SRREN 3rd Expert Meeting: Scenarios
Status of Scenarios in SRREN and Next Steps

Oxford, 28th February, 2010

Ottmar Edenhofer

Steffen Schlömer, Timm Zwickel

WMO UNEP

Table of Contents

- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

Table of Contents

- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

What are the important insights for stakeholders?

- Technical feasibility
- Integration costs and risks are important beyond the power sector
- Economic costs for a gradual and for a more radical change of the energy system
- Ten barriers which have to be removed anyway
- Policy instruments for a gradual and a more radical change

To what extent are renewables a dominant strategy? The answer is not policy prescriptive!

SRREN Challenge

Goal:
Climate Change Mitigation

SRREN Challenge

Goal:
Climate Change Mitigation

↓

GHG reduction

SRREN Challenge

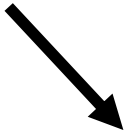
Goal:
Continued
Economic Growth

Goal:
Climate Change
Mitigation

GHG reduction

SRREN Challenge

Goal:
Continued
Economic Growth

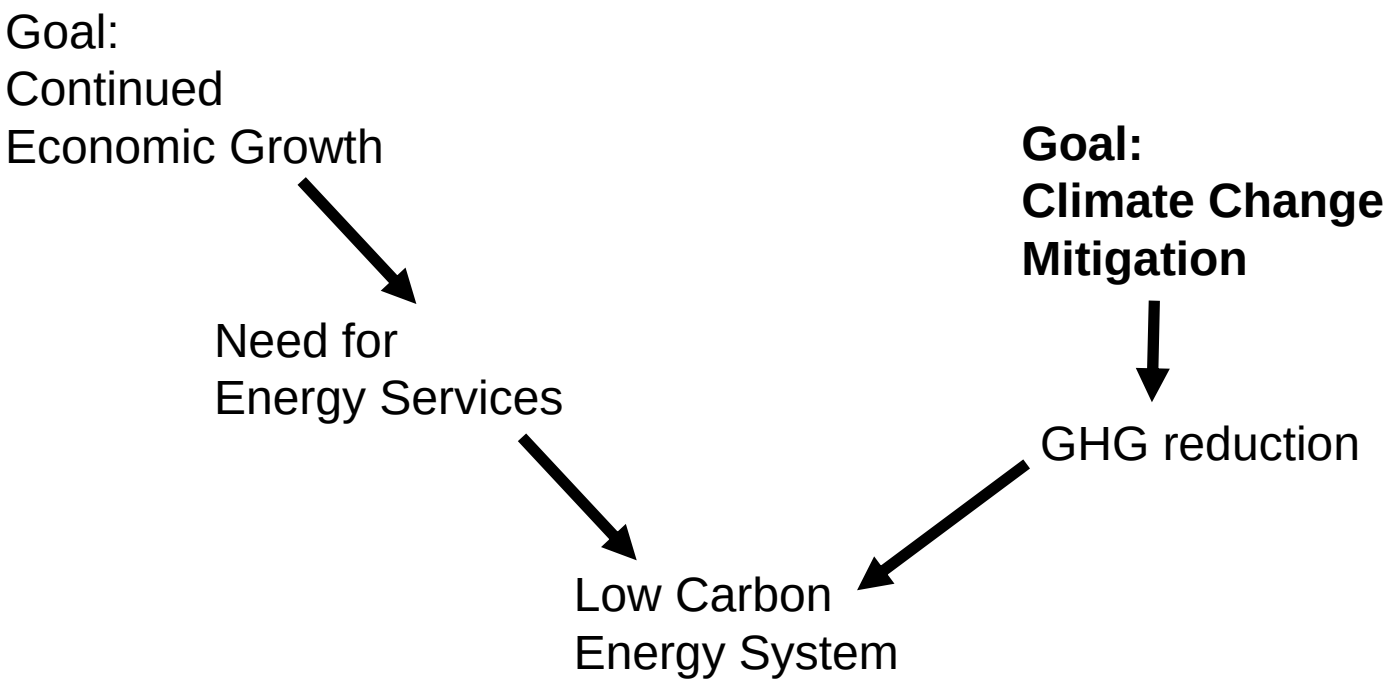


Need for
Energy Services

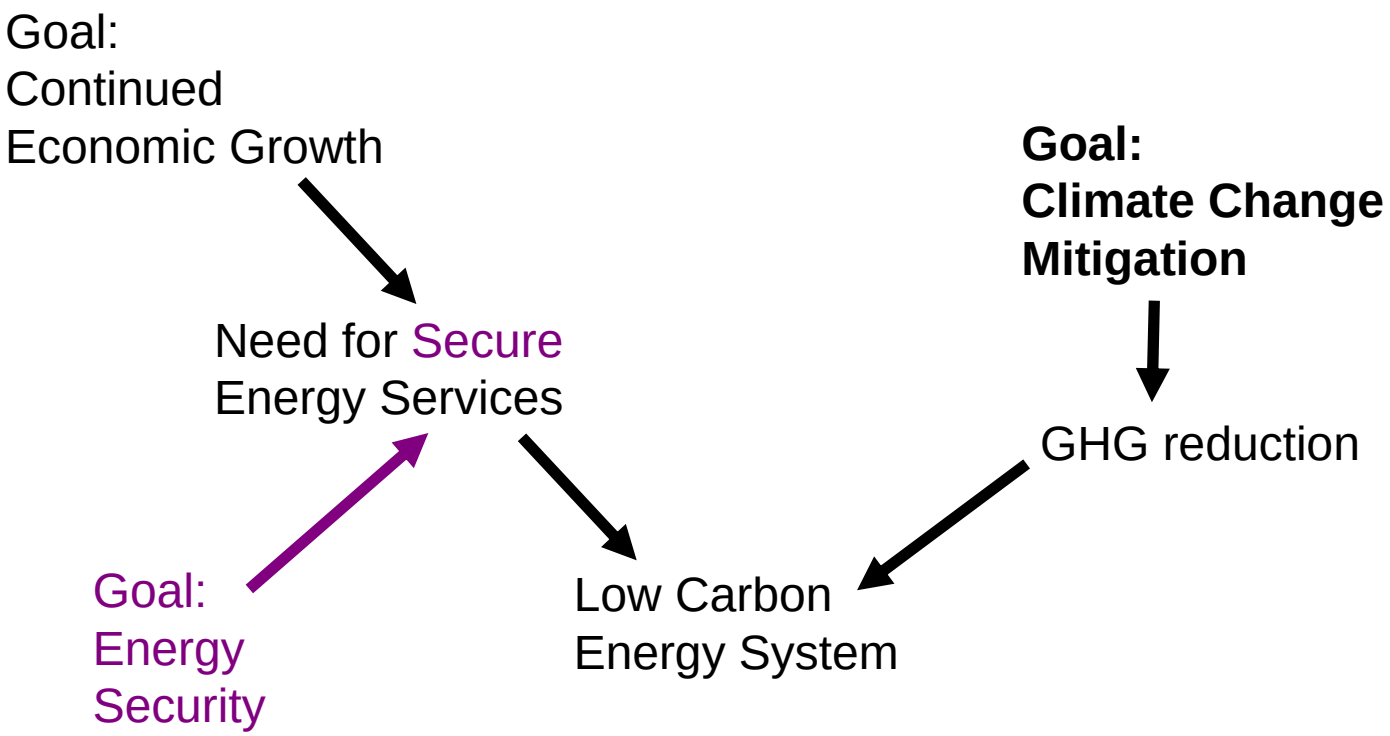
