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MULTI-REGIONAL LONG-TERM ELECTRICITY SUPPLY SCENARIOS WITH FUSION

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Outline

- Motivation and Objectives
- Approach / PLANELEC model
- Assumptions and Input Data
- Overview of Selected Scenarios
- Main Findings
- Conclusions and Recommendations

Motivation

- **The existing global long-term energy scenario studies** (*e.g. IIASA / WEC, IPCC SRES*) **does not consider Fusion power as potential energy supply option**
- **Region-specific conditions** (*availability of primary energy resources; CO_2 emission caps; public policy to support innovative technologies*) **may affect significantly the deployment rates of Fusion**
- **Need to complement the existing energy scenario studies emphasized on Fusion** (*e.g. Lako et al., 1999; Schmidt et al., 2000; Tokimatsu et al., 2002*) **with an in-depth prospective analysis of future regional electricity supply mixes**

Objectives

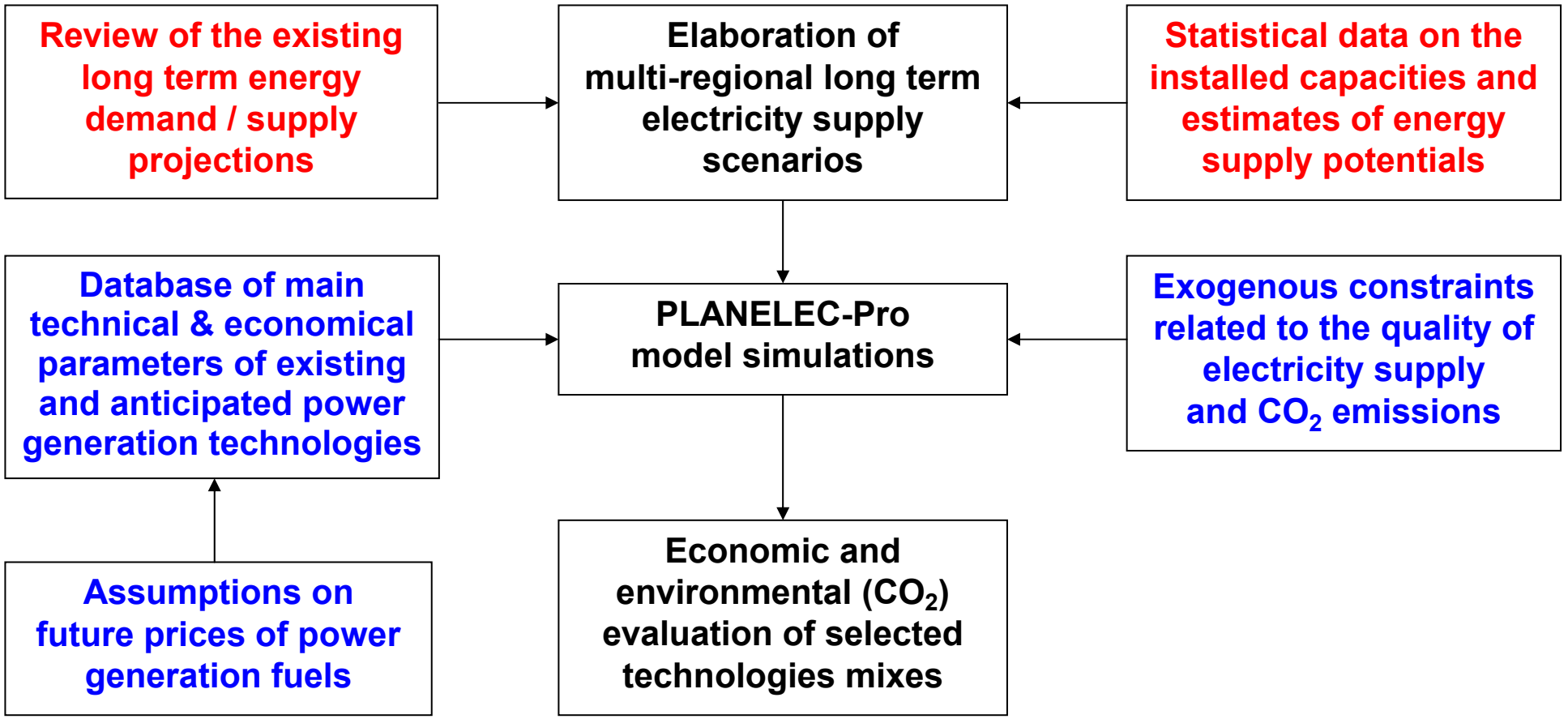
Main Goal

To assess possible market shares of Fusion power in future regional electricity supply mixes

