Scenarios for Driving Forces

Employing a Participatory Scenario Development Process

Futures of European Waters how should policies adapt?
SCENES Water Scenarios final results
Hungarian Academy of Sciences
Budapest
23 March 2011

Science for Global Insight
IIASA www.iiasa.ac.at

International Institute for Applied Systems Analysis

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Driving Force Scenario Development

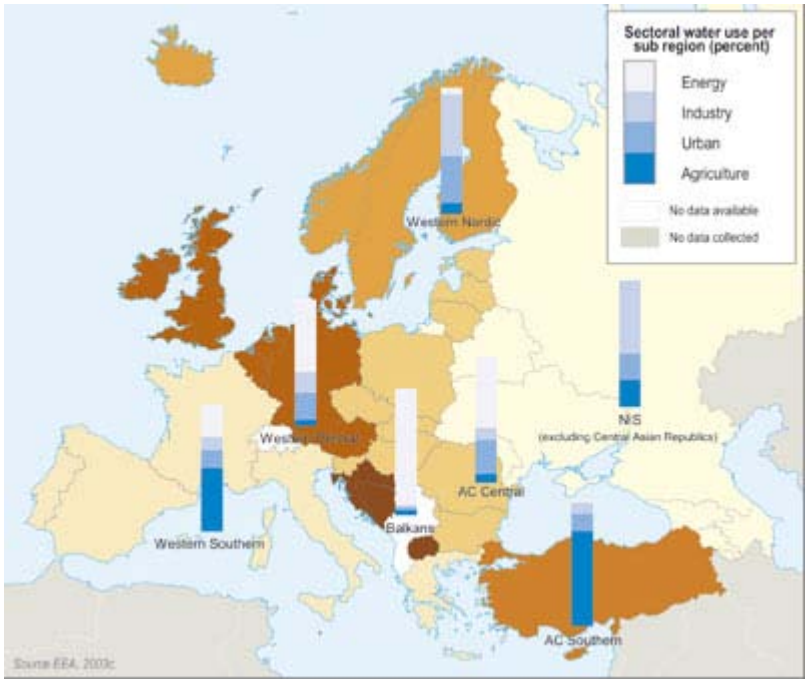
Scenario development Process

1. Stakeholders identified relevant factors
2. Stakeholders described changes in these factors
3. Stakeholders provided some quantitative estimates
4. Based on storylines and estimates from stakeholders, modeling teams further described changes in driving forces and produced quantified scenarios.
5. Return to step 2.

Scenario Storyline Development

Stakeholder Panels

- Water Use
  - Sectors: Agriculture, Energy, Industry, Domestic, Environmental
    - Political security, governance, public involvement
    - Policy, valuation (WFD, CAP)
    - Economic growth and consumption patterns (global and local)
    - Demographics
    - Technological development
    - Agricultural development
    - Land use change
    - Energy production
- Water availability
  - Climate
  - Current use
  - Policy and management
  - Desalination



Scenarios

- Economy First
  - Higher immigration
  - Efficiency and technology improvements, but energy consumption high
  - Abandonment of ag. subsidies, less production in less productive areas
  - Increased pollution

- Policy Rules
  - Higher immigration in Southern Europe, high urbanization
  - Higher agricultural product prices and more production for food and energy
  - Wastewater reuse
  - Water pricing leads to more efficient use
  - Desalination plants use more energy in South, but alternative energy increases
  - Water quality hurt by external demand, health affected in South, urban quality

Scenarios

- Fortress Europe
  - More focus on food and energy security, efficiency
  - New technologies and conservation
  - Decrease in immigration into the EU, within EU movement to water-rich areas
  - Environmental regulations relaxed

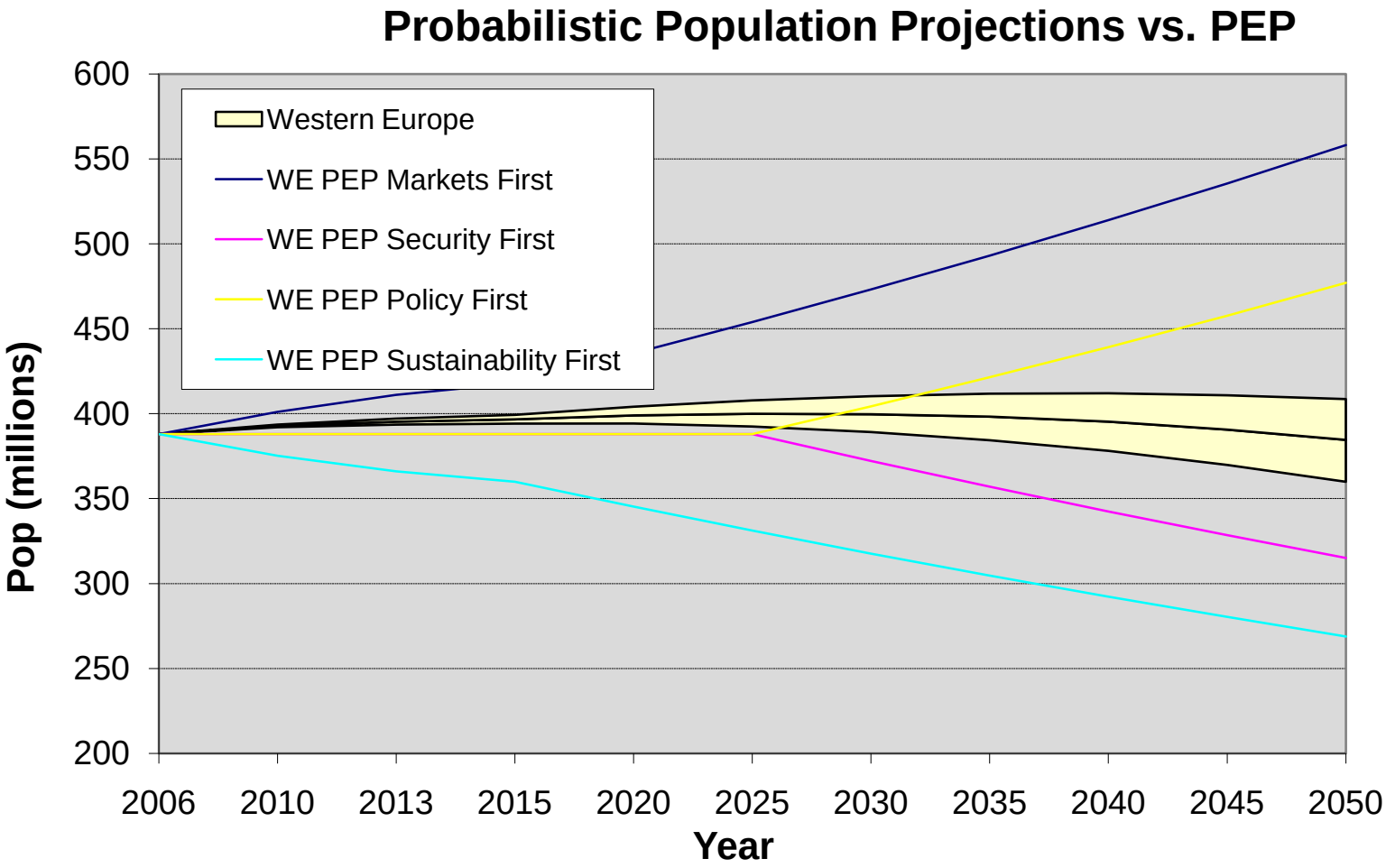
- Sustainability Eventually
  - More rural focus at the end
  - GDP less important – more barter, recession, decentralization
  - Promotion of greater biodiversity, less ag. demand, irrigation decreases
  - Population decreases and moves to water poor countries with nice climate
  - Technological development strong
  - Water demand reduced

PEP1 Annual Population Growth Estimates

Filtered through fuzzy sets

Qualitative	Quantitative
Medium decrease	-1.50%
Low decrease	-0.83%
No change	0.00%
Low increase	0.83%
Medium increase	2.00%
High Increase	2.80%