Goal:
Climate Change
Mitigation

GHG reduction

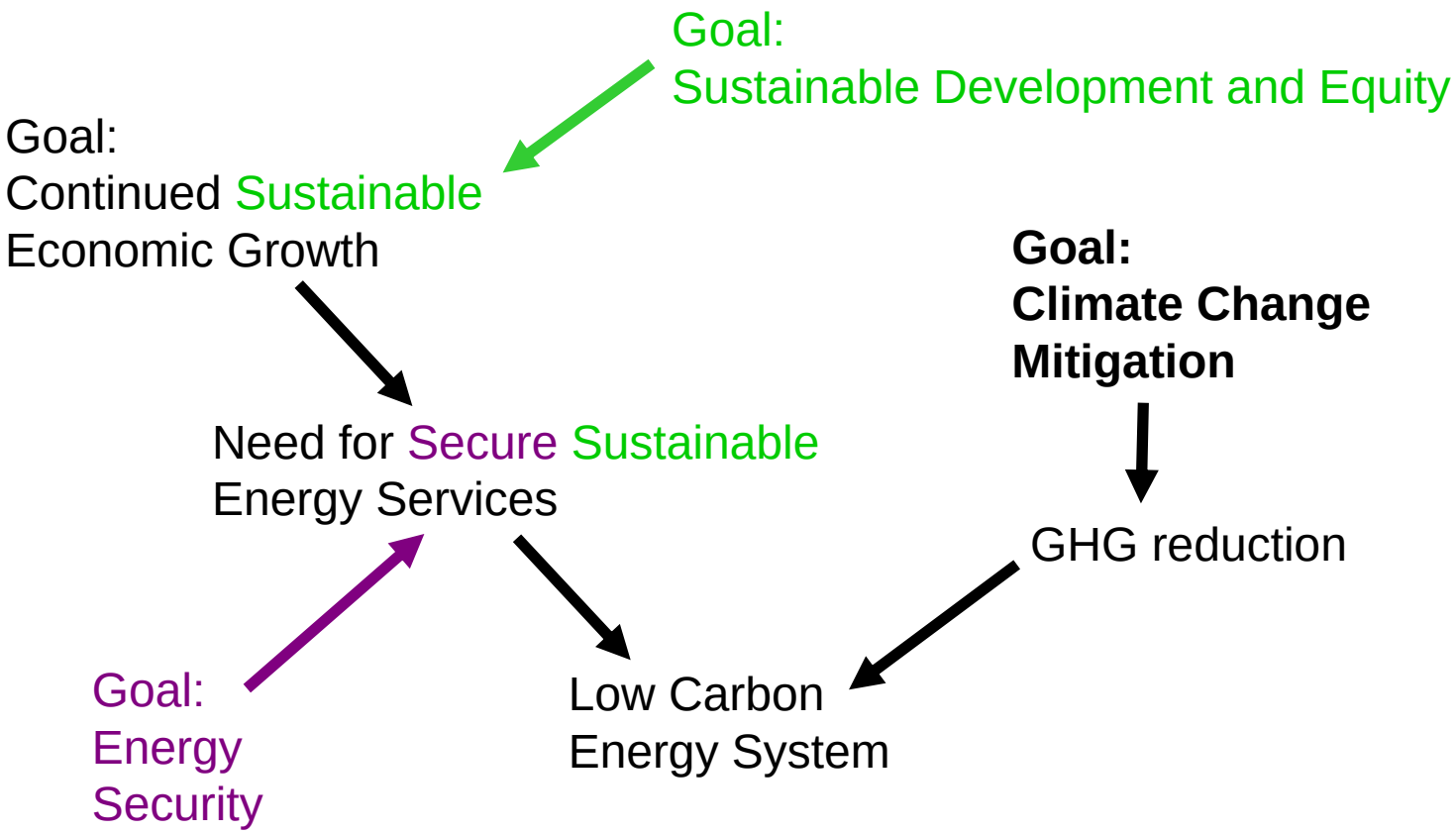
SRREN Challenge



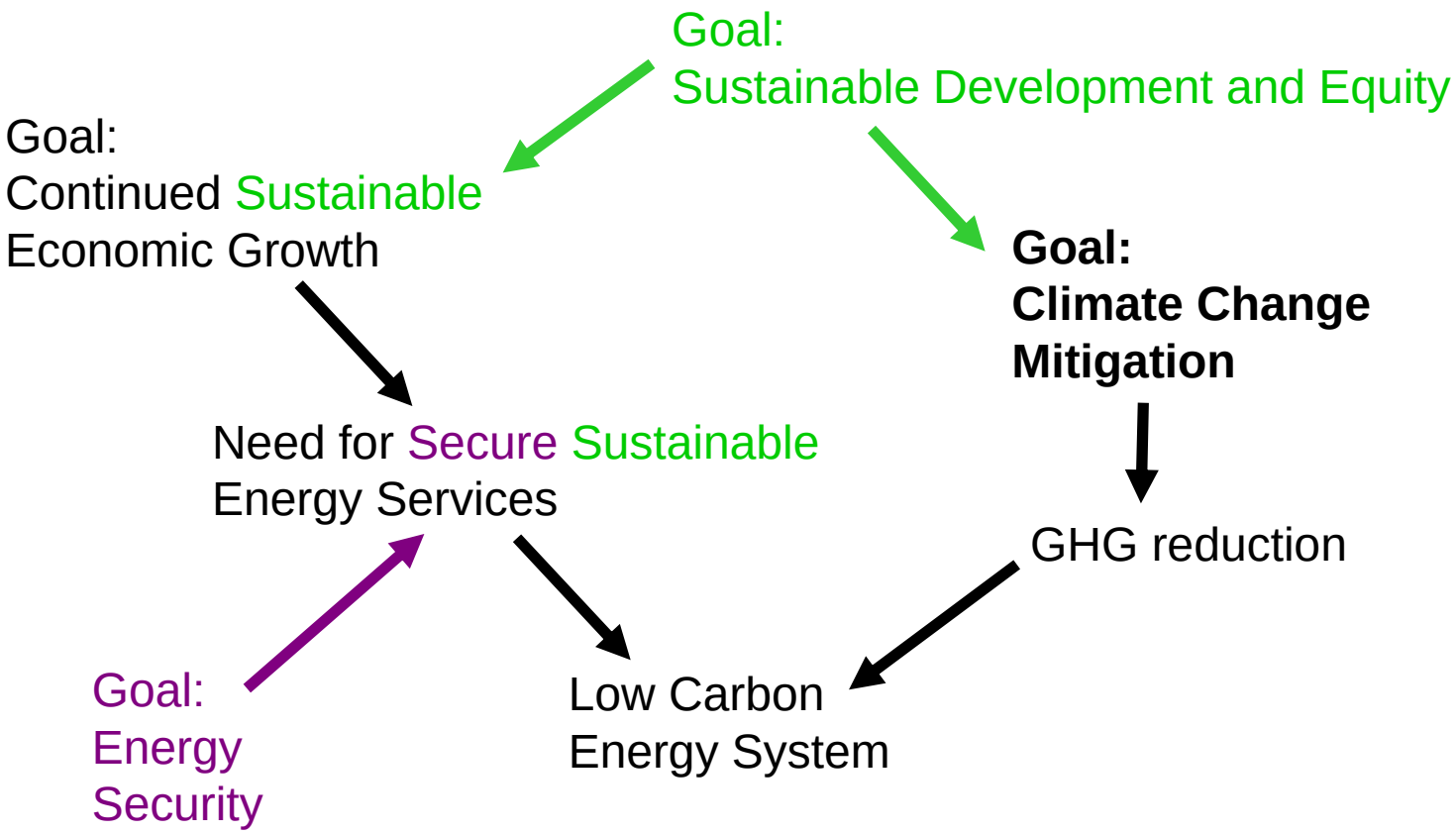
SRREN Challenge



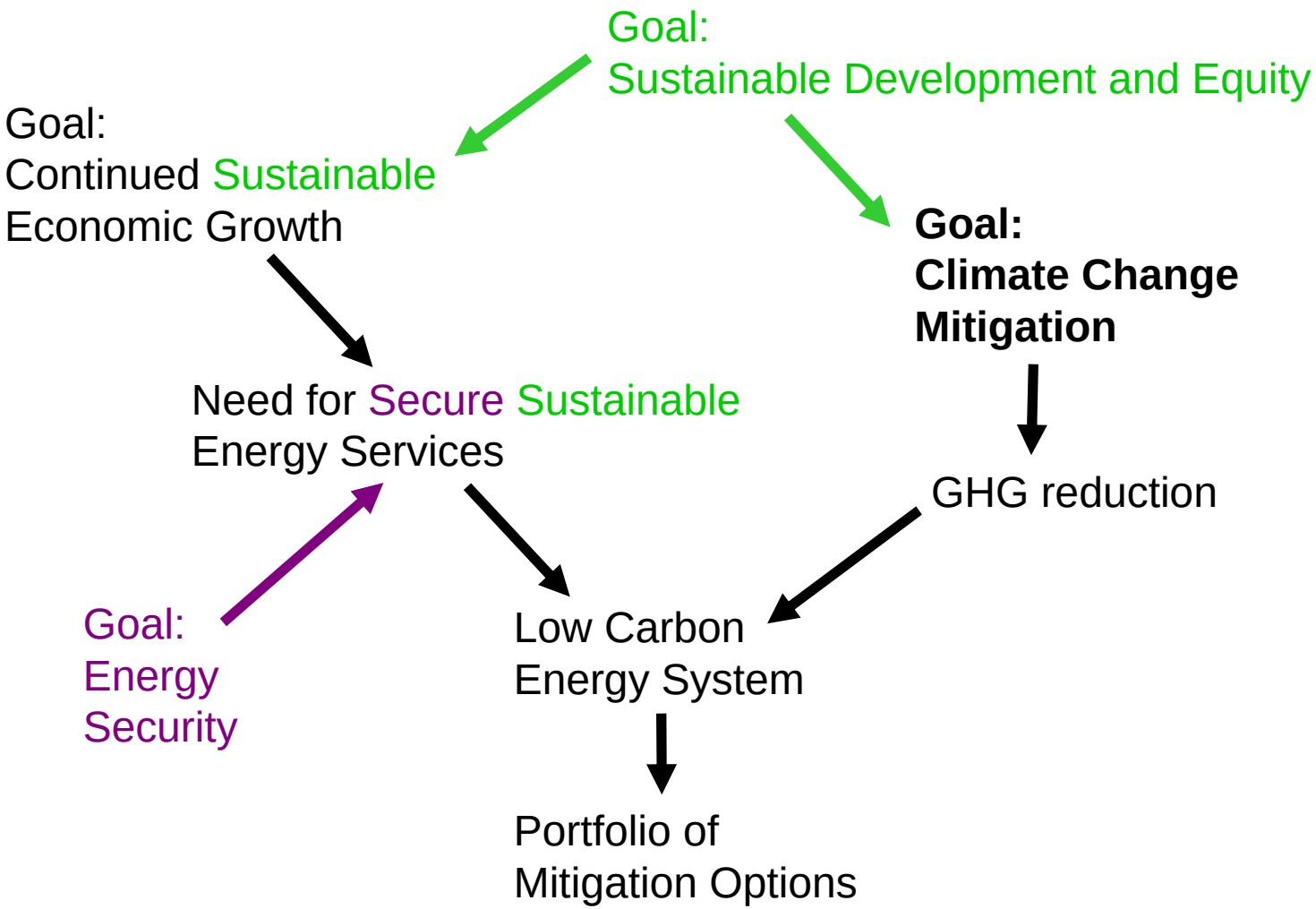
SRREN Challenge



SRREN Challenge



SRREN Challenge



SRREN Challenge

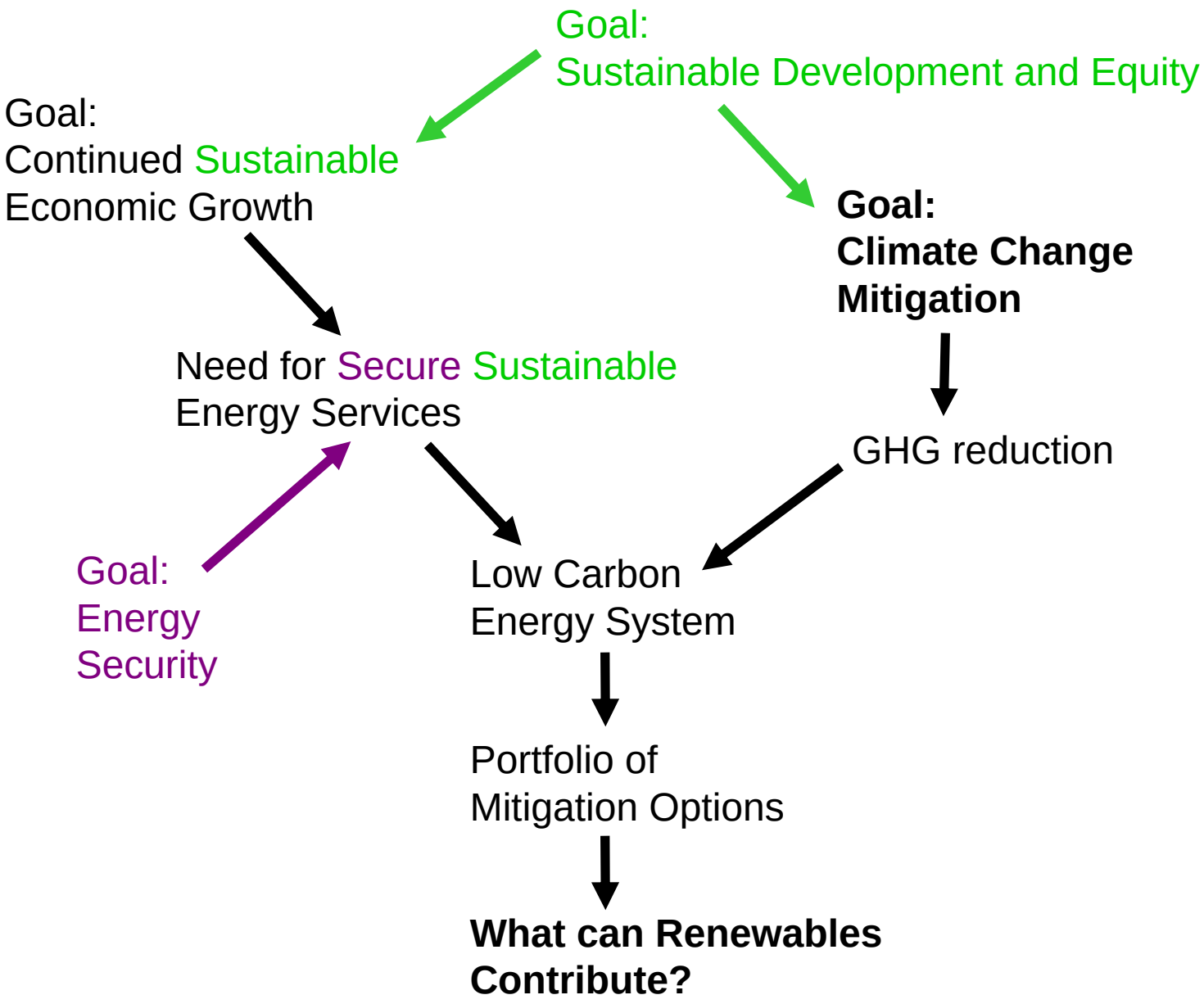


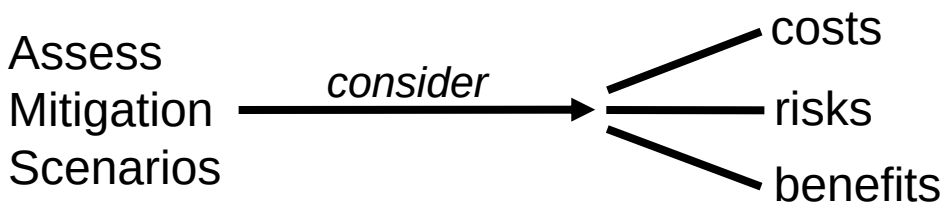
Table of Contents

- Vision for the SRREN
- At Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

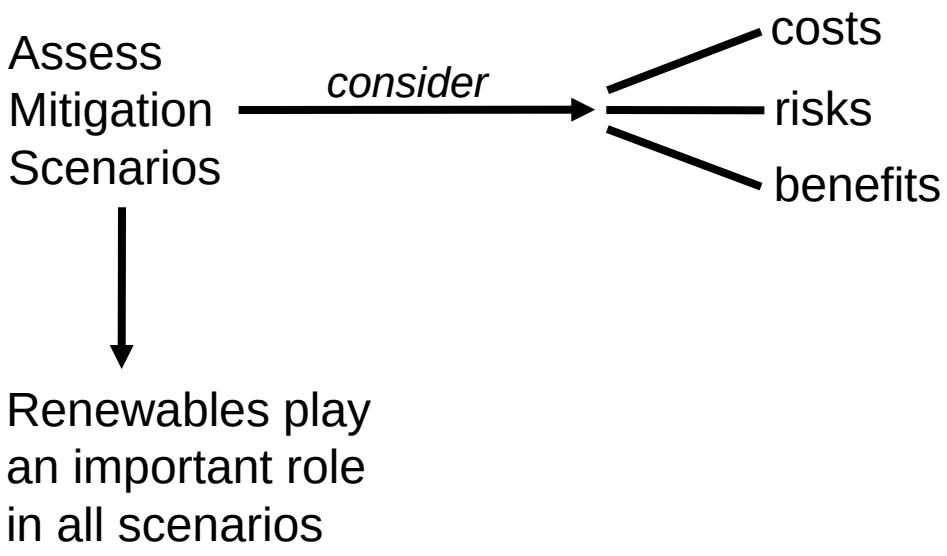
At Core of SRREN: Scenarios

Assess
Mitigation
Scenarios