Specific tasks

- ✓ **Building of credible multi-regional electricity supply scenarios**
- ✓ **Estimation of possible shares in total electricity production of different power generation technologies, including Fusion**
- ✓ **Simulation of selected scenarios with PLANELEC model to assess economic and environmental performance of Fusion power generation**

Approach / PLANELEC model

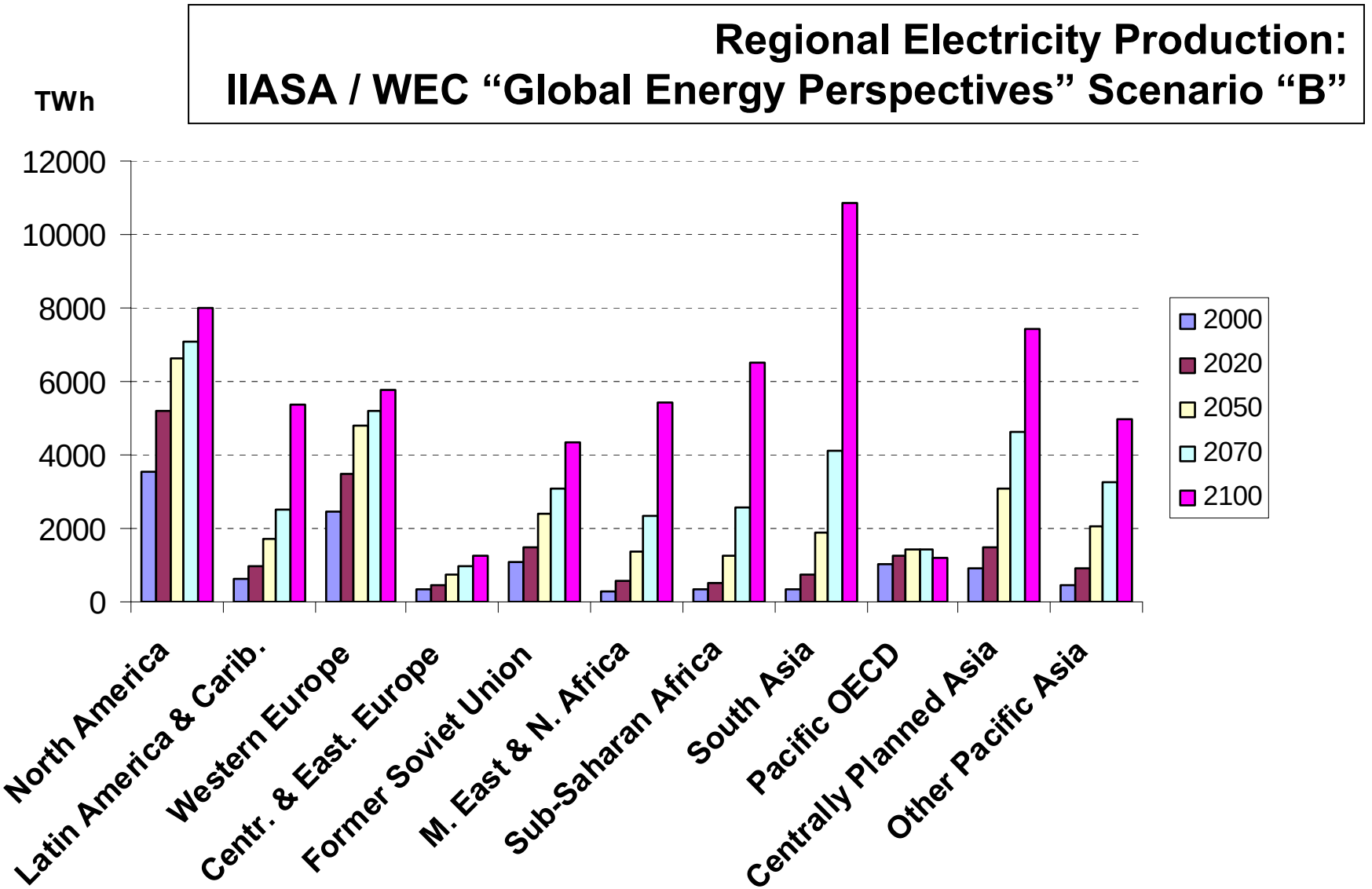


Approach / PLANELEC Model