Implications of PEP1 Estimates

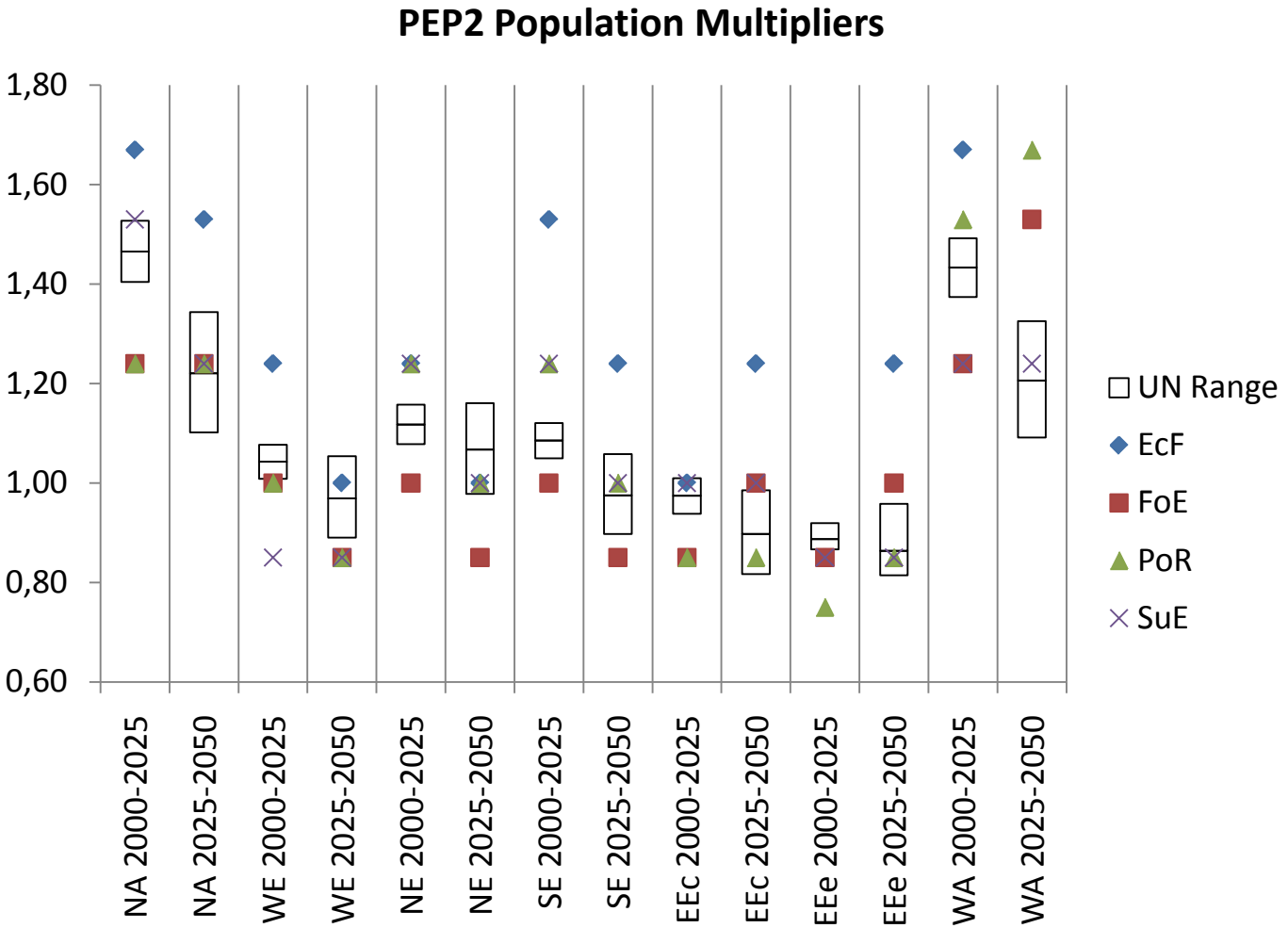


PEP2 Population Growth Estimates

Filtered through fuzzy sets

Qualitative	% of initial pop
Medium decrease	75%
Low decrease	85%
No change	100%
Low increase	124%
Medium increase	157%
High Increase	163%

Implications of PEP2 Estimates



Existing projections inadequate

- SCENES scale/regionalization different than others.
- The SCENES storylines were significantly different.
- SCENES needs consistent projections across drivers, time periods and regions.
- PEP estimates were not within the ranges of existing projections or the likely ranges set by experts.

SCENES Population Model

- Cohort Component Population Projection Model
  - P_{t+n} = survived population + births + net migrants
  - Rates varied each time period.
  - Optimization to near desired growth rate.

- Country level information required
  - Population
  - Age specific fertility, migration, and survival rates

Population Model Parameter Estimation

Scenario	EcF	FoE	PoR	SuE
SOCIAL VARIABLES (generally refers to EU member state weighted average).				
net population growth (relative to BAU trend)	Med-high	Low	High	Medium
fertility rates	Med-high (?)	Medium	Medium-high	Low
mortality rates	Medium-Low	Medium	Medium-high	Med-Low
demographic age structure	Slightly Older	older	Slightly older	older
in / net migration into EU	Medium-high	Very Low	High	Med-Low
internal migration within EU		med-high		

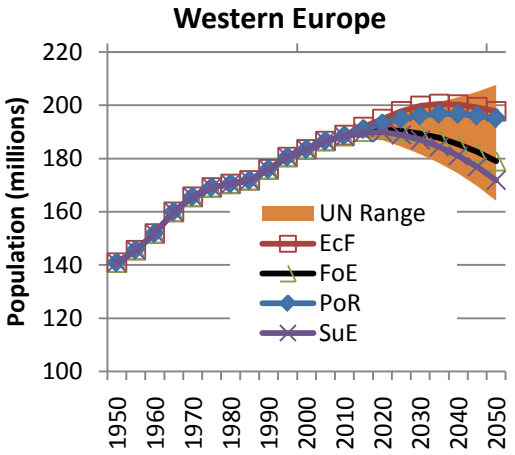
	Mortality	Migration	Fertility
low	0.67	0.67	0.77
med low	0.83	0.83	0.88
med-	0.92	0.92	0.94
medium	1.00	1.00	1.00
med+	1.08	1.13	1.08
med high	1.15	1.25	1.15
high	1.30	1.50	1.30

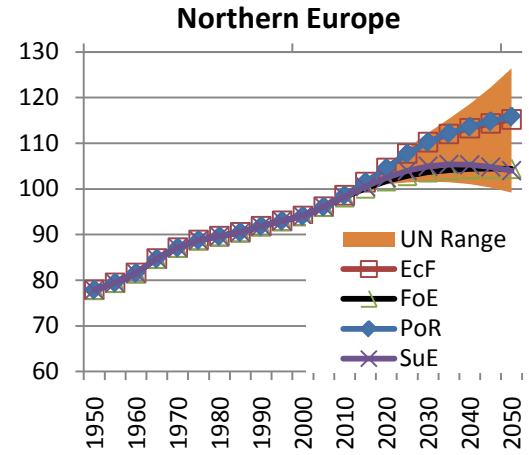
Quantified Parameter Multipliers Ranges

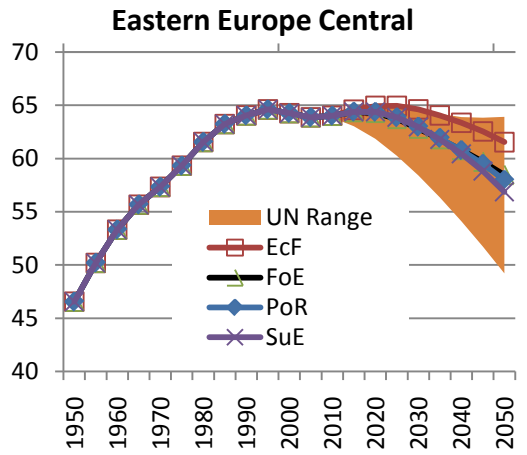
Regional Parameter Estimation

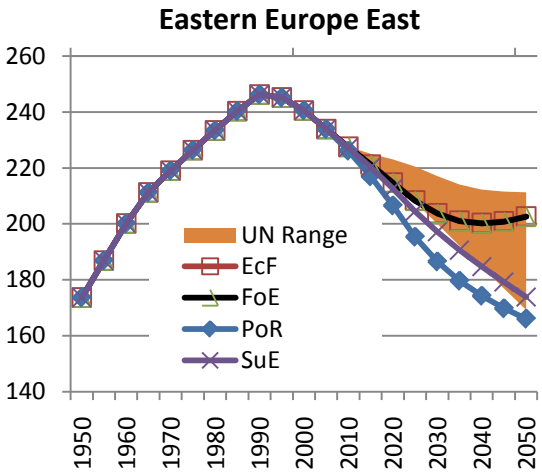
			Time Period					
			2008-2025			2025-2050		
Scenario	Region	Bounds	Mortality	Net Migration	Fertility	Mortality Rate	Net Migration	Fertility
FoR	NA	Low	low	low	low	low	low	low
FoR	NA	Hi	high	high	high	high	high	high
FoR	WE	Low	med-	low	med-	med-	low	med-
FoR	WE	Hi	med+	med low	med+	med+	med low	med+
FoR	NE	Low	med-	med-	med-	med-	med-	med-
FoR	NE	Hi	med+	med+	med+	med+	med+	med+
FoR	SE	Low	med-	low	med-	med-	low	med-
FoR	SE	Hi	med+	med low	med+	med+	med low	med+
FoR	Eec	Low	med-	low	med-	med-	low	med-
FoR	Eec	Hi	med+	med low	med+	med+	med low	med+
FoR	Eee	Low	low	low	low	low	low	low
FoR	Eee	Hi	high	high	high	high	high	high
FoR	WA	Low	low	low	low	low	low	low
FoR	WA	Hi	high	high	high	high	high	high

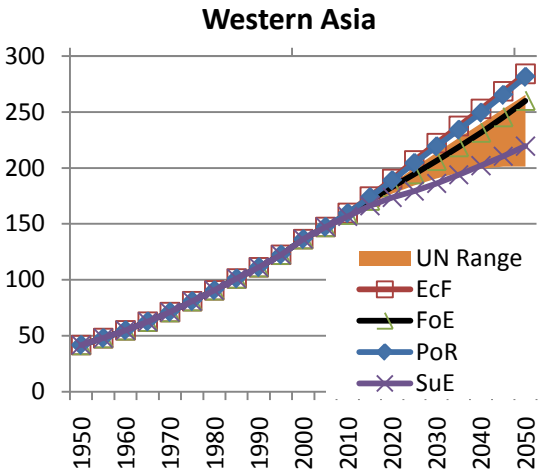
Regional Population Projections

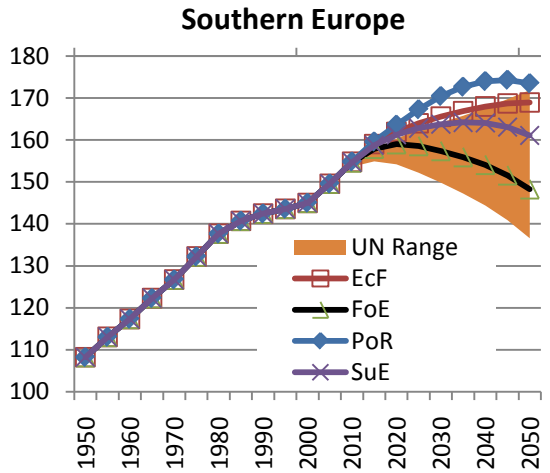












GDP vs. Population

- More commonly known
- More uncertain and volatile
  - Less restricted by physics/biology
  - Greater ranges possible