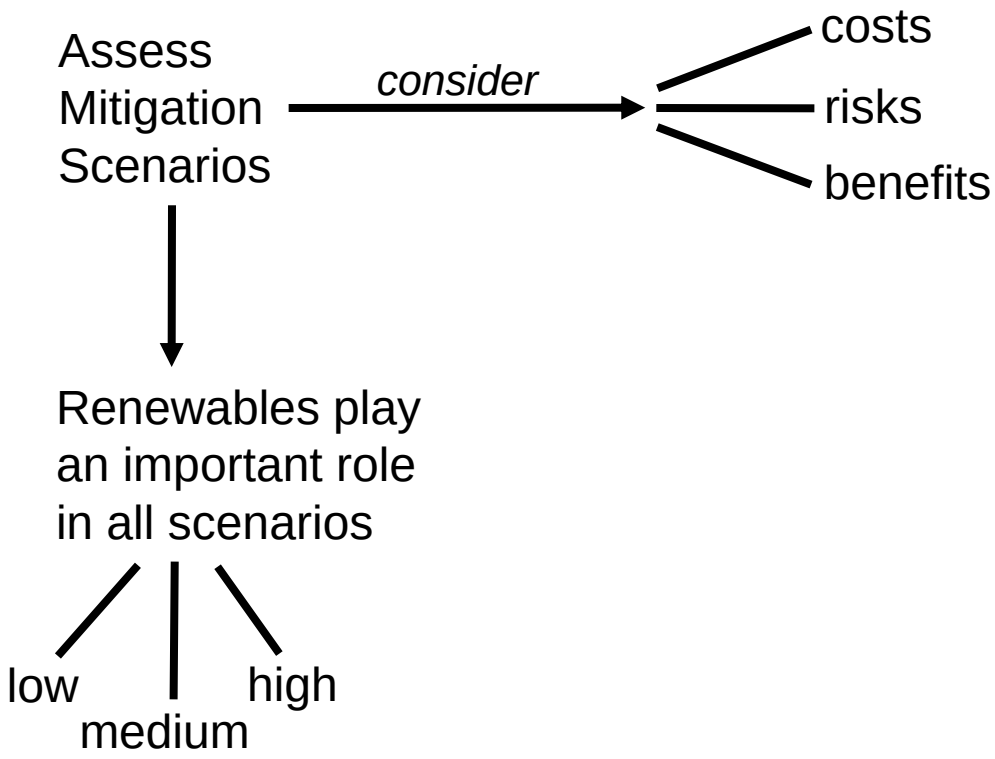
At Core of SRREN: Scenarios



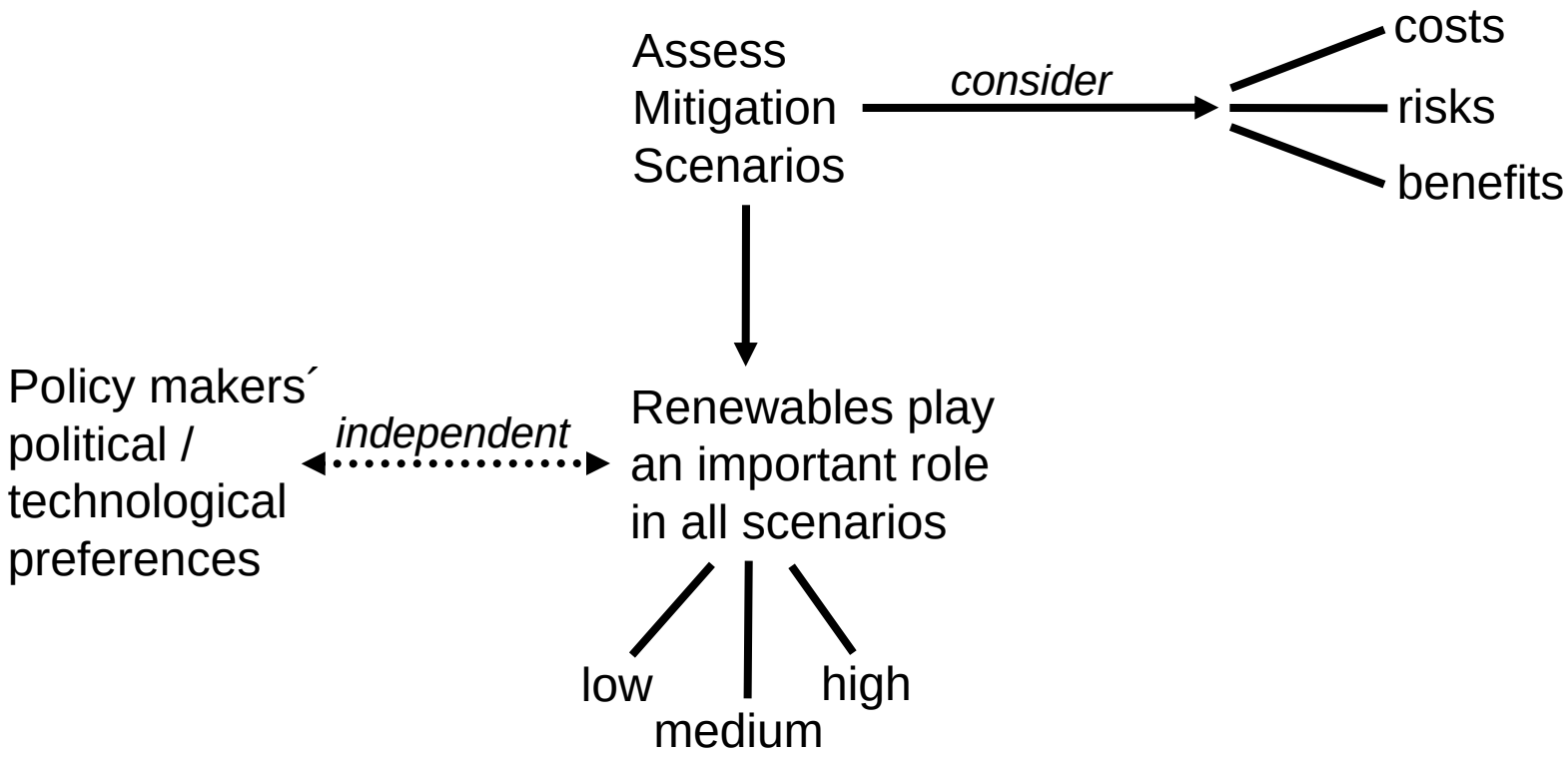
At Core of SRREN: Scenarios



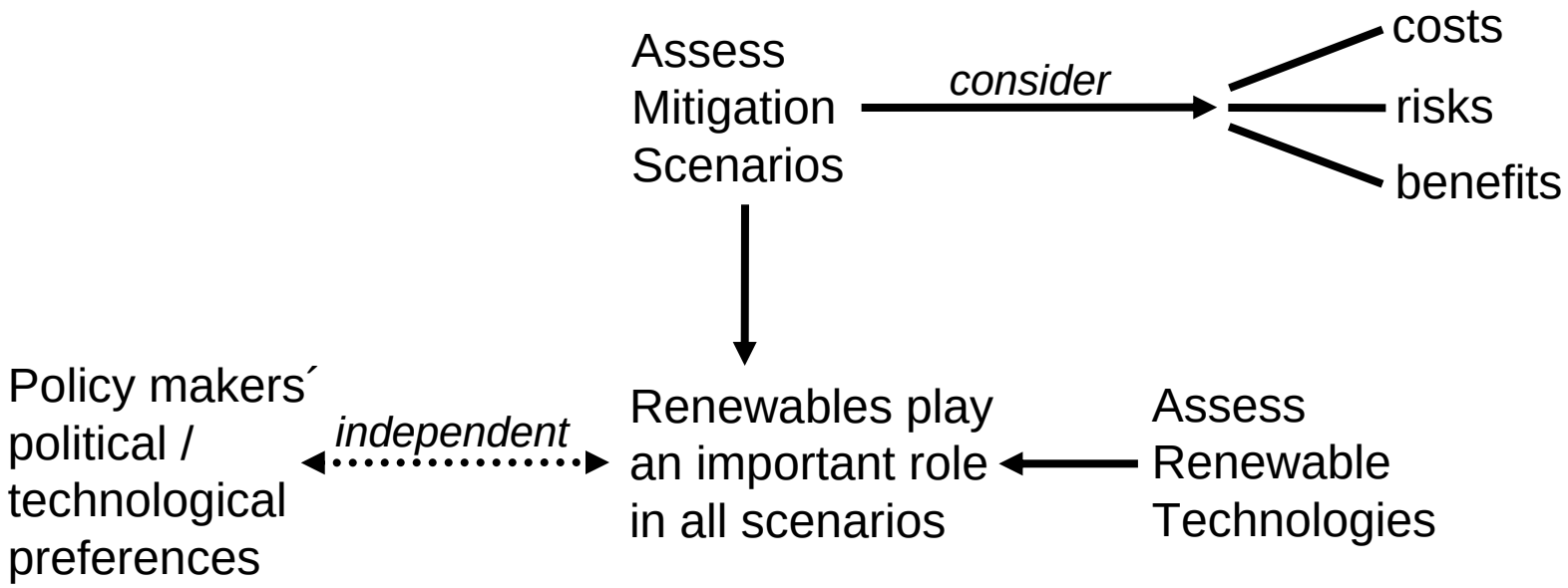
At Core of SRREN: Scenarios



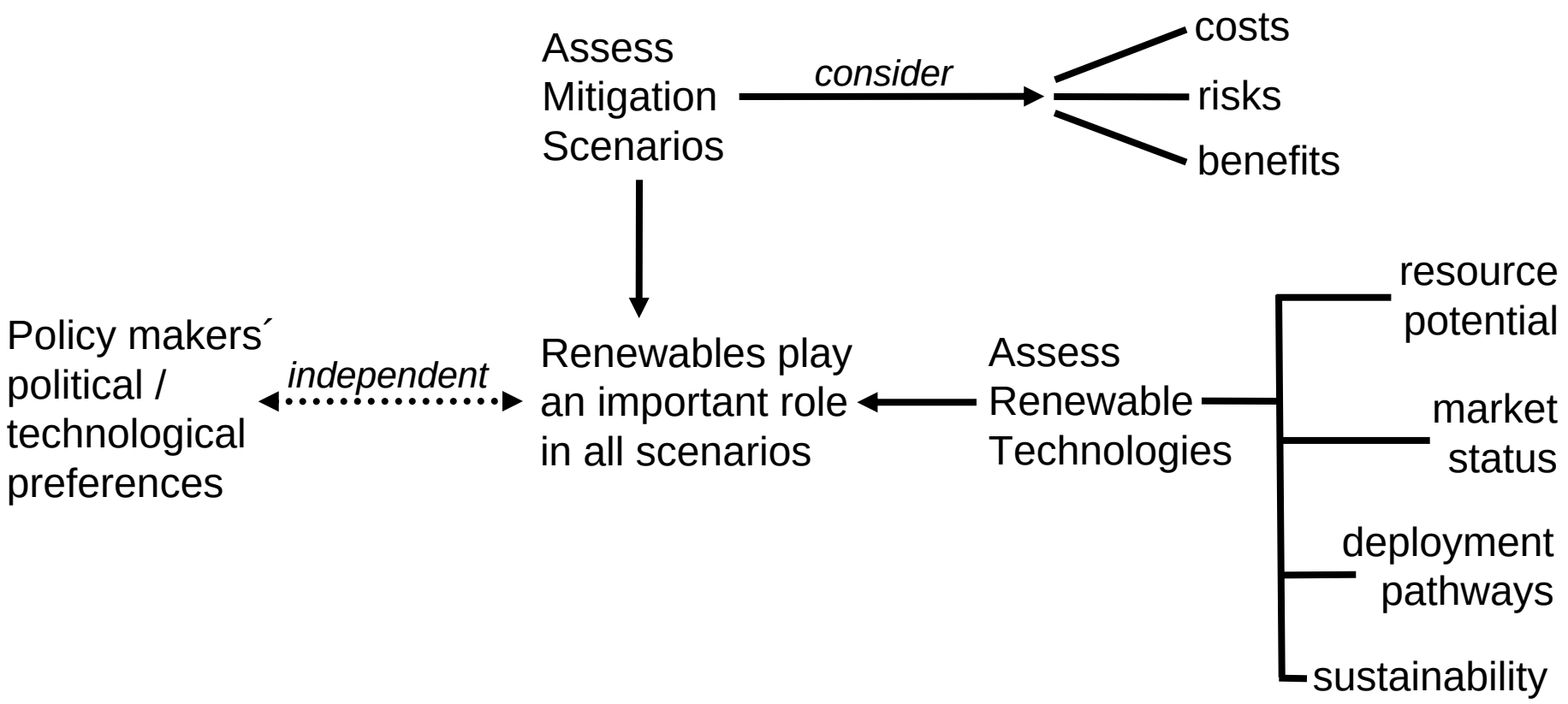
At Core of SRREN: Scenarios



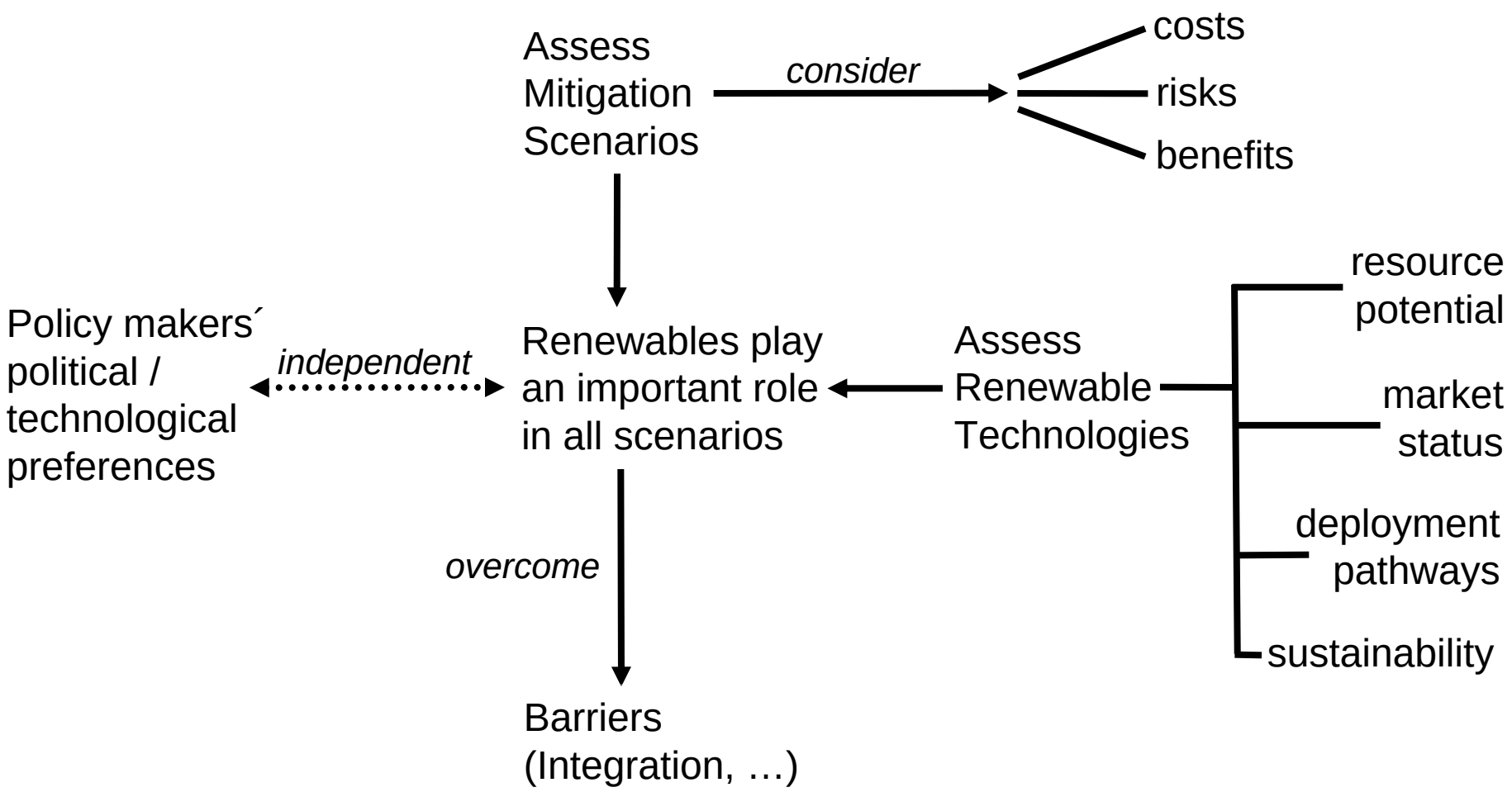
At Core of SRREN: Scenarios



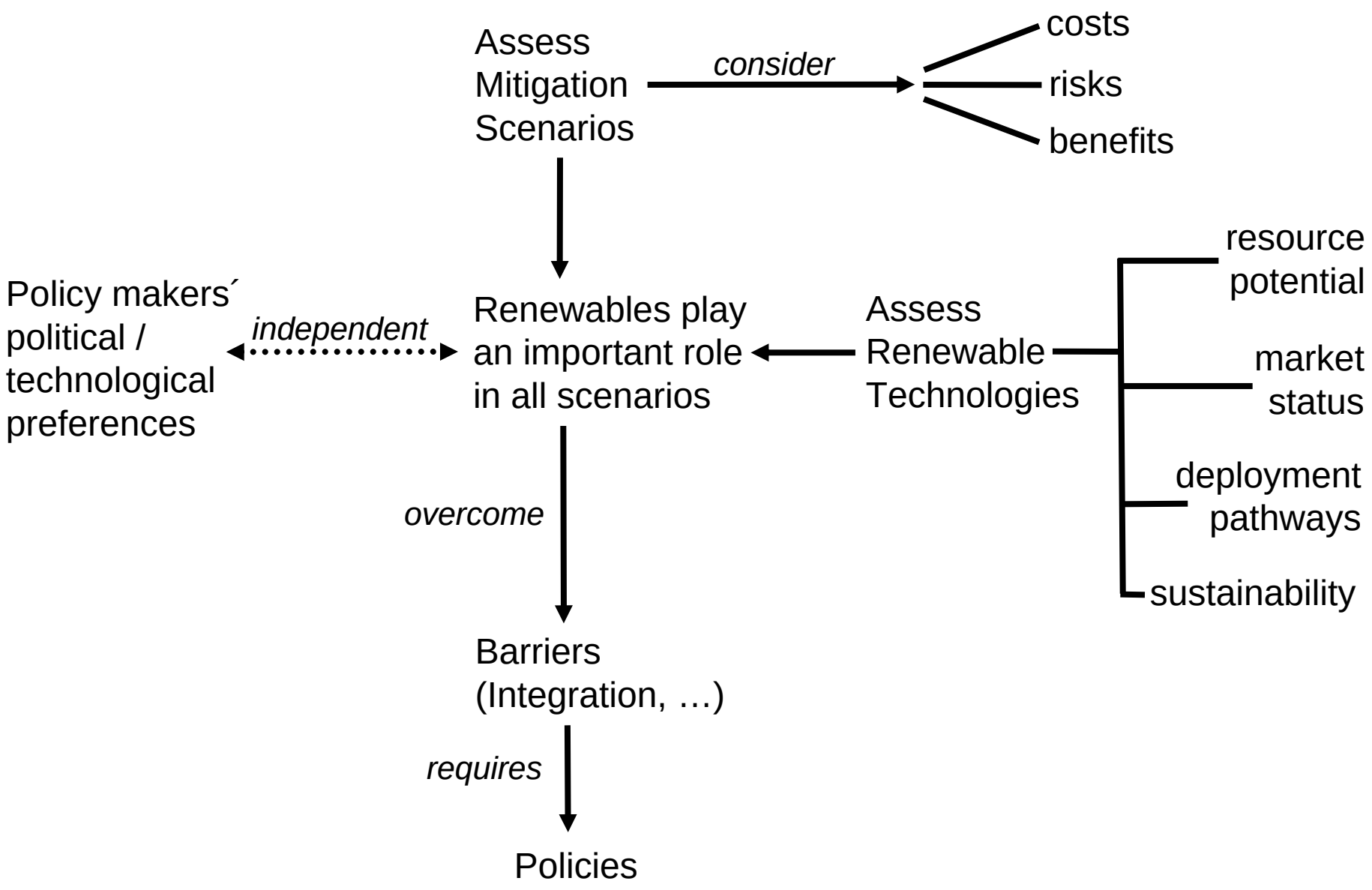
At Core of SRREN: Scenarios



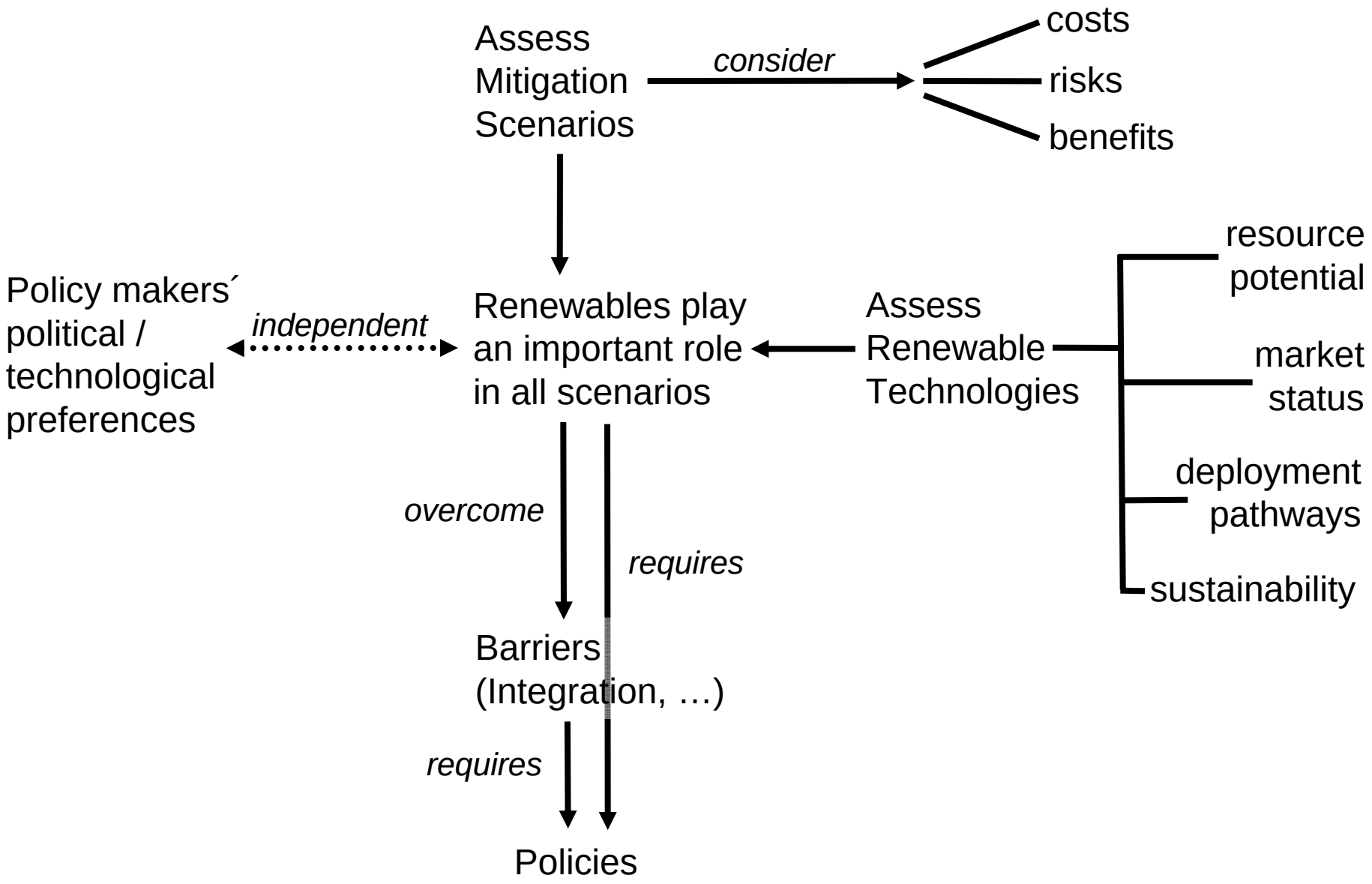
At Core of SRREN: Scenarios



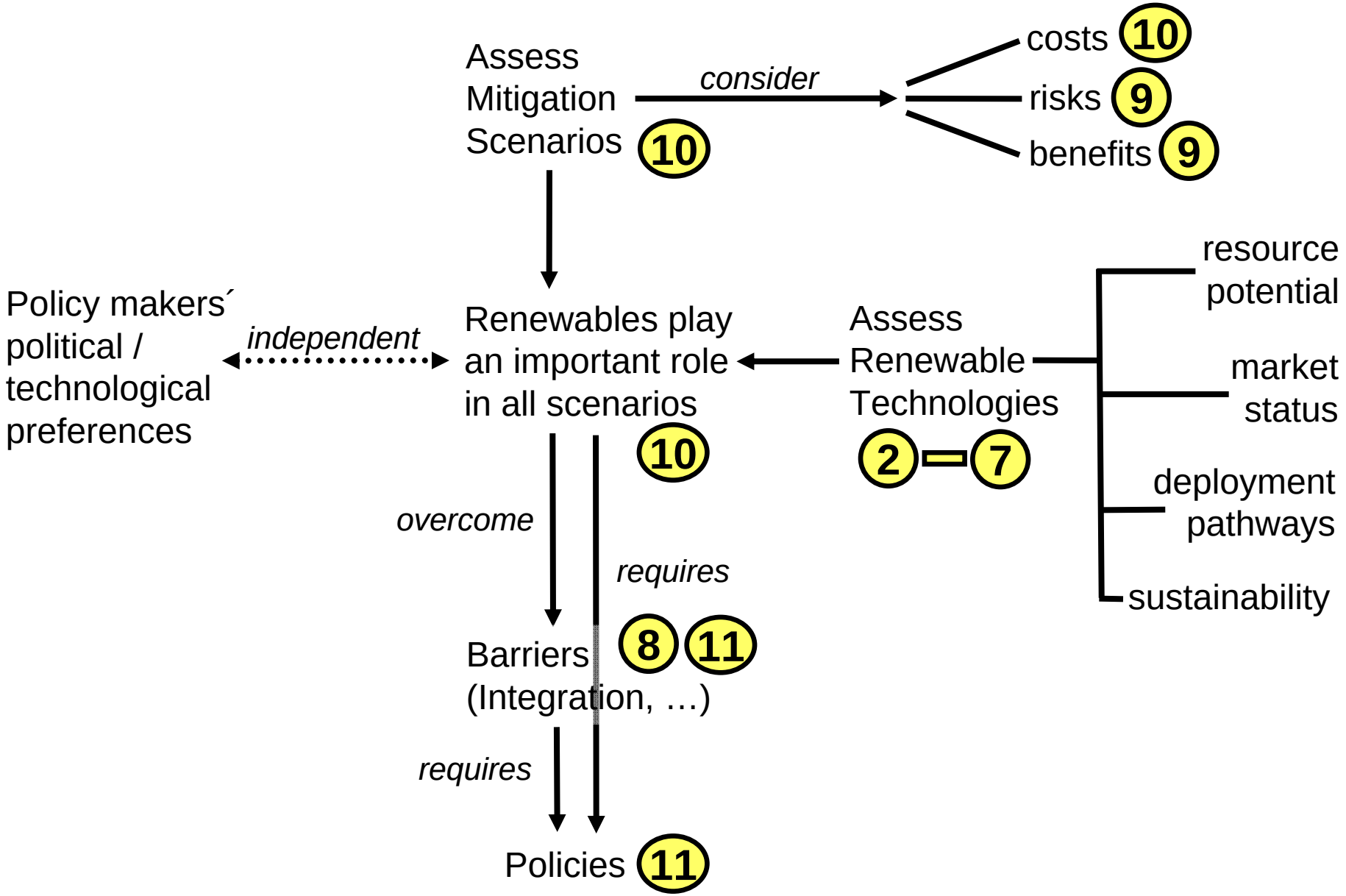
At Core of SRREN: Scenarios