Main indicators

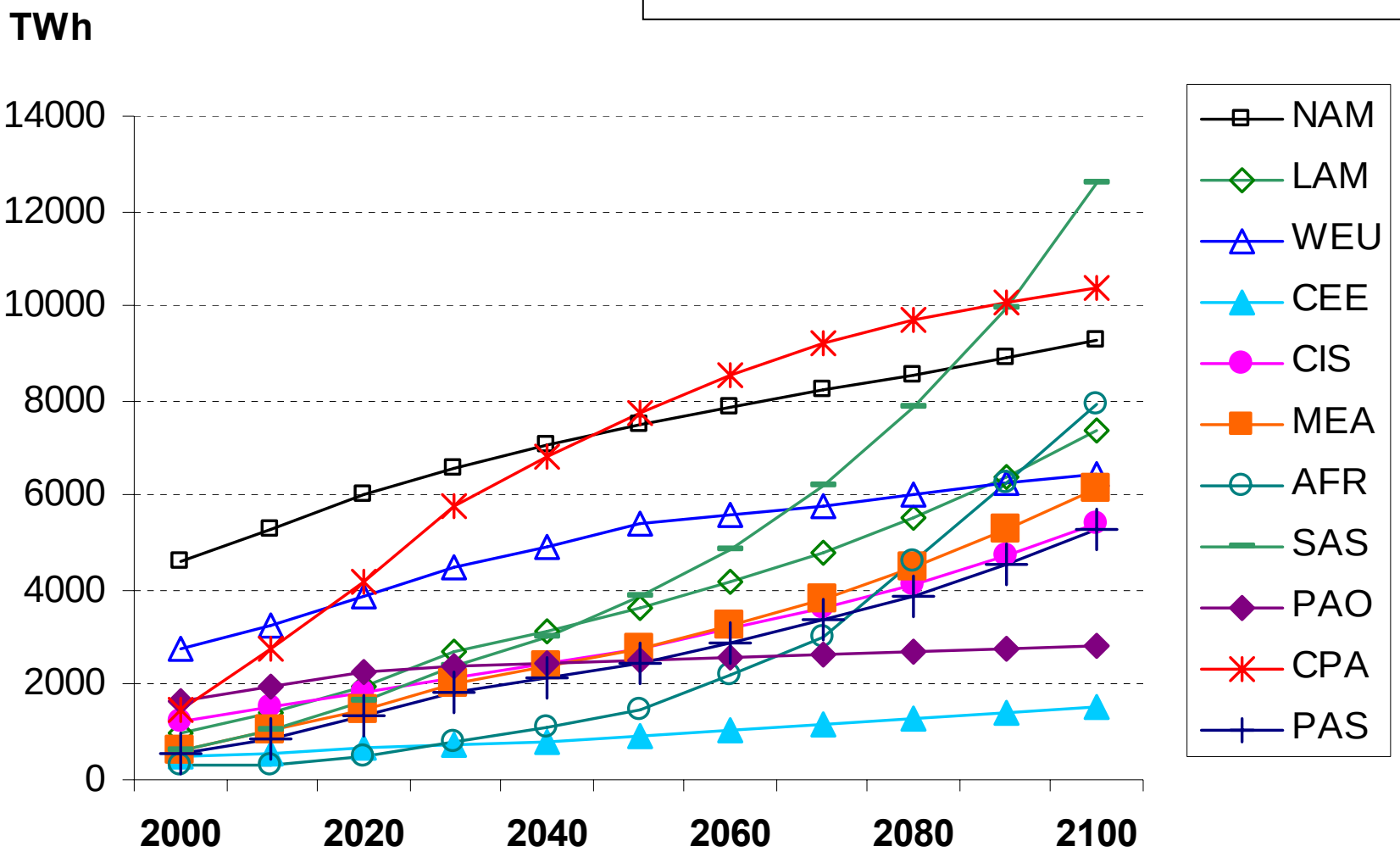
- **Impact on the levelized system electricity cost of the evolving share of Fusion power and competing electricity supply options** (*advanced nuclear fission, coal with CO_2 capture & sequestration*)
- **Total discounted cost of the system expansion plan**
- **Cumulated CO_2 emission reductions compared to Baseline scenario**
- **Technology-specific CO_2 abatement cost**