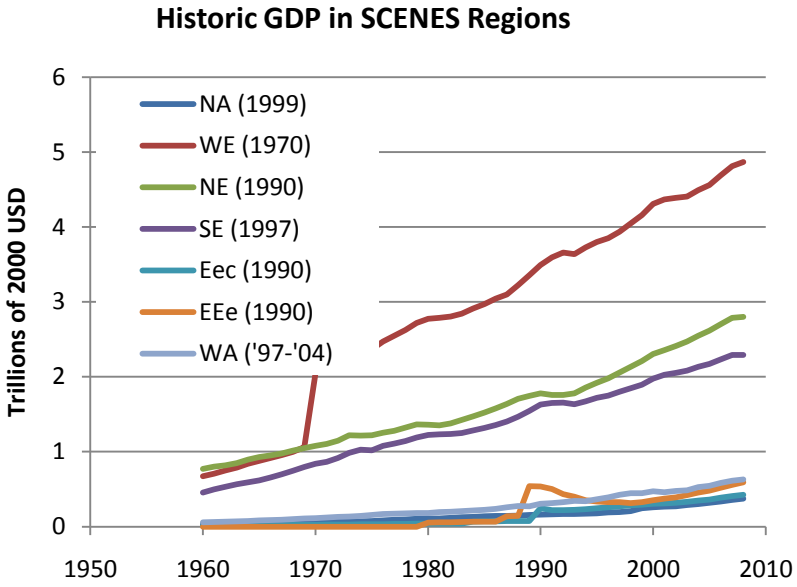
PEP1 Annual GDP Growth Estimates

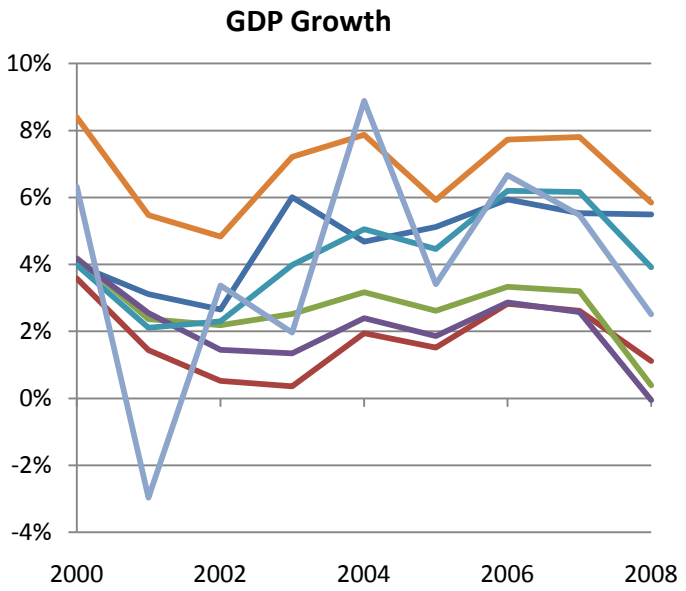
Filtered through fuzzy sets

GDP growth rate	2005-2025				2025-2050			
SuF Region	**WP**	**WE**	**EE**		**WP**	**WE**	**EE**	
Sustainability First (SuF)	Low increase	No change	Medium increase		Medium increase	←===→		
Region	**WE**	**CE**	**EE**		**WE**	**CE**	**EE**	
Market First (MaF)	Medium increase	Medium increase	Medium increase		Low increase	Low increase	Medium to high increase	
Security First (SeF)	Low decrease	No change	Low decrease		Medium decrease	Medium decrease	Medium decrease	
PoF Region	**WE**	**CE**	**EE**	**SEM**	**WE**	**CE**	**EE**	**SEM**
Policy First (PoF)	Low increase	Medium increase	Medium increase					

Qualitative	Quantitative
Low decrease	-1.7%
No change	0.33%
Low increase	2.3%
Medium increase	4.5%

Historic GDP Trends





PEP2 Annual GDP Growth Estimates

Filtered through fuzzy sets

EcF	NA		WE		NE		SE		EEc		EEe		WA	
2025	M+	3.2	L+	1.3	L+	1.3	L+	1.3	L+	1.3	M+	3.2	L+	1.3
2050	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3
FoE														
2025	M+	3.2	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3	M+	3.2
2050	L+	1.3	0	0.03	0	0.03	0	0.03	0	0.03	0	0.03	L+	1.3
PoR														
2025	M+	3.2	L+	1.3	M+	3.2	L+	1.3	M+	3.2	M+	3.2	M+	3.2
2050	M+	3.2	L+	1.3	L+	1.3	L+	1.3	M+	3.2	L+	1.3	M+	3.2
SuE														
2025	+	1.3	-	-1.1	+	1.3	+	1.3	0	0.03	-	-1.1	+	1.3
2050	+	1.3	-	-1.1	0	0.03	+	1.3	0	0.03	-	-1.1	+	-0.03
’99-’08														
Average		4.7		1.9		2.8		2.2		4.2		6.6		3.6
Min		2.7		0.4		0.4		-.05		2.1		4.6		-3.0
Max		6.0		3.6		4.2		4.2		6.2		8.4		8.9

PEP 2 GDP Quantifications

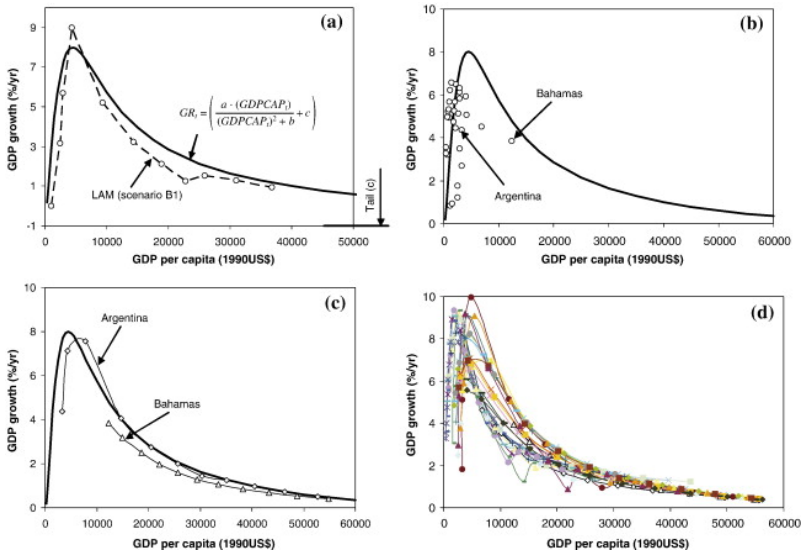
National GDP downscaling

GDP growth rate as a function of GDP/cap

$$GR_t = \left(\frac{a \cdot (GDPCAP_t)}{(GDPCAP_t)^2 + b} + c \right)$$

Or

$GR_t = (a \cdot \log(GDPCAP_t) + b)$

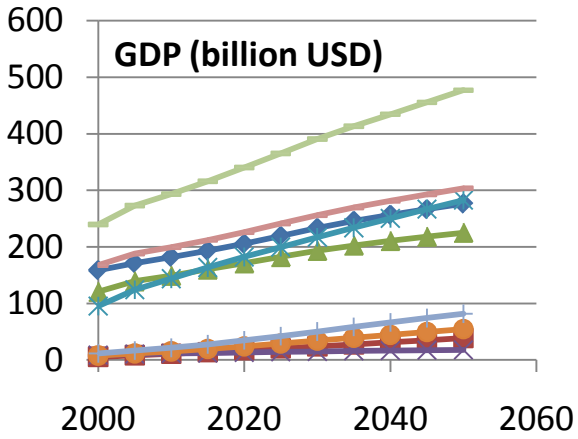


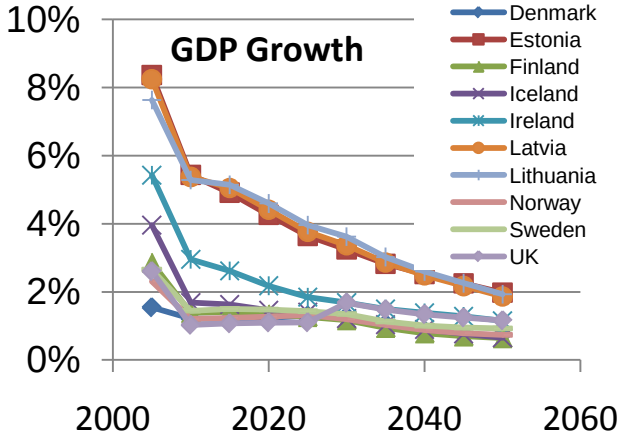
Source: Grubler et al, 2007

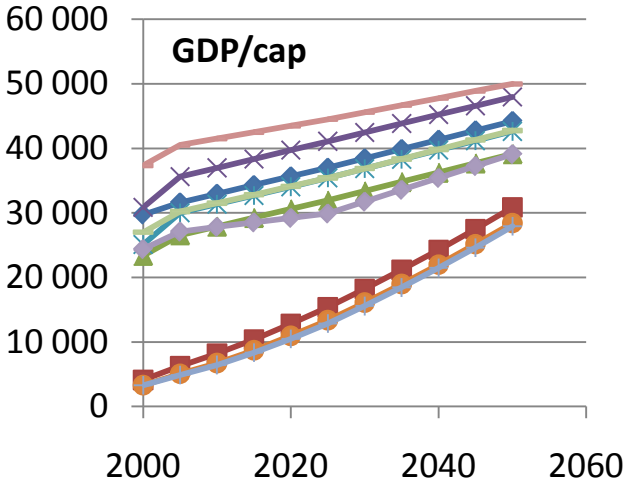
Equations applied for each country.