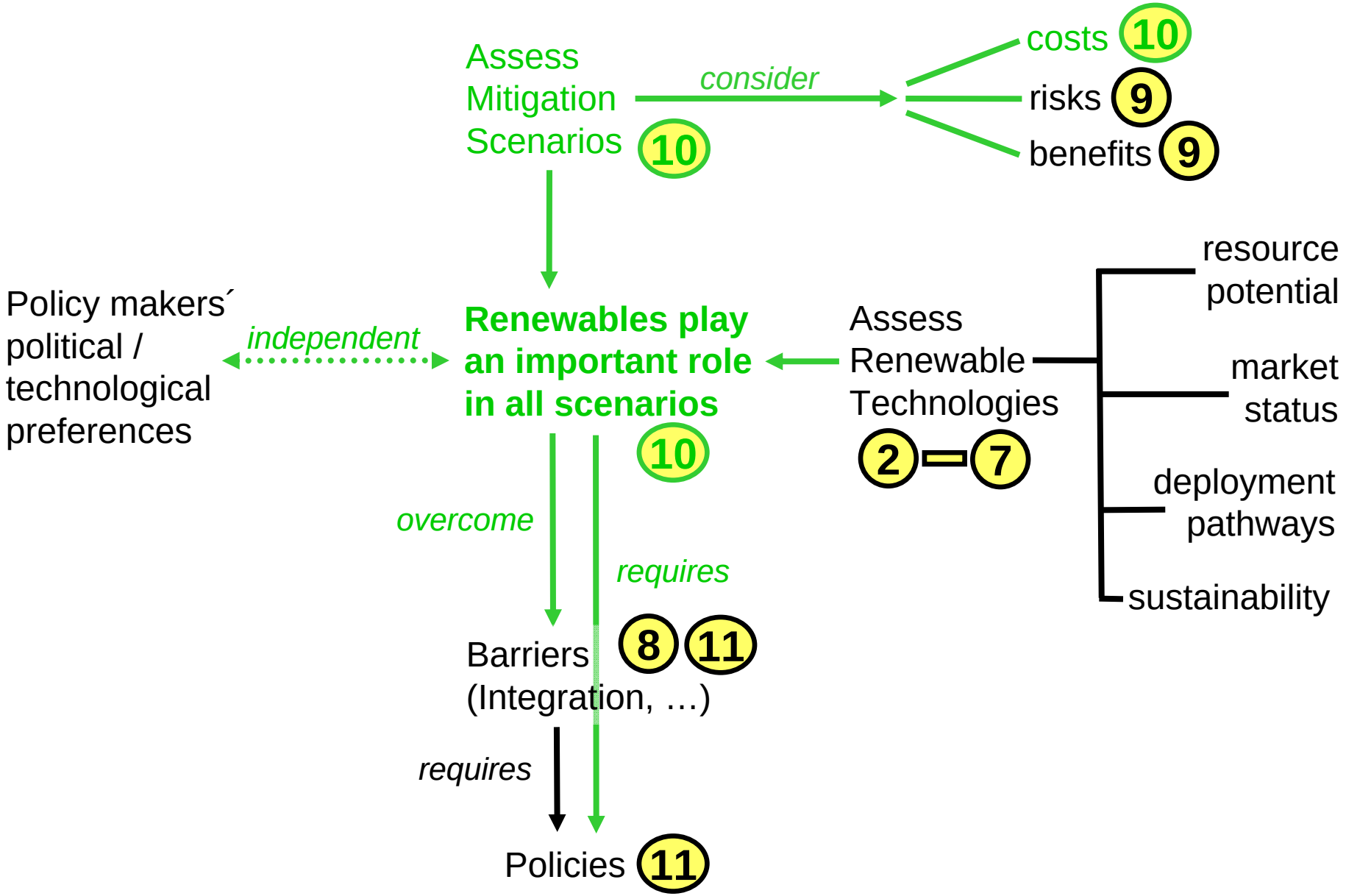
At Core of SRREN: Scenarios



At Core of SRREN: Scenarios



At Core of SRREN: Scenarios



A Pragmatic (Short-term) Approach Suitable for the IPCC SRREN as agreed in Oslo

Tasks of Chapter 10 (Mitigation Potential and Cost):

- Collect reference and climate protection scenarios
- Analyse the results
- Explore key assumptions concerning important input parameters, ask top-down modelers to reveal them
- Develop energy cost curves based on a reasonable selection of scenarios that span the range observed in the data base.