Overview of Existing Energy Scenarios



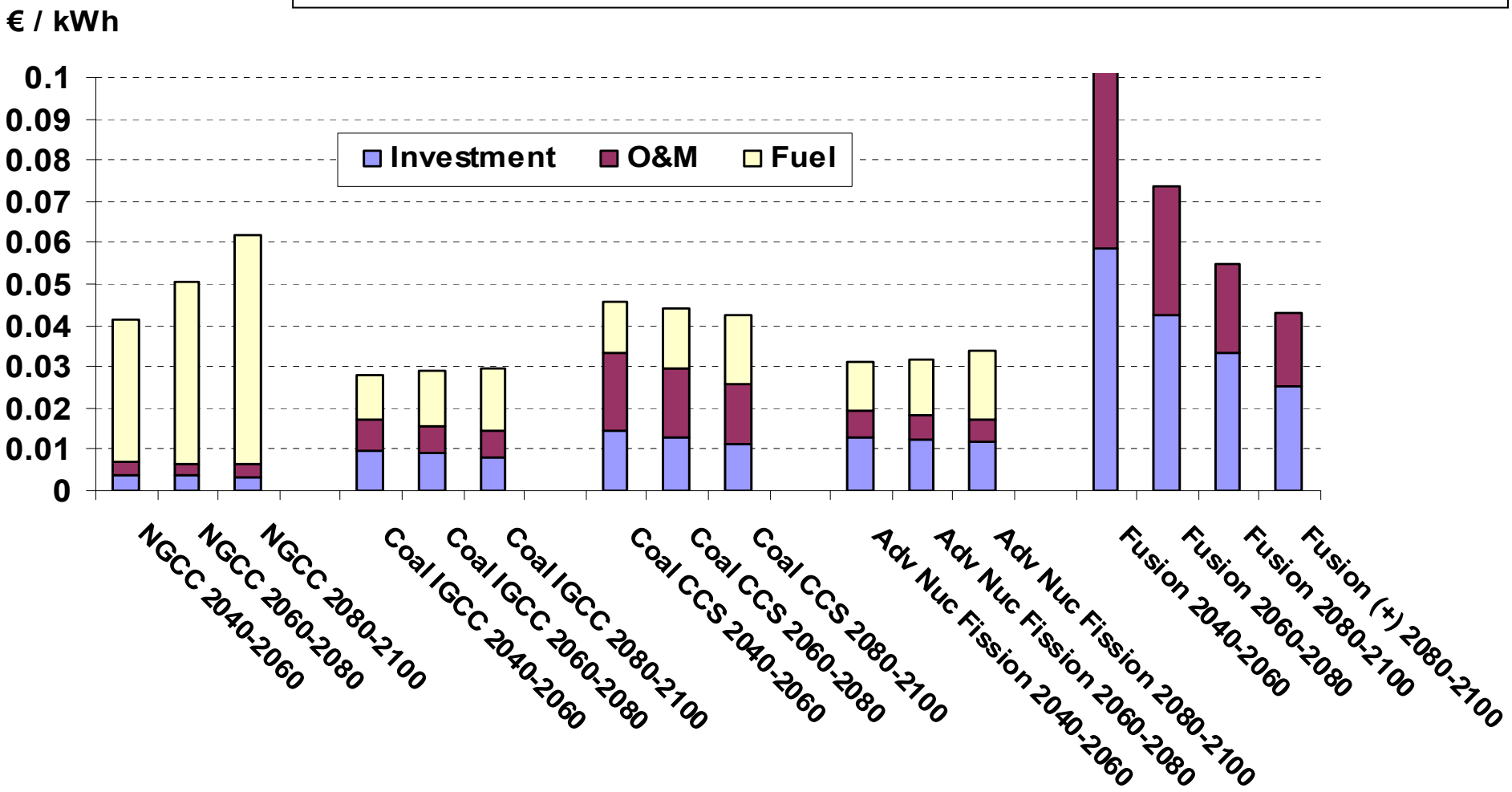
Input Assumptions in PLANELEC Model

Regional Electricity Demand