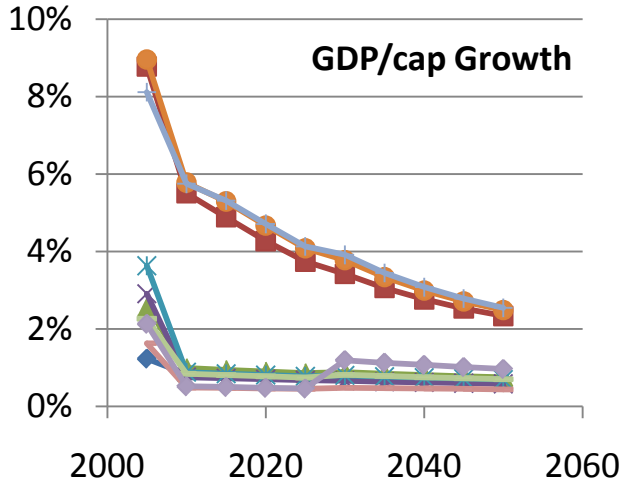
Optimization ensures countries fit total regional values.

National GDP downscaling





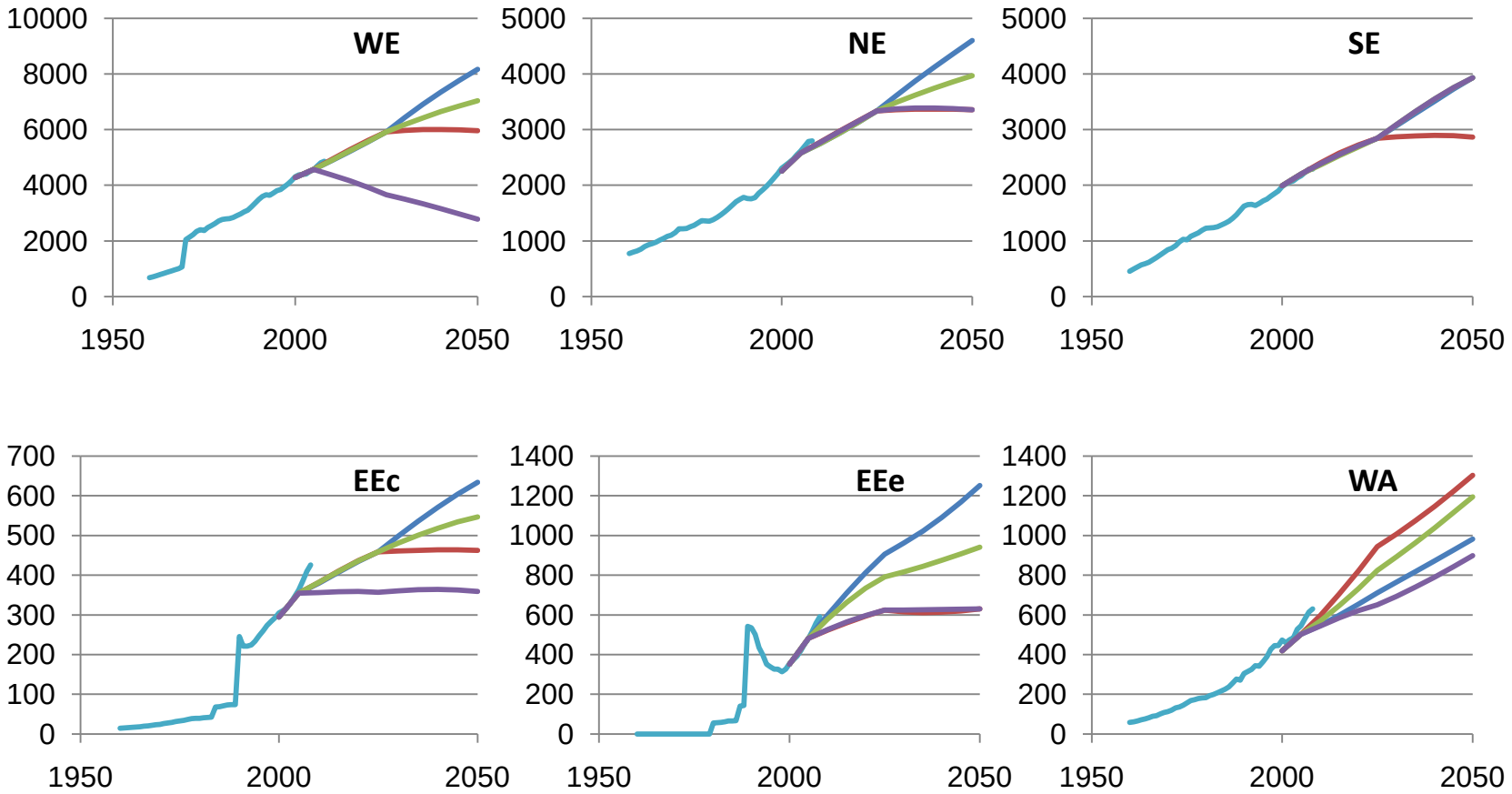




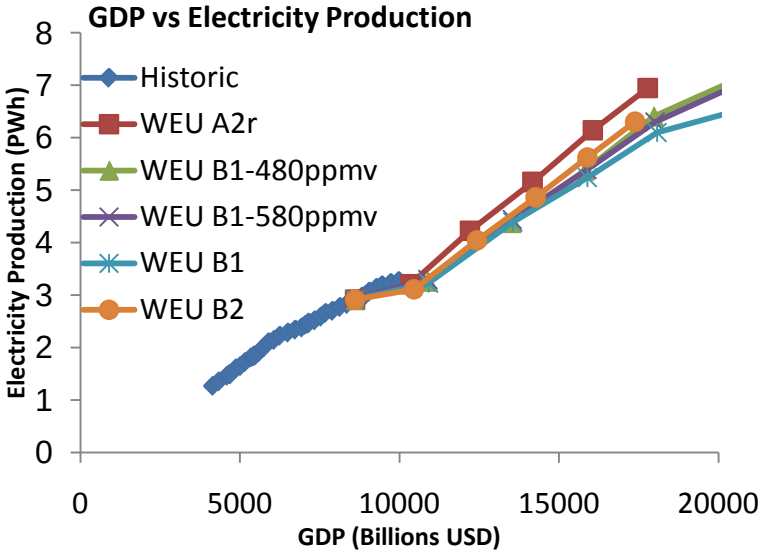
PEP 3 GDP growth rate revisions

EcF	NA		WE		NE		SE		EEc		EEe		WA	
2025	M+	3.2	L+	1.3	L+	1.3	L+	1.3	L+	1.3	M+	3.2	L+	1.75
2050	L+	1.75	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3
FoE														
2025	M+	3.2	L+	1.3	L+	1.3	L+	1.3	L+	1.3	L+	1.3	M+	3.2
2050	L+	1.3	0	0.03	0	0.03	0	0.03	0	0.03	0	0.03	L+	1.3
PoR														
2025	M+	3.2	L+	1.3	L+	1.3	L+	1.3	L+	1.3	M+-	2.5	M+-	2.5
2050	L+	1.3	L+-	0.7	L+-	0.7	L+	1.3	L+-	0.7	L+	0.7	L++	1.5
SuE														
2025	+	1.75	-	-1.1	+	1.3	+	1.3	0	0.03	+	1.3	+	1.3
2050	+	1.3	-	-1.1	0	0.03	+	1.3	0	0.03	0	0.03	+	-0.03
'99-'08														
Average		4.7		1.9		2.8		2.2		4.2		6.6		3.6
Min		2.7		0.4		0.4		-.05		2.1		4.6		-3.0
Max		6.0		3.6		4.2		4.2		6.2		8.4		8.9