Table of Contents

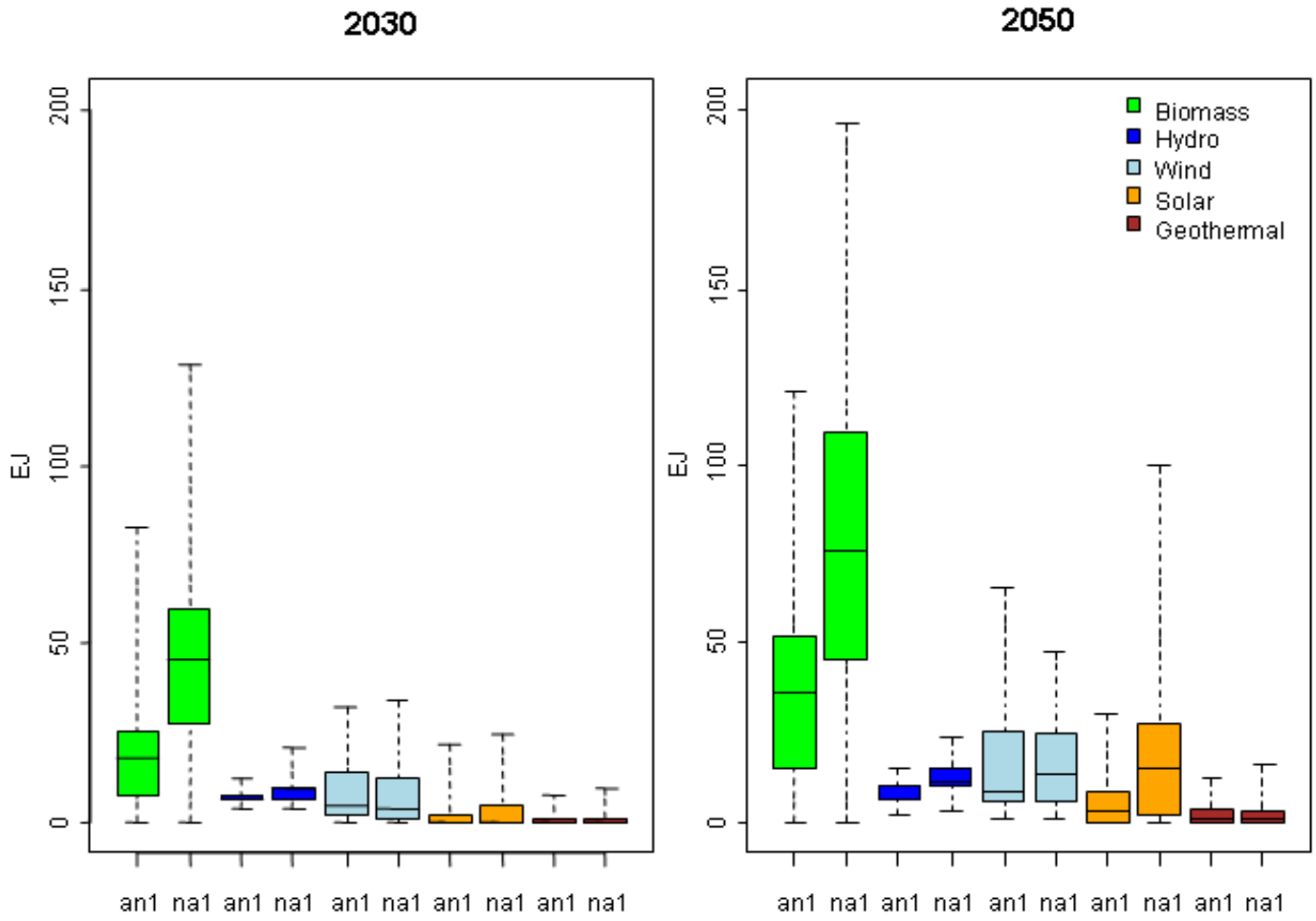
- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

Key Results

- Renewables can provide up to 61% of global TPES by 2050
  - Power: up to 100% RE
  - Heating and cooling: up to 69% RE
  - Transport: to be assessed
- Technical potentials do not constrain RE growth
- CO_2 reductions from RES could range from 5.8 Gt CO_2/a to 33.3 Gt CO_2/a by 2050

First Results 10.2 – Key Figure?

Primary RE consumption by source in Annex I (*an1*) and Non-annex I (*na1*) countries in long-term scenarios



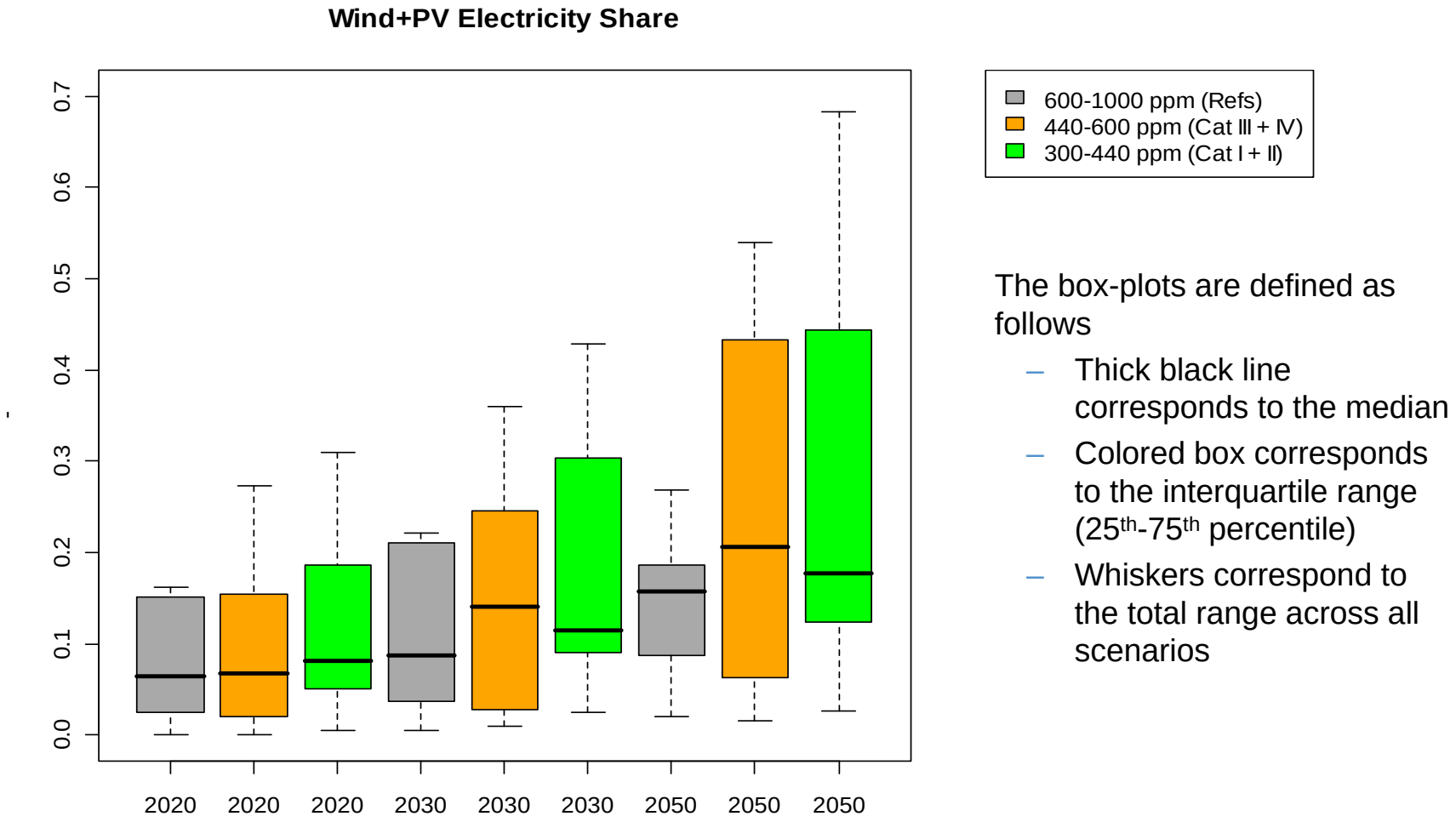
Source: various references, including van Vuueren et al. 2009

What can we learn from this figure

- RE shares grow increasingly over the coming decades
  - Solar energy growth increases after 2030, total solar energy supply overtakes wind, uncertainty increases disproportionally after 2030, *possible reason: uncertainty about CSP and/or PV cost reductions?*
  - Bioenergy: wide range of possible futures, *possible reason: uncertainty about competition for land with food production?*
  - Geothermal and hydro: only small increase, little variation across scenarios, *possible reason: little technological advance expected, established technologies?*
  - Wind: significant increase expected in majority of scenarios, higher uncertainty in 2050 in Annex I, *possible reason: risk in exploitation of offshore potentials?*

First Results 10.2 – Key Figure?

Variation in combined electricity share of wind and PV across scenarios (grouped by GHG concentration target)



The box-plots are defined as follows

- Thick black line corresponds to the median
- Colored box corresponds to the interquartile range (25^{th}-75^{th} percentile)
- Whiskers correspond to the total range across all scenarios

What can we learn from this figure

- RES shares increase with more stringent stabilization targets, but uncertainty grows as well
- The lower half of 300-440ppm scenarios shows combined solar and wind shares in the power sector that are lower than the pessimistic 50% of 440-600ppm scenarios – model selection bias

First Results 10.3 – Key Table?

Total RE supply (TWh/a), RE shares, annual market growth and market volume (GW/a) in **high, medium and low scenarios**

	Generation Twh/a			% of Global Demand				Capacity factor (average)	Annual market growth %/a			Annual market volume GW/a		
	high	medium	low	**Max:** Low global demand (3) Market development high	High global demand (1) Market development: high	Medium global demand (2) Market development medium	**MN:** low global demand (3) Market development low	%	high	medium	low	high	medium	low
Solar (A)														
PV - 2020	459	87	70	2%	1,7%	0,3%	0,3%	18%	39%	18%	16%	27	4,5	4
PV - 2030	2792	1351	142	8%	8,4%	4,5%	0,8%	18%	21%	18%	7%	159	65,2	5
PV - 2050	4754	2584	142	15%	9,4%	6,5%	0,4%	18%	22%	12%	5%	199	121,0	72
CSP - 2020	355	115	11	1%	1,3%	0,4%	0,2%	65%	40%	21%	10%	8	1,7	0
CSP - 2030	1732	971	24	5%	4,5%	3,2%	2,2%	68%	30%	15%	8%	26	14,2	10
CSP - 2050	7878	2731	24	26%	15,6%	6,8%	2,2%	75%	17%	15%	3%	118	63,8	4
Wind (B)	TWh (el./ therm)			% of Global Generation										
On+Offshore-2020	3.333	1.740	970	13%	12%	7%	4%	28%	24%	16%	9%	122	55	22
On+Offshore-2030	6.019	3.484	1.490	18%	18%	12%	6%	26%	9%	7%	4%	157	71	17
On+Offshore-2050	10.100	4.819	1.208	33%	20%	18%	3%	29%	5%	3%	1%	157	41	4
Geothermal [C]	TWh (el./ therm)			% of Global Generation										
Bio energy (D)	TWh (el./ therm)			% of Global Generation										
Ocean (E)	TWh (el./ therm)			% of Global Generation										
Hydro (F)	TWh (el./ therm)			% of Global Generation										
Total Renewables	TWh (el./ therm)			% of Global Generation										

References:

