	unrestrained	restrained	unrestrained
Energy demand: Priv. households	strong decline	grad. decline	grad./str. decline	strong decline	grad./str. decline
Energy demand: Ind.	strong decline	grad. Decline	grad./str. decline	strong decline	grad./str. decline
Fuel prices	strong increase	strong increase	moderate increase	moderate increase	moderate increase
Use of Renewables	strong increase	moderate increase	strong increase	strong increase	moderate increase
Energy perfor. (build.)	high	medium	medium	medium	medium
Rental charge/price of buildings and flats	increasing	const.	constant	constant	constant

3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS

PROVISION OF CONSISTENT FRAMEWORK DATA

	Scenario Trend	Scenario Transfor.
Future used as frame	Future “Black”	Future “Dark Green”
Growth of GDP (Germany)	1.0 %/year	1.0 %/year
Oil price	125$/bbl	175$/bbl
Population	79.0 million	79.0 million
CO_2-reduction policy EU	-30 %	-40 %
Climate change/ energy policy	-40 %	-60 %
Innovation dynamics	1.0 %/year	2.0 %/year
Fuel prices	1.5 %/year	3.0 %/year
Use of Renewables	30 %	50 %
Energy performance of buildings	140 kWh/(m²a)	100 kWh/(m²a)
Rental charge/ price of buildings	1.5 %/year	2.5 %/year

Final energy consumption for space heating and hot water



3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS

II. DEVELOPMENT OF SOCIO-TECHNO-ECONOMIC SCENARIOS

Research topic:

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Dissemination of PV-Battery systems in the German residential sector up to 2050: Technological diffusion from multidisciplinary perspectives

Stefan Vögele [a, *], Witold-Roger Poganietz [b], Max Kleinebrahm [c], Wolfgang Weimer-Jehle [d], Jesse Bernhard [a], Wilhelm Kuckshinrichs [a], Annika Weiss [e]

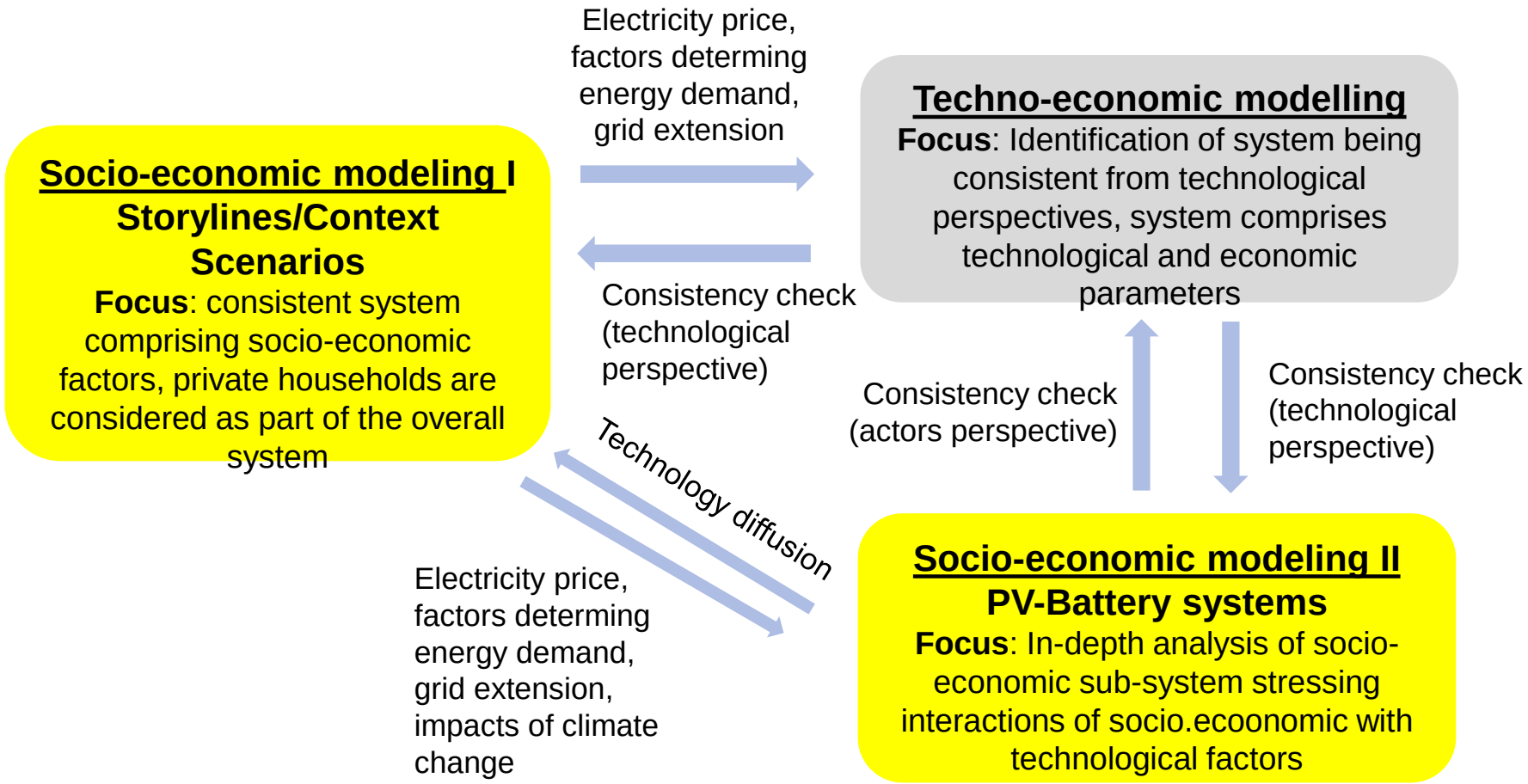
[a] Forschungszentrum Jülich, Institute of Energy and Climate Research – Systems Analysis and Technology Evaluation (IEK-STE), 52425, Jülich, Germany
[b] Karlsruhe Institute of Technology, Institute for Technology Assessment and Systems Analysis (ITAS), 76021, Karlsruhe, Germany
[c] Karlsruhe Institute of Technology, Institute for Industrial Production (IIP), Chair of Energy Economics, 76131, Karlsruhe, Germany
[d] Stuttgart Research Center for Interdisciplinary Risk and Innovation Studies (ZIRIUS) University Stuttgart, 70174, Stuttgart, Germany
[e] 76131, Karlsruhe, Germany