GDP Scenario Projections after PEP3

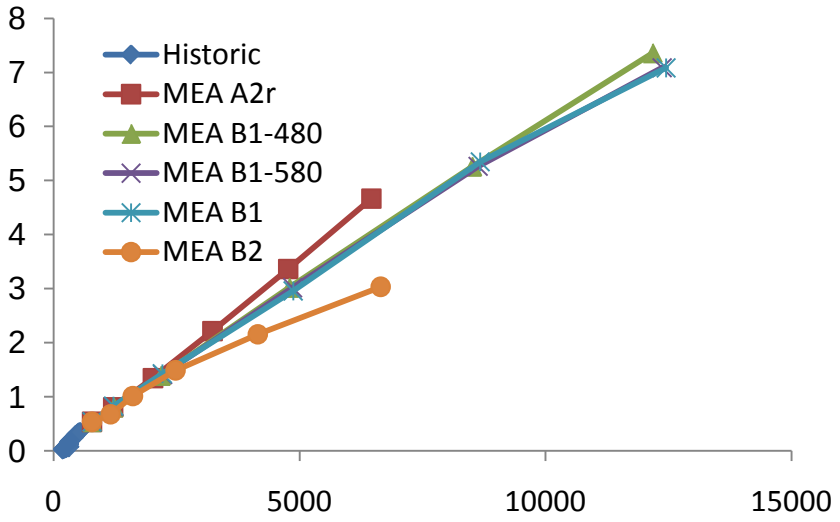


Projecting Thermal Energy Production

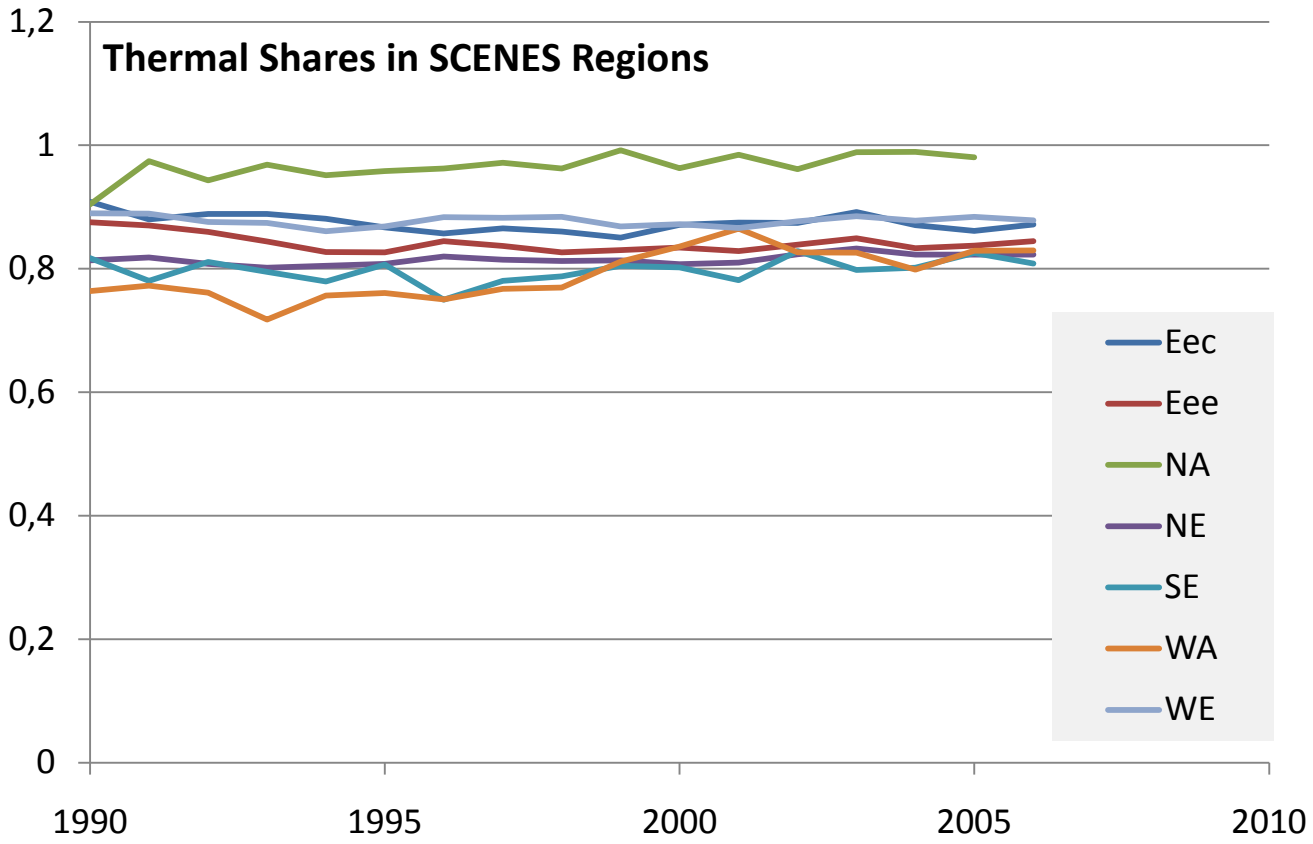


Slope Multiplier Range

	EEU	FSU	WEU	MEA
Maximum	1.12	1.23	1.15	1.19
Average	1.00	1.00	1.00	1.00
Minimum	0.84	0.75	0.80	0.69



Thermal Shares



Thermal electricity production

Parameterization for EcF scenario

- Clues in storylines
  - High material consumption and increased resource use per capita vs. less material intensive with greater efficiency?
  - EcF immediate push to reduce greenhouse gas emissions
  - Efficiency increases
  - Greater transport energy requirement in EE
  - Later thermal production increases with more Nuclear and fossil fuels.
  - Hydropower only increased in area of plentiful water

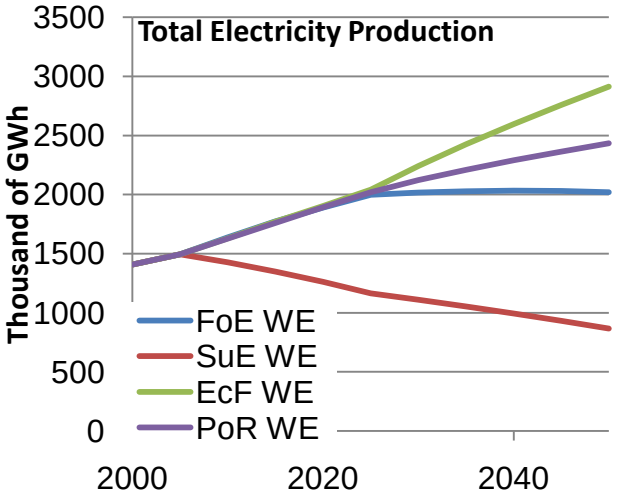
Thermal electricity production

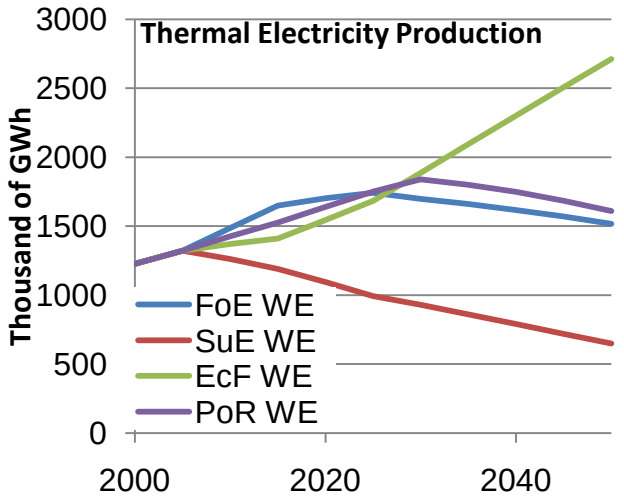
Parameterization for EcF scenario

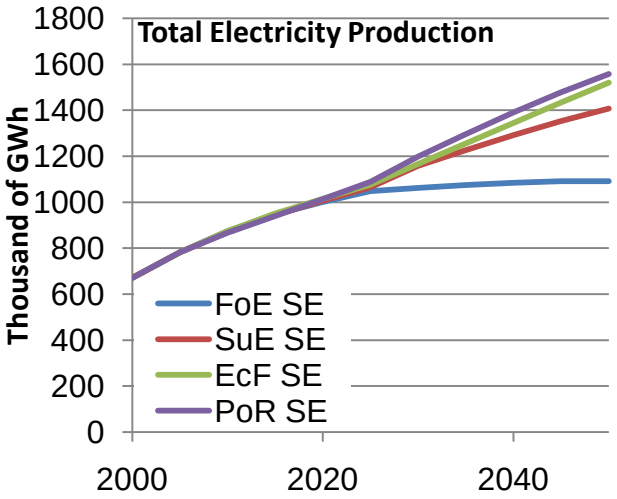
Region	E/GDP slope multiplier			Thermal Share (end of period)				Change from historical		
	-2015	-2030	-2050	2000	-2015	-2030	-2050	-2015	-2030	-2050
EEc	0.98	0.9	0.8	0.97	0.97	0.92	0.82	0%	-5%	-15%
EEe	0.98	0.9	0.8	0.83	0.88	0.79	0.71	5%	-5%	-15%
NA	1	1	1	0.89	0.89	0.91	0.93	0%	2%	5%
NE	0.98	0.9	0.8	0.73	0.76	0.69	0.62	5%	-5%	-15%
SE	0.98	0.9	0.8	0.80	0.84	0.76	0.68	5%	-5%	-15%
WA	1	1	1	0.80	0.80	0.82	0.84	0%	2%	5%
WE	0.98	0.9	0.8	0.88	0.92	0.83	0.75	5%	-5%	-15%