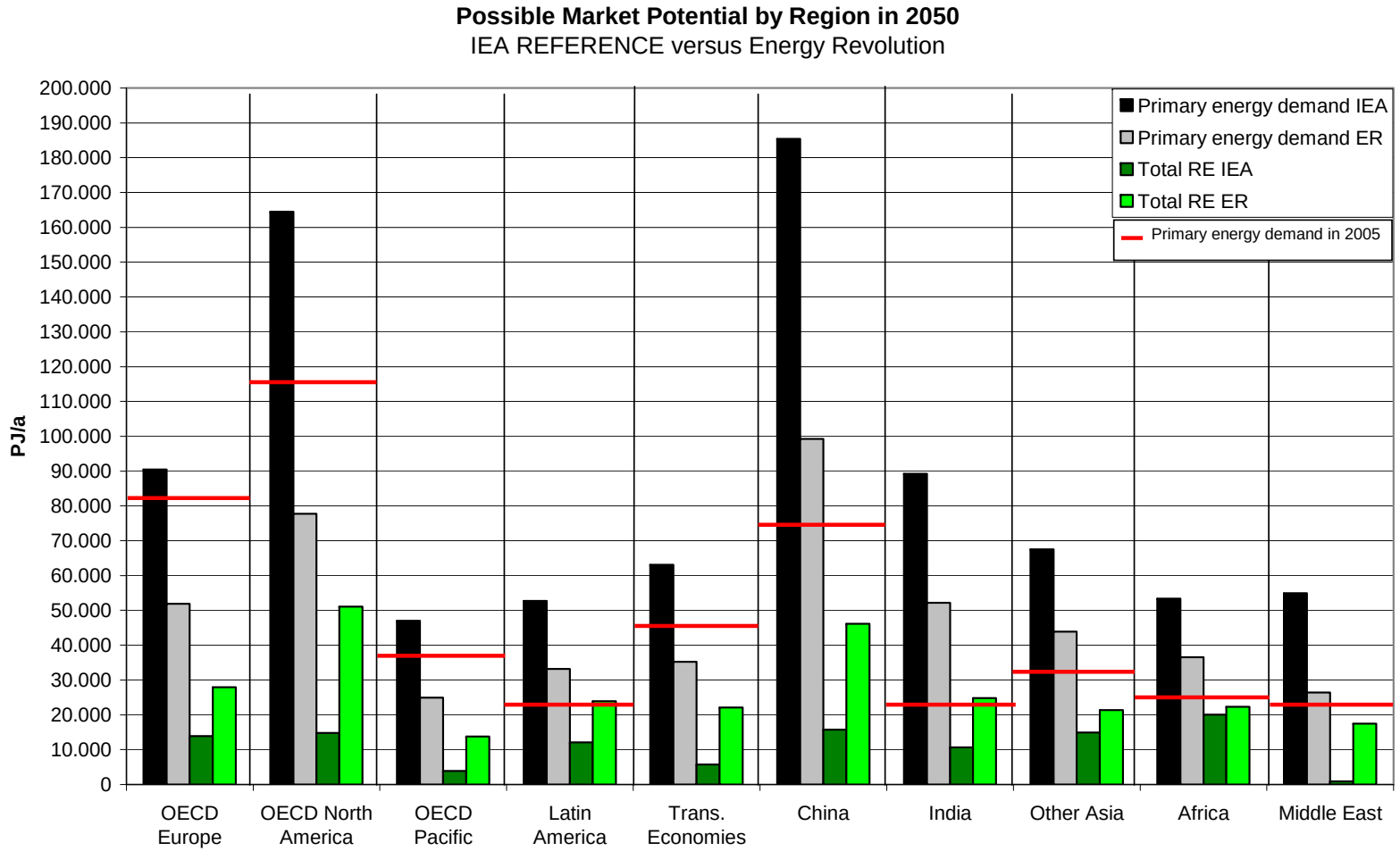
- IEA WEO 2008, 2009
- IEA ETP 2008
- DLR/EREC/GPI 2008: Energy Revolution
- EPIA Roadmap
- Solar Generation V
- WETO 2050
- ESTELA CSP Outlook 2009
- GWEC: Global Wind Energy Outlook
- Information from technology chapters

What can we learn from this figure

- The share of RES depends on the scale of the overall energy system
- At a combination of low demand and low RE market development their share will still range at 20% by 2020 and beyond
- Required RES growth rates can be considered realistic given historic market developments

First Results 10.3 Key Figure?

Regional breakdown of possible RE market potential in 2050.



Sources: IEA WEO 2009, Reference Scenario; DLR 2008, Energy Revolution

What can we learn from this figure

- Projections across regions vary across models
- IEA projections expect increasing primary energy demand and a limited role for RES in all world regions
- DLR projections expect a strong decrease in primary energy demand that will largely be supplied by RES in all world regions

First Results 10.4 – Key Table?

Summary of regional/national literature on RE supply curves, potentials grouped by cost categories

Country/Region	Cost ($/MWh)	Total RES (TWh/yr)	% of baseline	Discount rate (%)	Notes	Source
US (AZ 2025)	<100	0.28	N/A	Biomass and PV: 7.5 Rest: 8	- State of Arizona, United States - RES: wind, biomass, solar, hydro, geothermal - Interest rates vary between energy sources	RES data: Black & Veatch Corporation (2007)
	<200	10.5	N/A			
	<300	20	N/A			
Czech Republic	<100	101	19.93	4	- Only biomass production - Best case scenario where future yields equal the level of the Netherlands	RES data: Lewandowski et al. (2006) Baseline data: IEA (2005)
Germany	<100	160	24.24	N/A	- Only Wind and PV are included - PV only enters above 200 USD	RES data: Scholz (2008) Baseline data: McKinsey and Company (2007)
	<200	177	26.76			
	<300	372	56.20			
Germany	<100	174	N/A	N/A	- Only wind and PV are included - PV available between 100 and 200 USD	Scholz (2008)
	<200	393	N/A			

Table continues with data from several studies on:

- Netherlands
- UK
- United States
- Central and Eastern Europe
- Europe
- Global

What can we learn from this figure

- Regional studies on RES at varying energy prices show a wide range of differing results
- Different assessments of the same region show RE deployments varying by orders of magnitude even for the same energy price

First Results 10.4 Key Figures?

Regional Renewable Energy Supply Cost Curves

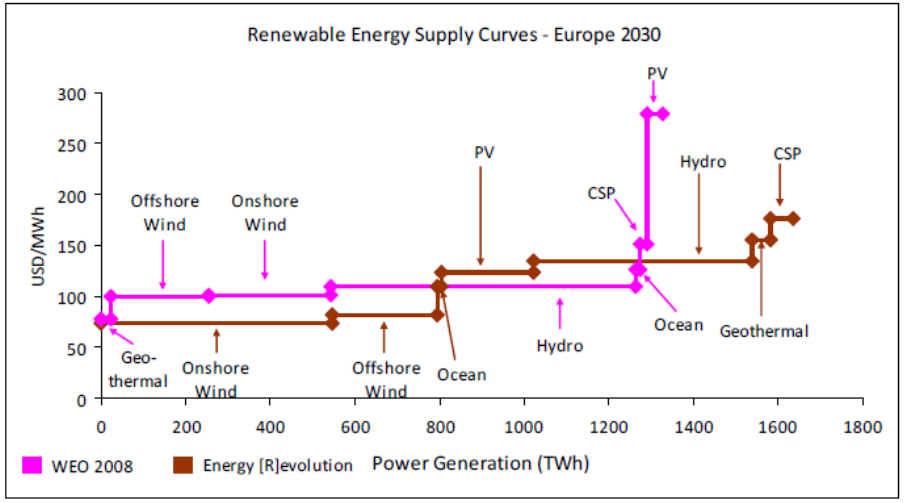


Figure 10.4.6: Renewable energy supply curves for Europe for the year 2030.

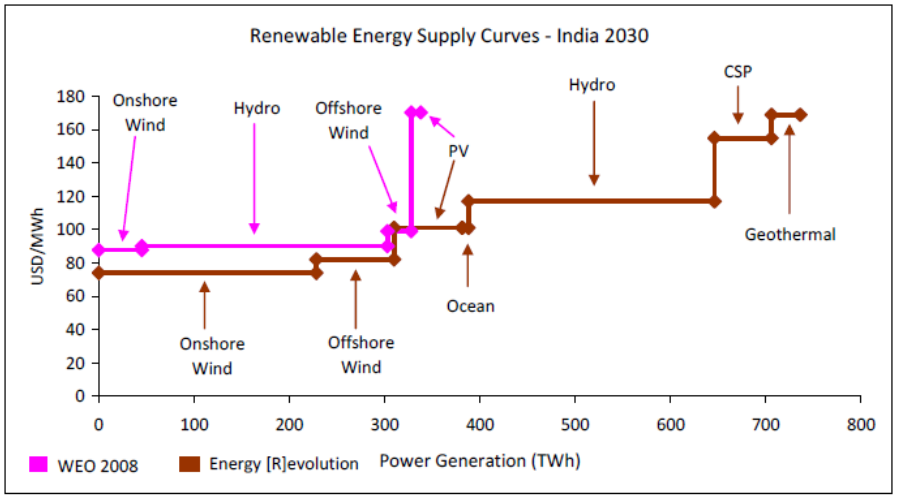


Figure 10.4.8: Renewable energy supply curves for India for the year 2030.

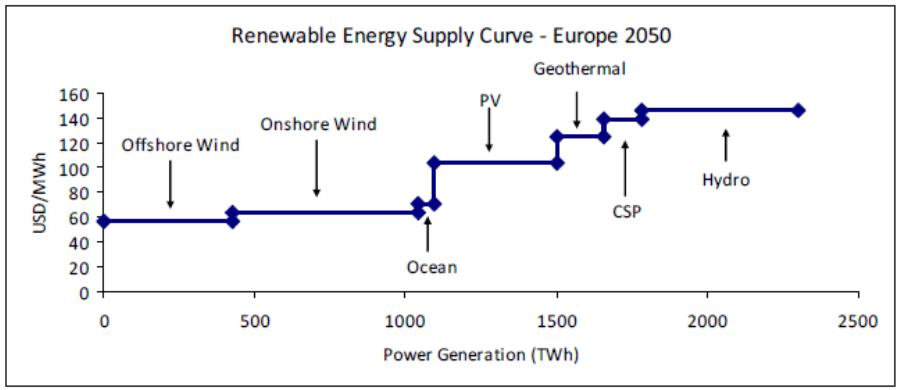


Figure 10.4.7: Renewable energy supply curve for Europe for the year 2050.

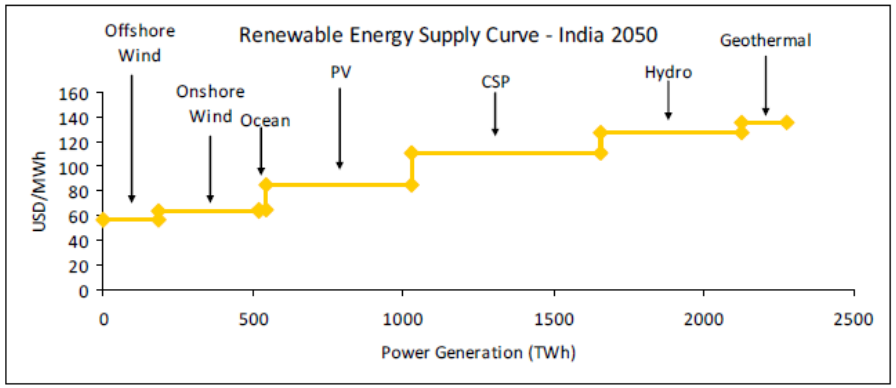


Figure 10.4.9: Renewable energy supply curve for India for the year 2050.

What can we learn from this figure

- Regional RE supply cost curves show very different potentials and costs across scenarios
- Different cost degression across RE technologies changes the ranking of RE by costs over time
- The main problem: Ceteris paribus!!