Input Assumptions in PLANELEC Model

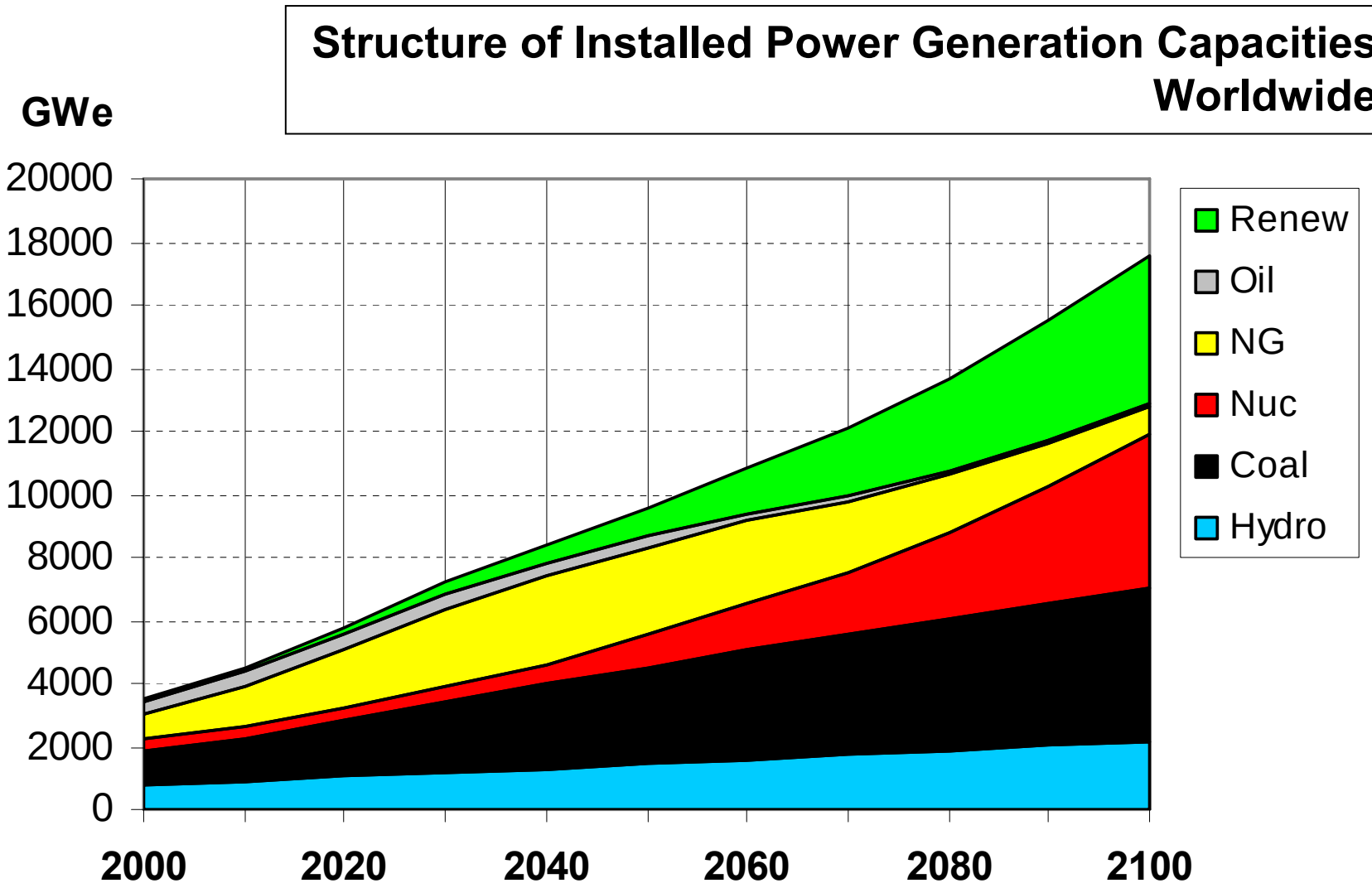
Technical-economical characteristics of selected base-load power generation technologies