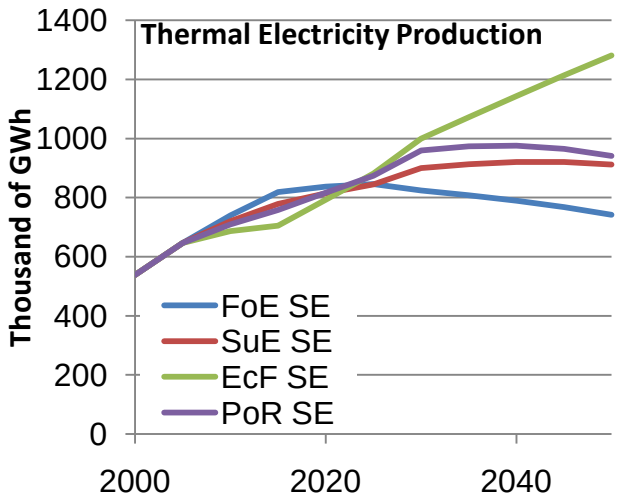
Thermal Electricity Production

Sample scenario projections



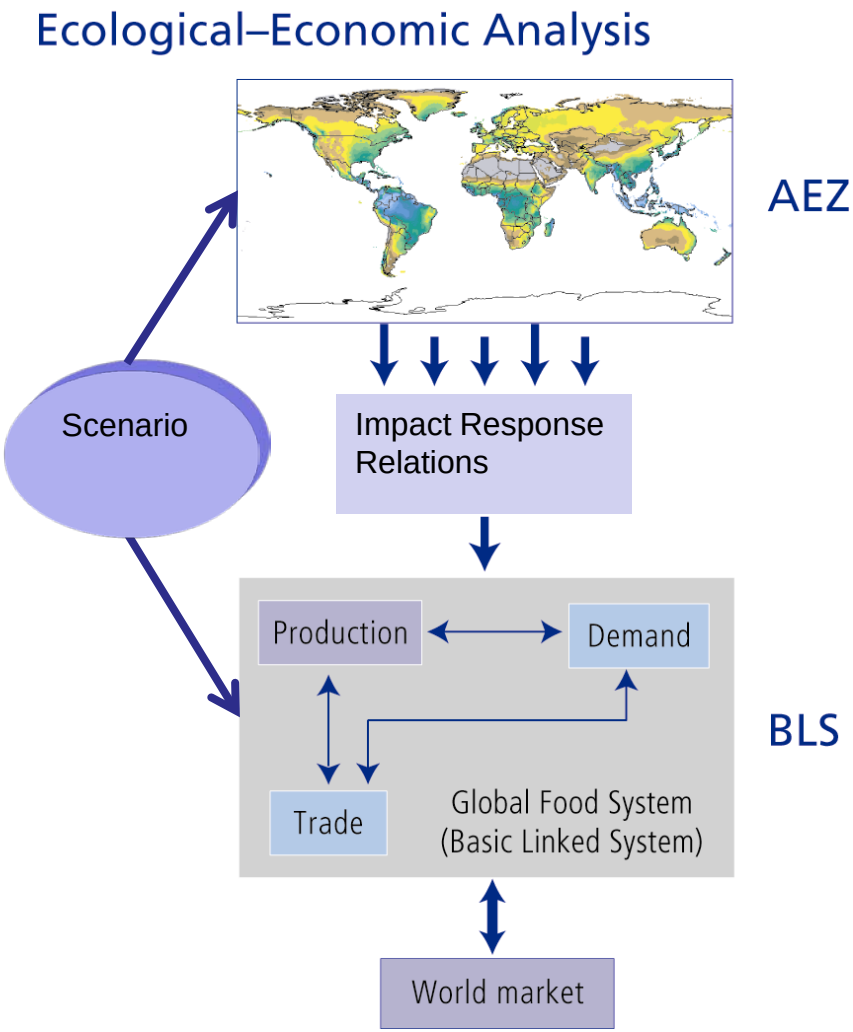






Land Use/Agriculture Production Projections

AEZ/BLS system



Land Use/Agriculture Production Projections

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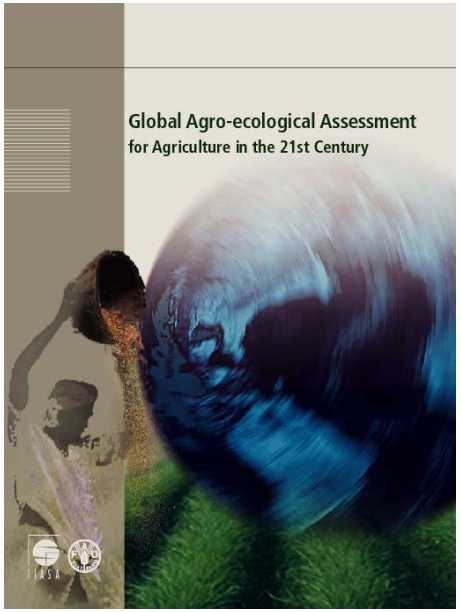


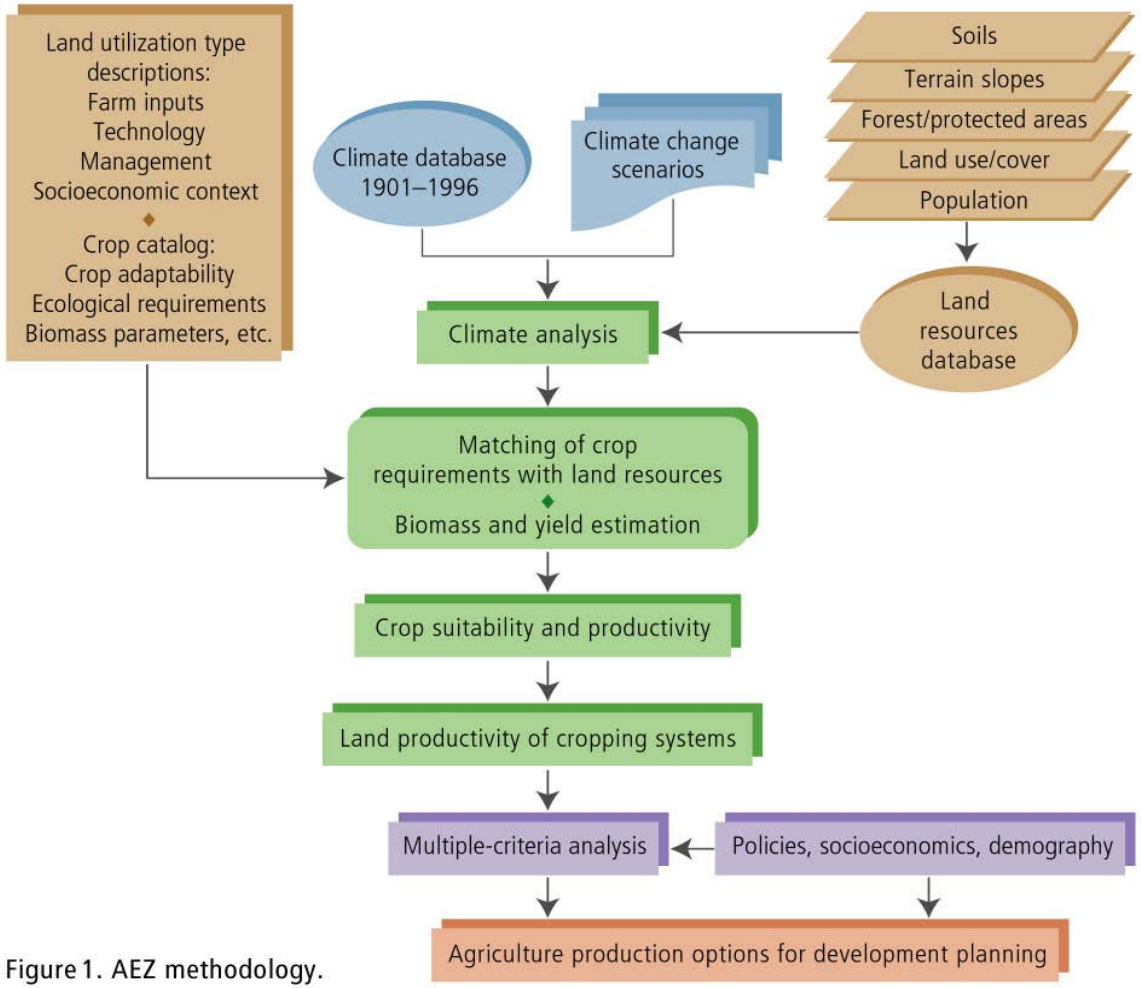


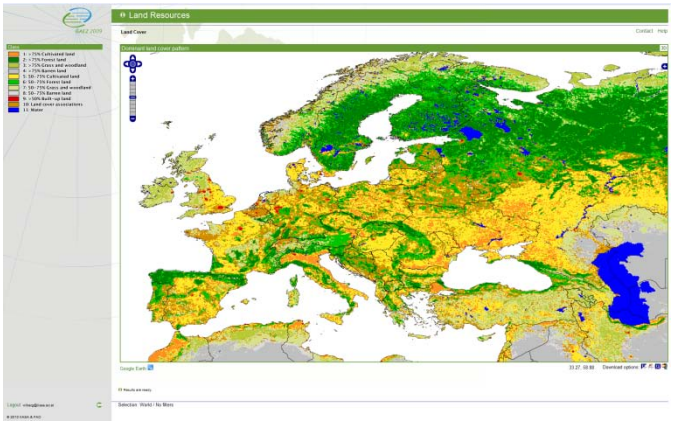
Figure 1. AEZ methodology.