Table of Contents

- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

Methodological Issues

- Section is currently missing
- Very important to evaluate different types of models, their advantages and shortcomings
- Outline main methods for representing technology choice (logit sharing, production functions, optimization)
- Assess models‘ ability to represent important factors for RE deployment, e.g. …
  - fluctuating supply
  - modeling of the grid
  - regional detail wrt to resource potential
  - technological detail

Scenario Analysis

- Currently mainly statistical analysis
- Compare consistent sets of baseline and policy scenarios
  - clustering RES in different models by GHG stabilization scenarios provides limited insight
- Try to identify and evaluate (with the help from technology chapters) key characteristics of models with low vs. high RES
- Add more detail on model‘s assumptions
- Distinguish more clearly between description of assumptions and presentation of results
- Include analysis of costs across different scenarios

Bottom-up Perspective

- Once available, make use of bottom-up information to evaluate top-down modelling results
- Provide list of assumptions of analyzed models to technology chapters to comment, e.g. learning rates, “current“ cost assumptions (starting point)

Table of Contents

- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

The FOD: Goals and Next Steps

- General: Improve integration of technological expertise – need for interaction with technology chapters
- 10.1: Restore methodology section
- 10.3: Make model assumptions more explicit
- 10.4: Better reflect different resource qualities for each technology in RE supply cost curves, e.g. wind speeds

The FOD: Goals and Next Steps

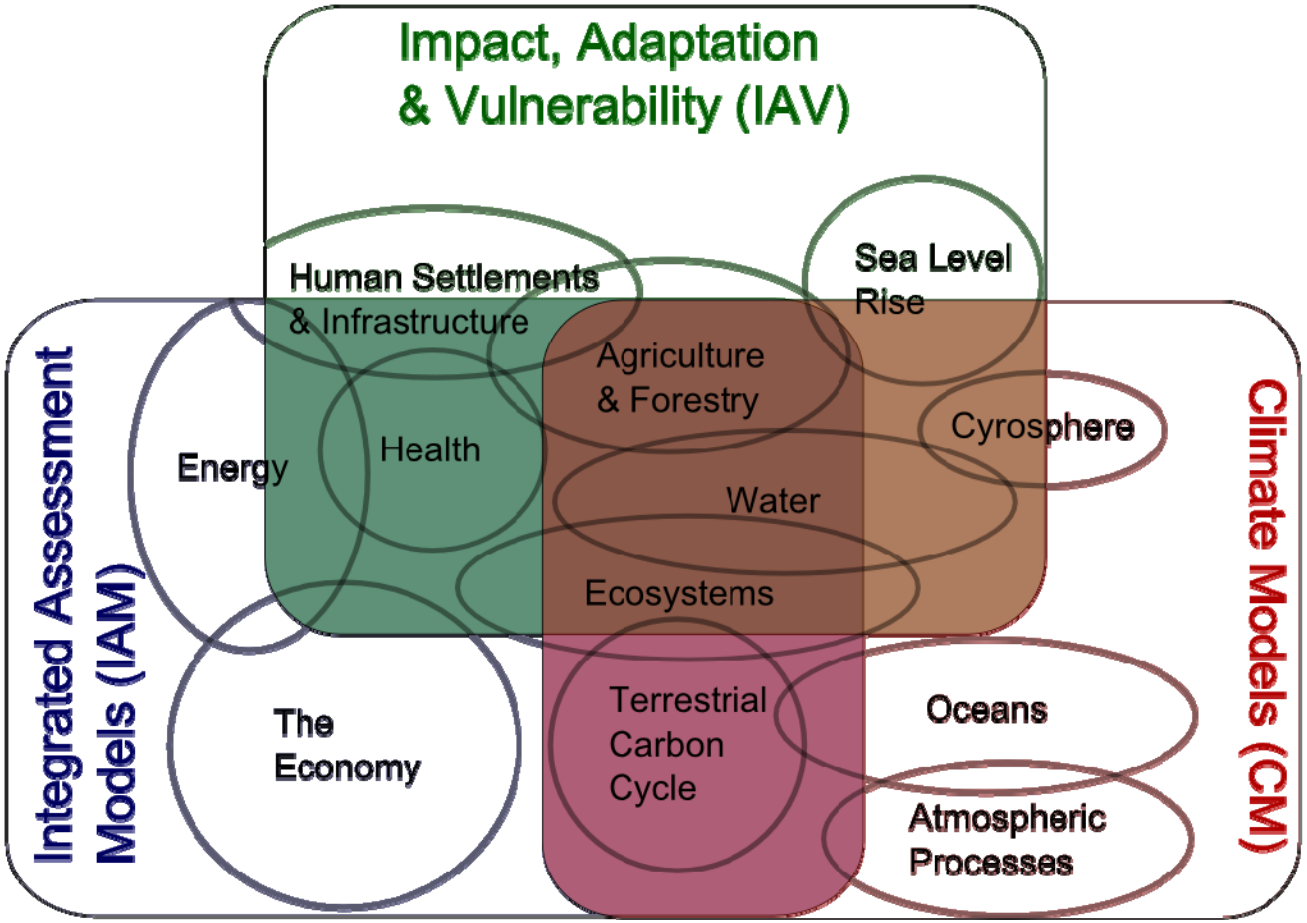
10.2: Strengthen analysis of RE scenarios

- Go beyond statistical analysis
  - Compare sets of baseline and policy scenarios
  - Identify key characteristics of high/low RE scenarios
- Add model descriptions
- Explore in more detail key assumptions on input parameters
- Include cost comparison across scenarios

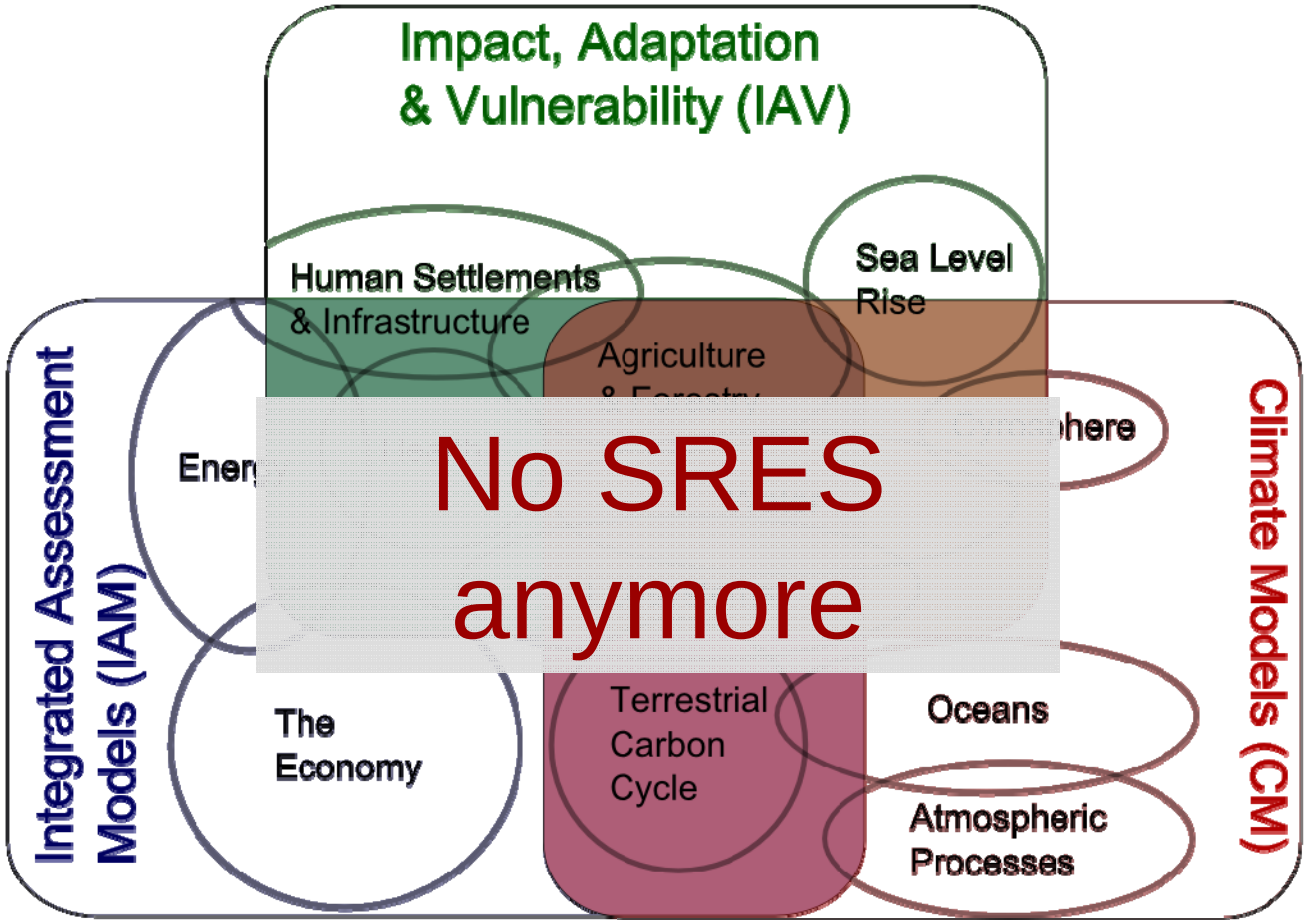
Table of Contents

- Vision for the SRREN
- Core of SRREN: Scenarios
- RE Mitigation Potential and Costs: Results from FOD Chapter 10
- Gaps in SRREN Scenario Analysis
- SRREN: Way Forward
- AR5: IPCC Scenario Process

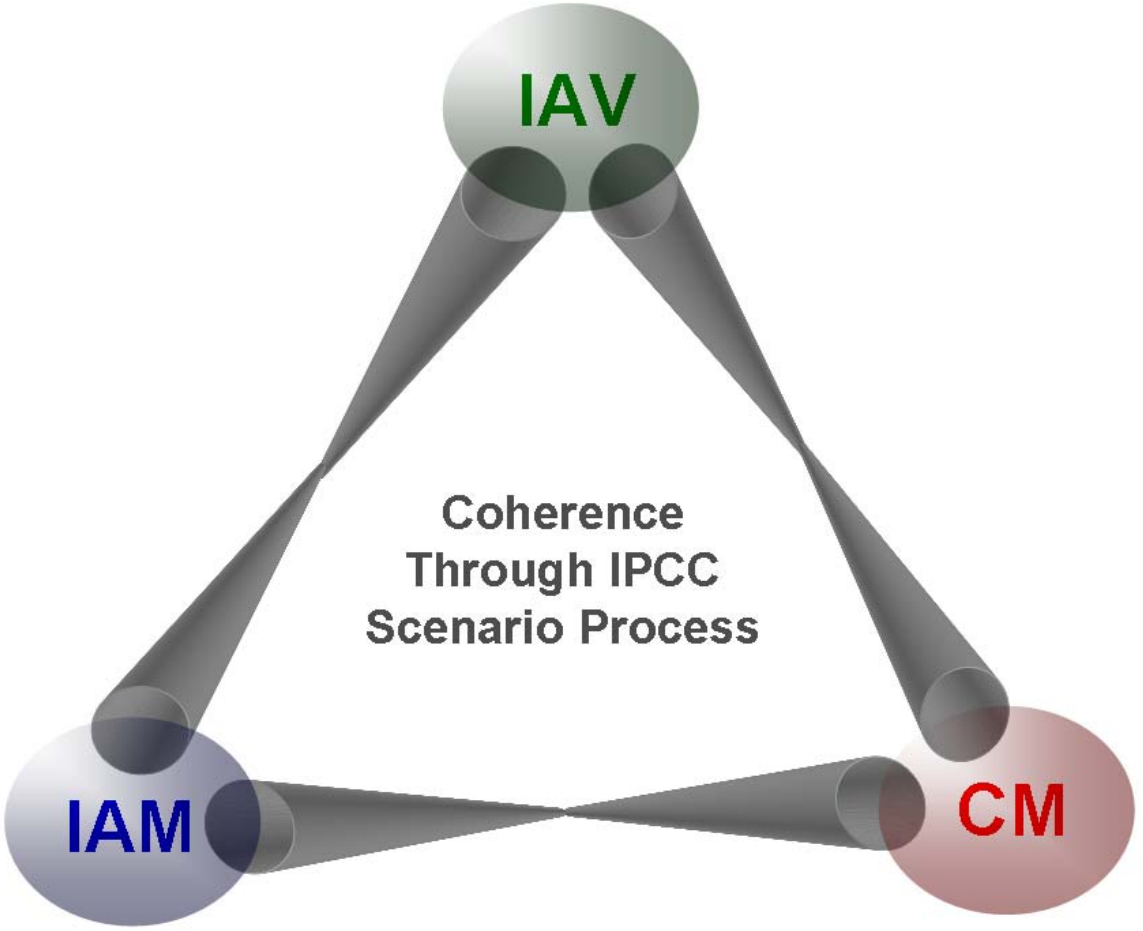
Scientific Communities Involved with IPCC



Scientific Communities Involved with IPCC



AR5 Scenarios: Aim for Coherence



SRREN EM1 & EM3:

Bottom-up and top-down modelling communities

Final Remark

The IPCC is the honest broker between experts and decision makers in business, politics and civil society.

The IPCC should be policy relevant without being policy prescriptive.