Simulated Scenarios

- **"Baseline "** (*no Fusion*)
- **"Introduction of Fusion"** (*Fusion power plants are built in the countries participating in ITER initiative; 330 GWe of Fusion capacities by 2100*)
- **"Massive Deployment of Fusion"** (*Fusion power plants are built world-wide; 950 GWe of Fusion capacities by 2100*)
- **"Coal CCS"** (*Indicative scenario: the same 950 GWe capacity of Coal with CO_2 Capture & Storage power plants are built world-wide; no Fusion*)
- **"Extra Nuclear Fission"** (*Indicative scenario: additional 950 GWe capacity of advanced nuclear fission power plants are built world-wide; no Fusion*)
- **"CO_2 tax"** (*the above scenarios in the case of the Western Europe region are simulated under CO_2 tax: € 20 and € 50 / t CO_2*)

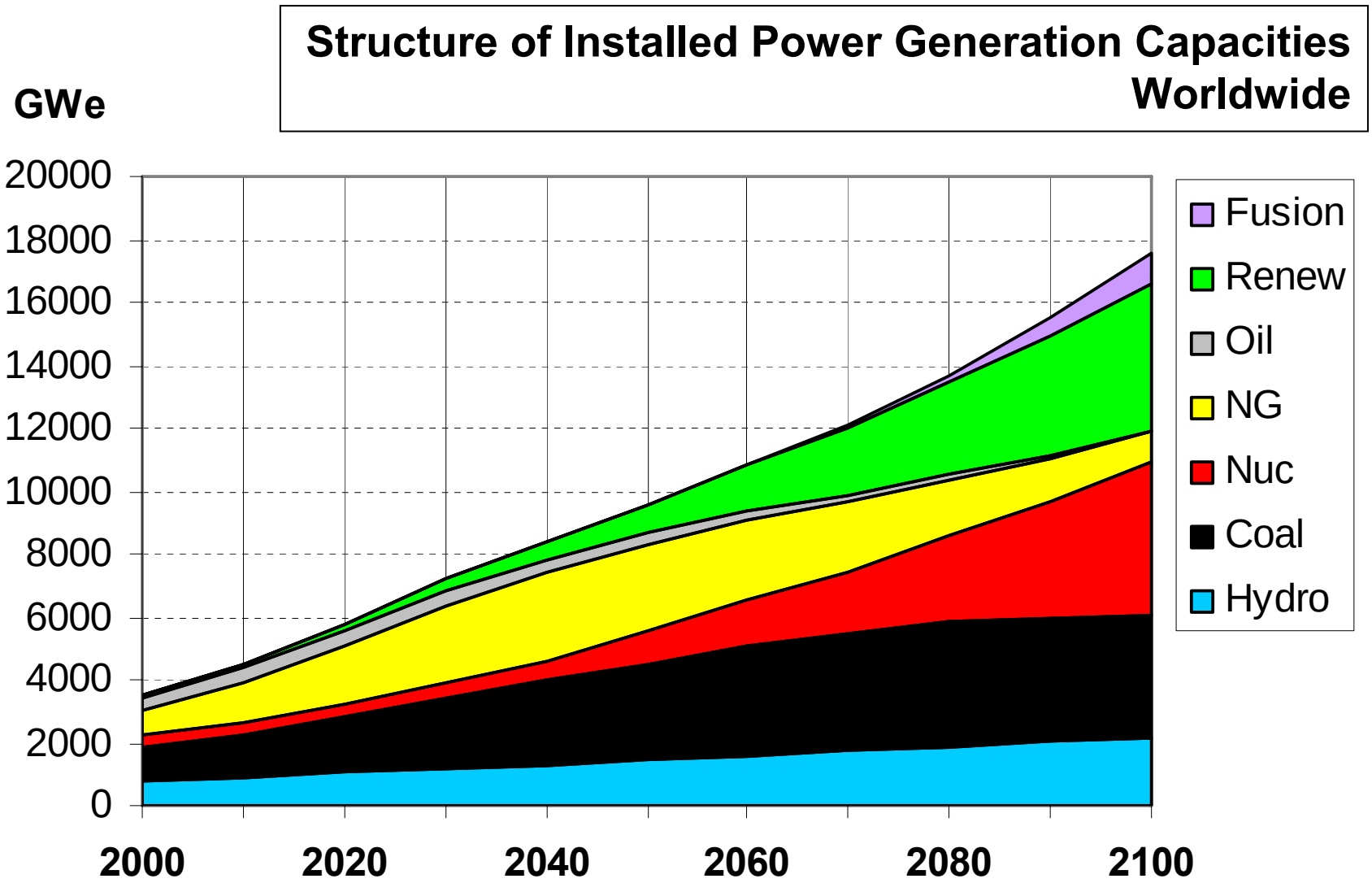
Baseline Scenario



Total Fusion Power Generation Capacities in Selected Fusion Scenarios (GWe)