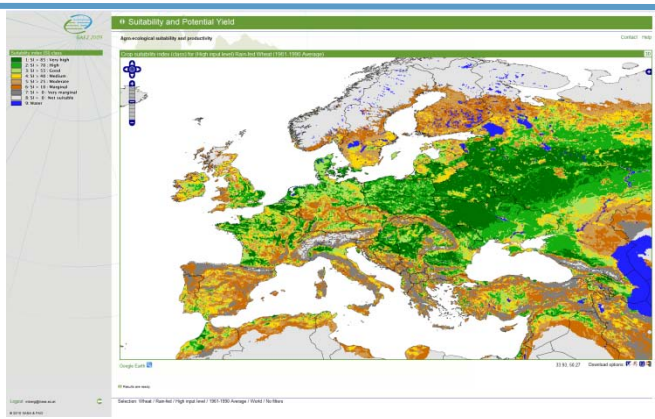
Land Use/Agriculture Production Projections

AEZ/BLS system

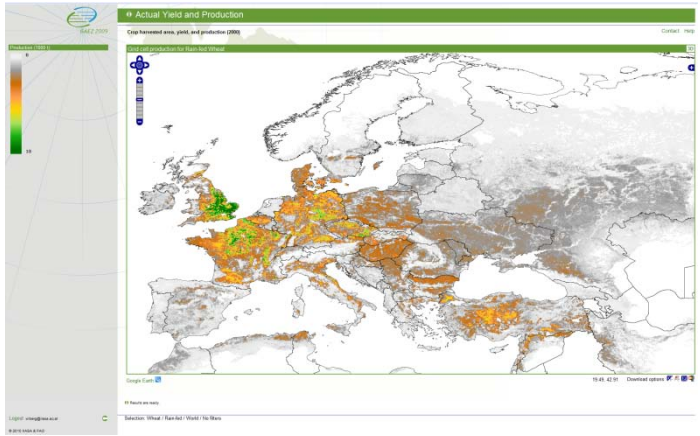
Food and Agriculture Organization of the United Nations

for a world without hunger





Ag. Statistics + Spatial Land Use + Crop Suitability



= Downscaled Crop Production

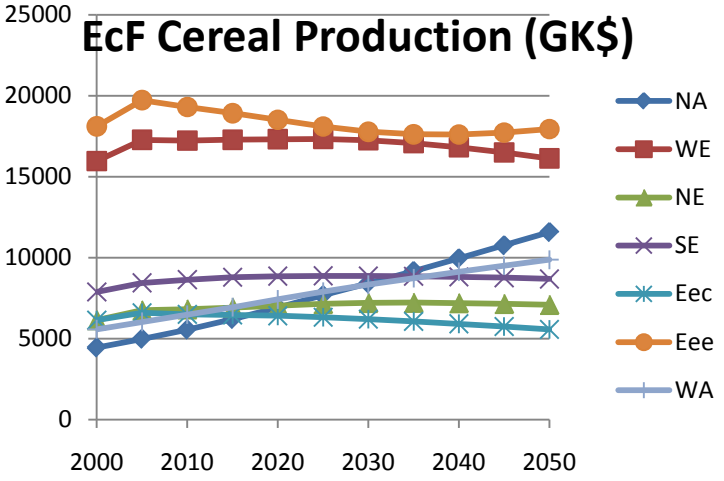
+ Scenarios (POP, GDP, Energy) + BLS (Global Food System Economic Model)

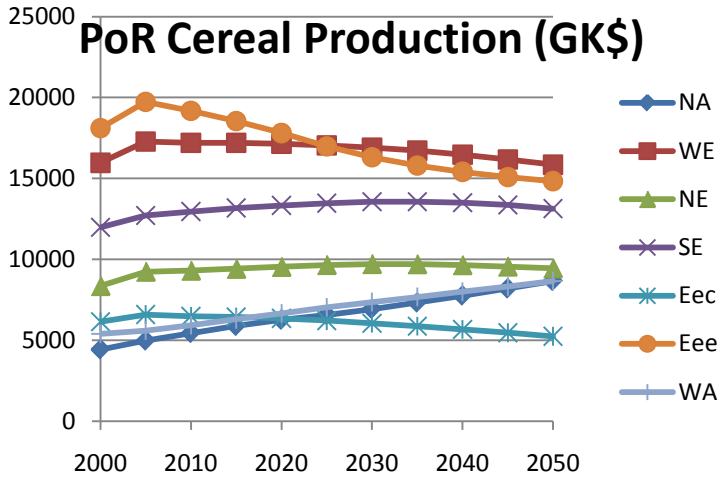
Land Use/Agriculture Production Projections

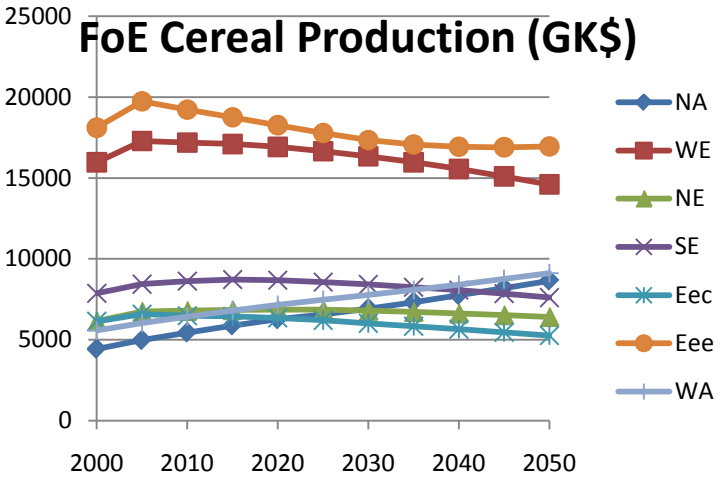
Crops and Livestock for SCENES

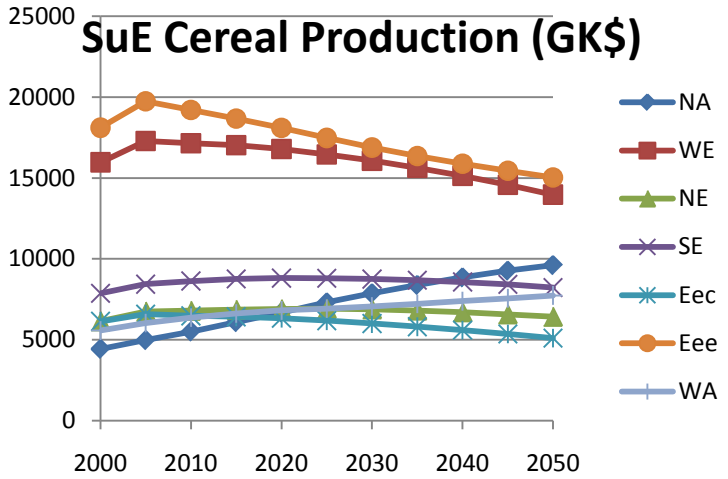
- Cereals: wheat, rice, maize, other cereals
- Other crops: root crops, sugar crops, pulses, oil seeds/crops, fruit, vegetables, stimulants, fibres and tobacco
- Fodder crops
- Ruminants: cattle and buffalo, sheep and goat
- Other livestock: other large animals, pigs, and poultry.