Future of PV-Battery systems in the German residential sector up to 2050”

➔ Which techno-economic scenarios are feasible from socio-economic point of view and vice versa?

3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS
PROVISION OF CONSISTENT FRAMEWORK DATA

Approach



3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS
PROVISION OF CONSISTENT FRAMEWORK DATA

Results

		Storyline/context scenario														
		From socio-economic point of view possible PV-Battery system – scenarios														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Cluster 3			Cluster 2		Cluster 1									
Techno-economic scenario	"Low pursuit for self-sufficiency"						X	X	X	X	X	X	X	X	X	X
	"Medium pursuit for self-sufficiency"				X	X										
	"High pursuit for self-sufficiency"	X	X	X												

III. CONSISTENCY CHECK OF STORYLINES

Research topic

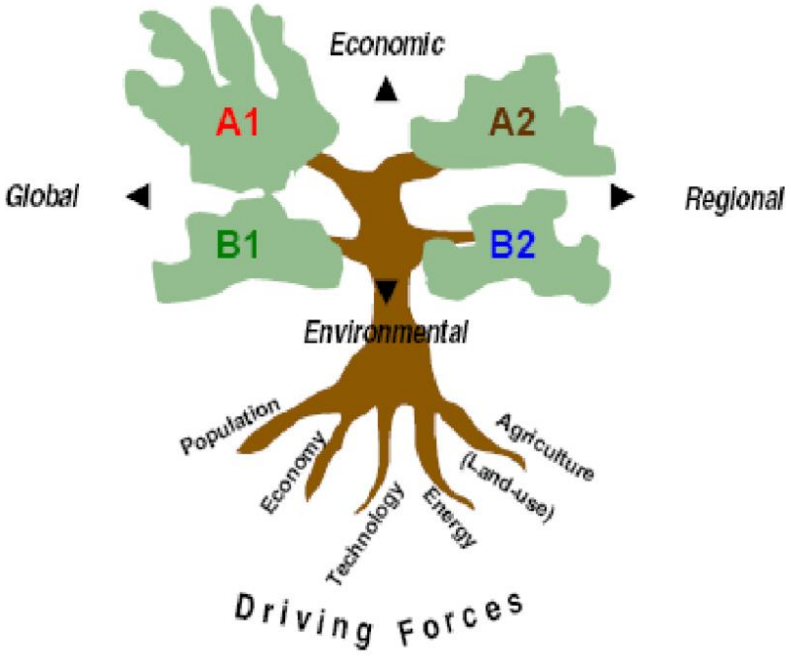
- Usually, storylines are results of intensive consulting processes
- In principle, these storylines have not to be consistent.
- A consistency check is required

Example: Shared Socioeconomic Pathways (SSP)

3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS

III. CONSISTENCY CHECK OF STORYLINES

IPPC Storylines



Source: IPPC (2007)

Identification of Driving forces

Descriptors	States
Population	Low: <8 billion, Medium: 8–12 billion High: >12 billion
Economic development	Low: <1.4%, Medium: 1.4%–2.0% High: 2.0%–2.6%, Very high: >2.6%
Energy resources (availability)	Low fossil availability Low fossils, high coal availability High fossil availability
Carbon intensity	Very low: <6%, Low: 10%–29% Balanced: 30%–49%, High: >50%
Primary energy intensity	Low: <4.3 MJ/$, Medium: 4.3–6.5 MJ/$ High: >6.5 MJ/$
Economic policy orientation	Regional, Global
Environmental policy orientation	Regional, Global