Region	Moderate Introduction					Massive Deployment				
	2060	2070	2080	2090	2100	2060	2070	2080	2090	2100
NAM	*6*	*24*	*48*	*81*	*120*	*15*	*58*	*100*	*200*	*300*
LAM	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*12*	*30*
WEU	*6*	*24*	*42*	*66*	*90*	*9*	*35*	*60*	*123*	*186*
CEE	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*6*	*18*
CIS	*-*	*-*	*3*	*9*	*15*	*-*	*3*	*9*	*24*	*42*
MEA	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*12*	*30*
AFR	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*6*	*15*
SAS	*-*	*3*	*9*	*18*	*30*	*-*	*6*	*30*	*60*	*99*
PAO	*3*	*6*	*12*	*21*	*33*	*3*	*9*	*21*	*36*	*60*
CPA	*-*	*3*	*12*	*24*	*42*	*-*	*9*	*30*	*75*	*140*
PAS	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*12*	*30*
Total	***15***	***60***	***126***	***219***	***330***	***27***	***120***	***259***	***566***	***950***

“Massive Deployment of Fusion”



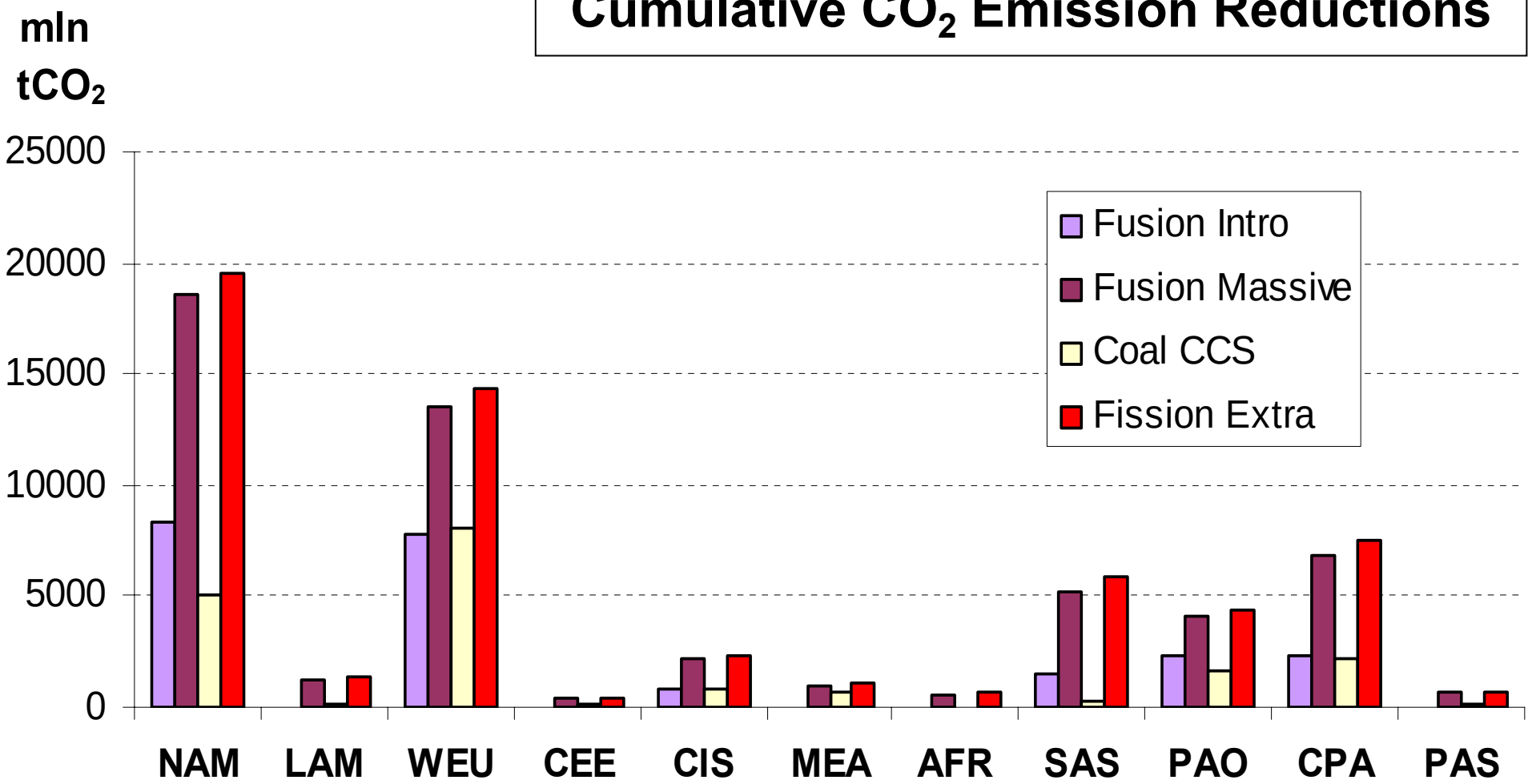
Main Results

Fusion Share in Total Regional Electricity Generation (2100) and Increment of Levelized System Electricity Cost (2080 – 2100)

	Moderate Introduction		Massive Deployment	
	Fusion share (%)	Electricity cost increment (€cent / kWh)	Fusion share (%)	Electricity cost increment (€cent / kWh)
NAM	*9.2*	*0.20*	*22.9*	*0.28*
LAM	-	-	*2.9*	*0.02*
WEU	*9.9*	*0.26*	*20.4*	*0.38*
CEE	-	-	*8.3*	*0.04*
CIS	*2.0*	*0.04*	*5.6*	*0.06*
MEA	-	-	*3.5*	*0.04*
AFR	-	-	*1.4*	*0.01*
SAS	*1.7*	*0.03*	*5.6*	*0.04*
PAO	*8.3*	*0.21*	*15.1*	*0.30*
CPA	*2.9*	*0.04*	*6.8*	*0.06*
PAS	-	-	*4.1*	*0.03*

Main Results

Cumulative CO_2 Emission Reductions