Cereal Production Scenarios





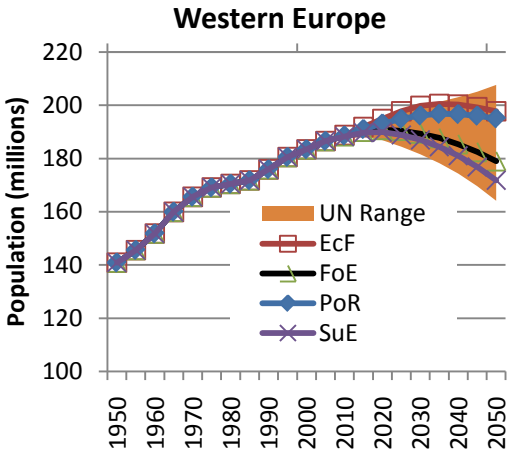


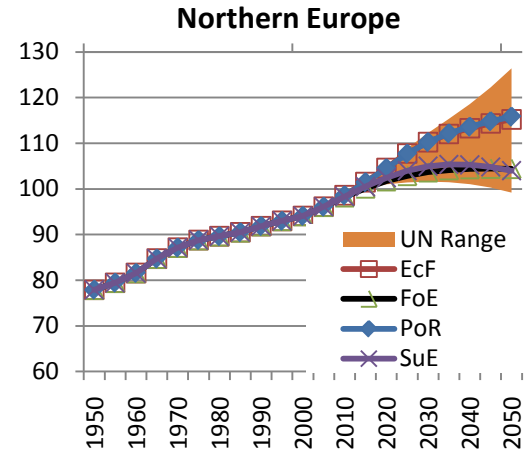


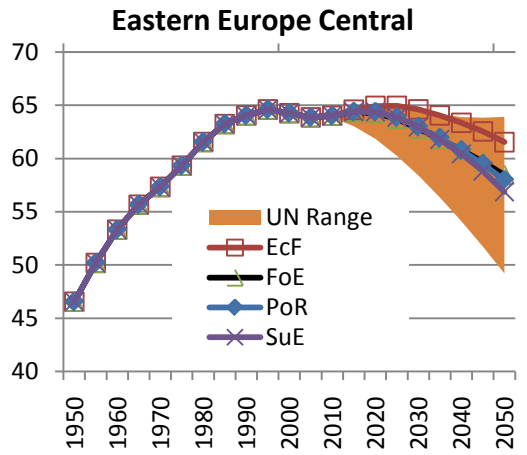
Summary

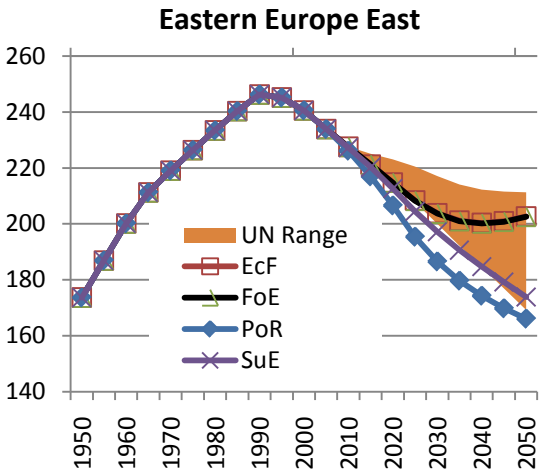
- **Successes**
  - Knowledge and experience gained
  - Consistent driver projections produced
  - Set of projection models built
- **Lessons learned**
  - More guidance needed for panels
  - Reduce complexity: Simplified presentation of select drivers and options
  - Faster inter-scenario feedback needed during meetings
  - Process most effective when motivated by needed decision
  - Integration of bottom-up and top-down approaches beneficial
- **Ultimate objectives**
  - Continuous stakeholder involvement at all scales for adaptive management.
  - Real-time decision support systems for testing scenario options

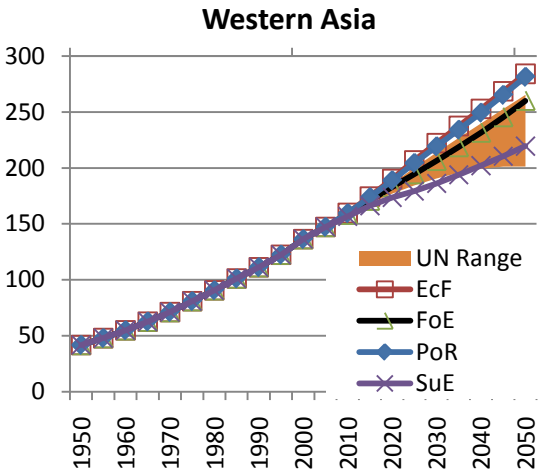
Regional Population Projections

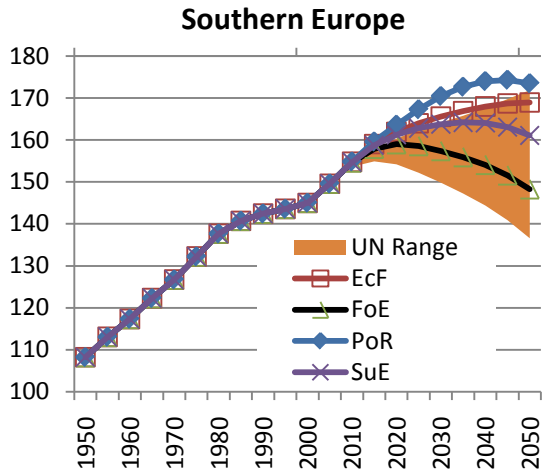


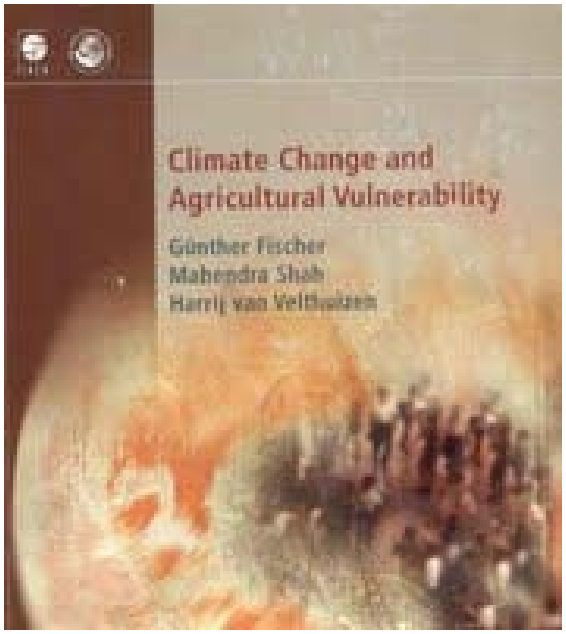






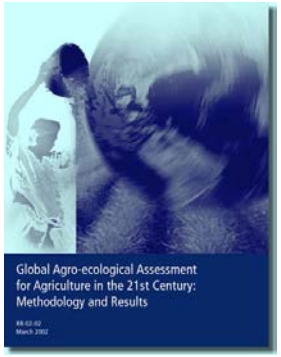






THANK YOU

http://www.iiasa.ac.at/Research/LUC



Land Resources & Agro-ecological Zoning:

GAEZ 2009

- Land Resources
- Agro-climatic Resources
- Suitability and Potential Yield
- Actual Yield and Production
- Yield and Production Gaps

Global Agro-ecological Zones

Help

GAEZ Web Interface

The International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization of the United Nations (FAO) have been continuously developing the Agro-Ecological Zones (AEZ) methodology over the past 30 years for assessing agricultural resources and potential. Rapid developments in information technology have produced increasingly detailed and manifold global databases, which have made the first global AEZ assessment possible in 2000. Since then global AEZ assessments have been performed every few years, with the data being published on CD or DVD. With each update of the system, the issues addressed, the size of the database and the number of results has multiplied. GAEZ 2009 is the most ambitious assessment yet and the goal is to make publicly available the entire database and all results of this assessment. This amounts to many Terabytes of data covering five thematic areas:

- land resources, including soils, terrain, and land cover;
- agro-climatic resources, including a variety of climatic indicators;
- agricultural suitability and potential yields for some 90 crop types under multiple management levels;
- downscaled actual yields and production of about 25 crops; and
- yield gaps in terms of differences between the potential yields a various levels of input and the actual downscaled yields of crops.

With this huge amount of data, a new system had to be created to make the data accessible to a variety of users. The result is the new GAEZ Web Interface, which not only gives access and allows visualization of data but also provides the user with various analysis and download options.

Thermal electricity production

Parameterization for FoE scenario

Region	E/GDP slope multiplier			Thermal Share (end of period)				Change from historical		
	-2015	-2030	-2050	2000	-2015	-2030	-2050	-2015	-2030	-2050
EEc	0.98	0.9	0.8	0.97	0.97	0.92	0.82	0%	-5%	-15%
EEe	0.98	0.9	0.8	0.83	0.88	0.79	0.71	5%	-5%	-15%
NA	1	1	1	0.89	0.89	0.91	0.93	0%	2%	5%
NE	0.98	0.9	0.8	0.73	0.76	0.69	0.62	5%	-5%	-15%
SE	0.98	0.9	0.8	0.80	0.84	0.76	0.68	5%	-5%	-15%
WA	1	1	1	0.80	0.80	0.82	0.84	0%	2%	5%
WE	0.98	0.9	0.8	0.88	0.92	0.83	0.75	5%	-5%	-15%

Thermal electricity production

Parameterization for PoR scenario

Region	E/GDP slope multiplier			Thermal Share (end of period)				Change from historical		
	-2015	-2030	-2050	2000	-2015	-2030	-2050	-2015	-2030	-2050
EEc	0.99	0.98	0.95	0.97	0.95	0.95	0.73	-2%	-2%	-25%
EEe	0.99	0.98	0.95	0.83	0.82	0.82	0.63	-2%	-2%	-25%
NA	1.02	1.1	1	0.89	0.87	0.87	0.80	-2%	-2%	-10%
NE	0.99	0.98	0.9	0.73	0.71	0.58	0.47	-2%	-20%	-35%
SE	1.02	1.1	1	0.80	0.78	0.78	0.60	-2%	-2%	-25%
WA	1.02	1.1	1	0.80	0.79	0.79	0.72	-2%	-2%	-10%
WE	0.99	0.98	0.9	0.88	0.86	0.86	0.66	-2%	-2%	-25%

Thermal electricity production

Parameterization for SuE scenario

Region	E/GDP slope multiplier			Thermal Share (end of period)				Change from historical		
	-2015	-2030	-2050	2000	-2015	-2030	-2050	-2015	-2030	-2050
EEc	1	1	1	0.97	0.97	0.95	0.92	0%	-2%	-5%
EEe	1	1	1	0.83	0.83	0.82	0.79	0%	-2%	-5%
NA	1	0.95	0.7	0.89	0.89	0.84	0.71	0%	-5%	-20%
NE	1	0.95	0.9	0.73	0.73	0.71	0.64	0%	-3%	-12%
SE	1	0.95	0.7	0.80	0.80	0.76	0.64	0%	-5%	-20%
WA	1	0.95	0.8	0.80	0.80	0.76	0.64	0%	-5%	-20%
WE	1	0.95	0.9	0.88	0.88	0.83	0.75	0%	-5%	-15%

- Additional Slide Ideas
  - Mention actual pop growth rate and 2025/2050 projections
  - Cohort Component Equation/description
  - Population pyramid and impacts of rate changes
  - Show example of where optimizer needed to bring together population values
  - GDP methodology development plot and equations
  - Make sure you understand units on graphs.
  - Equation for power generation? E2 = c2*(c1*E1)
  - Conclusions – reduce complexity, provide bounds to stakeholders, develop real-time models.