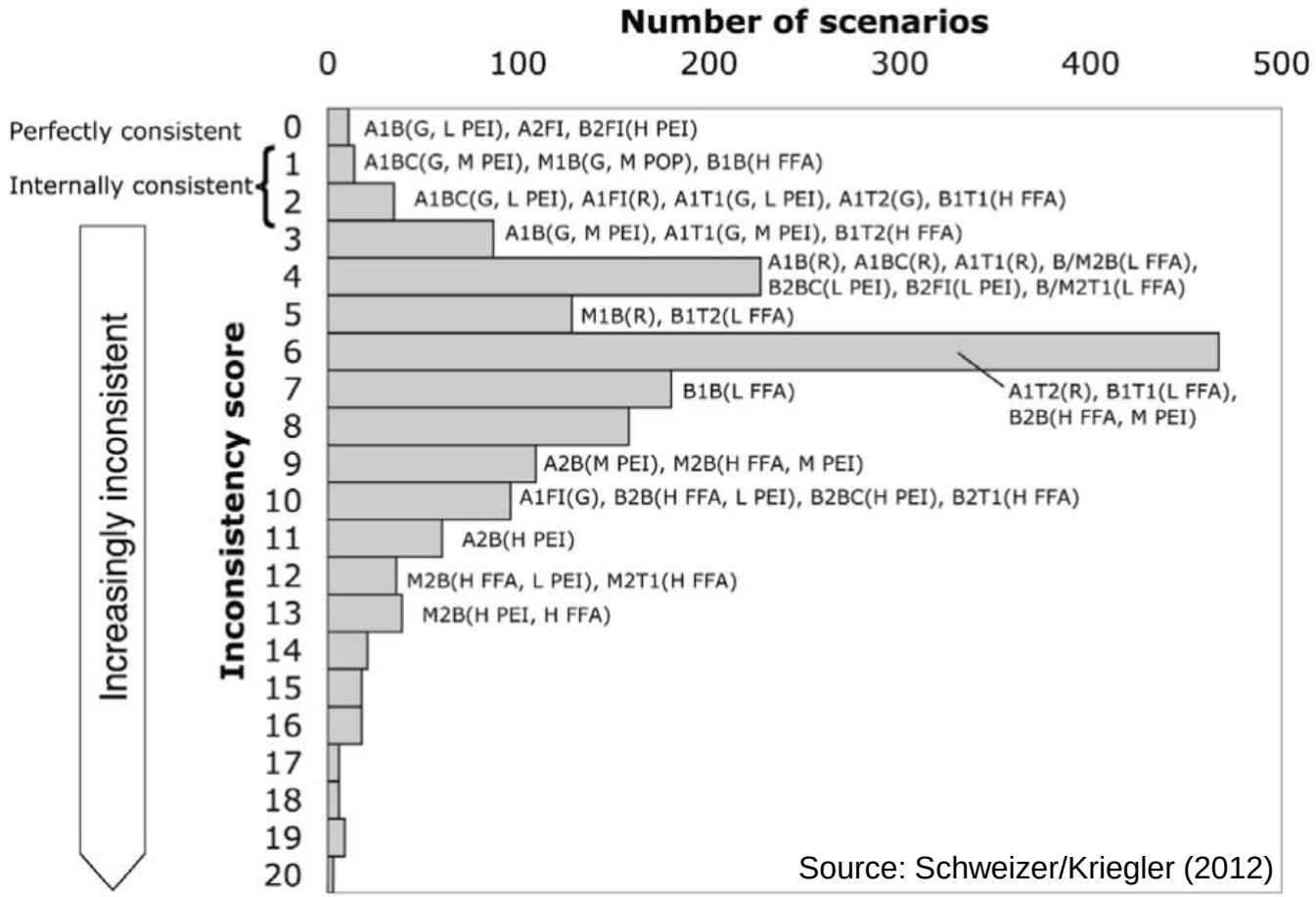
CIB Analyses:
Objective:
Identification of consistent sets of Driving forces

Source: Schweizer/Kriegler (2012)

3. APPLICATIONS OF SOCIO-ECONOMIC SCENARIOS
III. CONSISTENCY CHECK OF STORYLINES

Results

- More than 70 % of the possible SRES scenarios are inconsistent.
- Some SRES constellations might be overlooked



Source: Schweizer/Kriegler (2012)

4. CONCLUSIONS

- Socio-economics factors frame future developments
- They do have to be taken into consideration like other factors.
- A consistency check is needed.
- Dealing with uncertainties is essential for provision of reliable scenarios

Contact:
s.voegele@fz-juelich.de