Main Results

CO_2 Abatement Cost (€ / t CO_2)

	Fusion Intro	Fusion Massive	Coal CCS	Fission Extra
NAM	40.3	27.0	19.3	3.2
LAM	-	15.2	64.2	2.3
WEU	40.0	32.3	16.8	9.6
CEE	-	18.0	24.2	3.7
CIS	32.7	18.3	15.0	2.4
MEA	-	25.6	19.2	4.1
AFR	-	15.8	167.4	2.5
SAS	26.9	12.1	71.0	1.8
PAO	48.6	37.0	22.8	3.9
CPA	25.3	12.5	15.4	1.5
PAS	-	25.8	34.2	5.5

Main Results

Evolution of Levelized System Electricity Cost (€cent / kWh) in the Western Europe Region at Different Levels of CO_2 Tax

	Baseline	Fusion Intro	Fusion Massive	Coal CCS	Fission Extra
€ 20 / tCO_2					
2040 - 2060	*4.6*	*4.7*	*4.7*	*4.7*	*4.6*
2060 - 2080	*4.5*	*4.6*	*4.6*	*4.5*	*4.4*
2080 - 2100	*4.4*	*4.6*	*4.6*	*4.4*	*4.4*
€ 50 / tCO_2					
2040 - 2060	*5.4*	*5.4*	*5.4*	*5.4*	*5.3*
2060 - 2080	*5.2*	*5.3*	*5.2*	*5.2*	*5.1*
2080 - 2100	*5.0*	*5.1*	*5.0*	*4.9*	*4.8*

Conclusions

- Massive deployment of Fusion power (≈ 20% market share) entails only a modest increase of levelized system electricity cost (by ≈ 0.3 – 0.4 €cent / kWh)
- Potential contribution of Fusion to reduction of global CO_2 emissions from power generation is estimated at 1.8 - 4.3 %
- Reasonably good commercial prospects for Fusion power by the end of the century, but substantial public funding and other forms of support will be required during initial deployment stage
- Evaluation in terms of social rate of return taking into account spillover benefits may provide additional arguments for policymakers to support Fusion RTD program

Further Work: Estimating Spillover Benefits and Social Rate of Return of Fusion RTD Program