A Look at the U.S. Energy System – A Strategic Impact Model (2050 SIM)

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There is a great deal of discussion about the future of the U.S. energy infrastructure

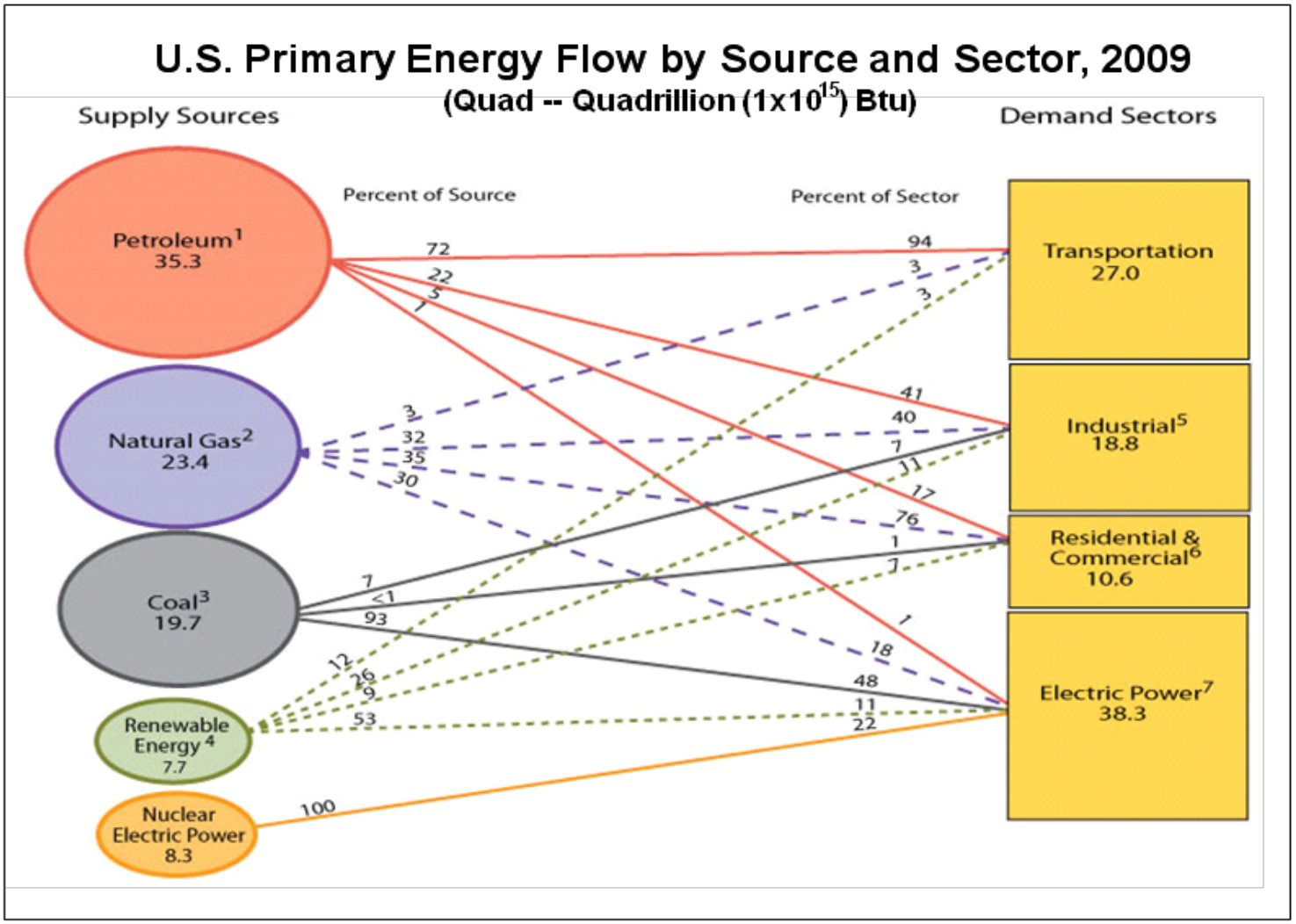
- Simpson/Nunes Bill – A Roadmap for America's Energy Future
- Waxman - Markey Bill – Reduce GHG Emissions by 47% (w/o offsets)
- Fortune Magazine – A New American Energy Plan
- Mechanical Engineering Magazine – Energy Choices for World 2050
- Popular Mechanics – Top Ten Energy Fixes (#7 Combine Heat and Power Systems)

Requires a Comprehensive and Systematic Approach

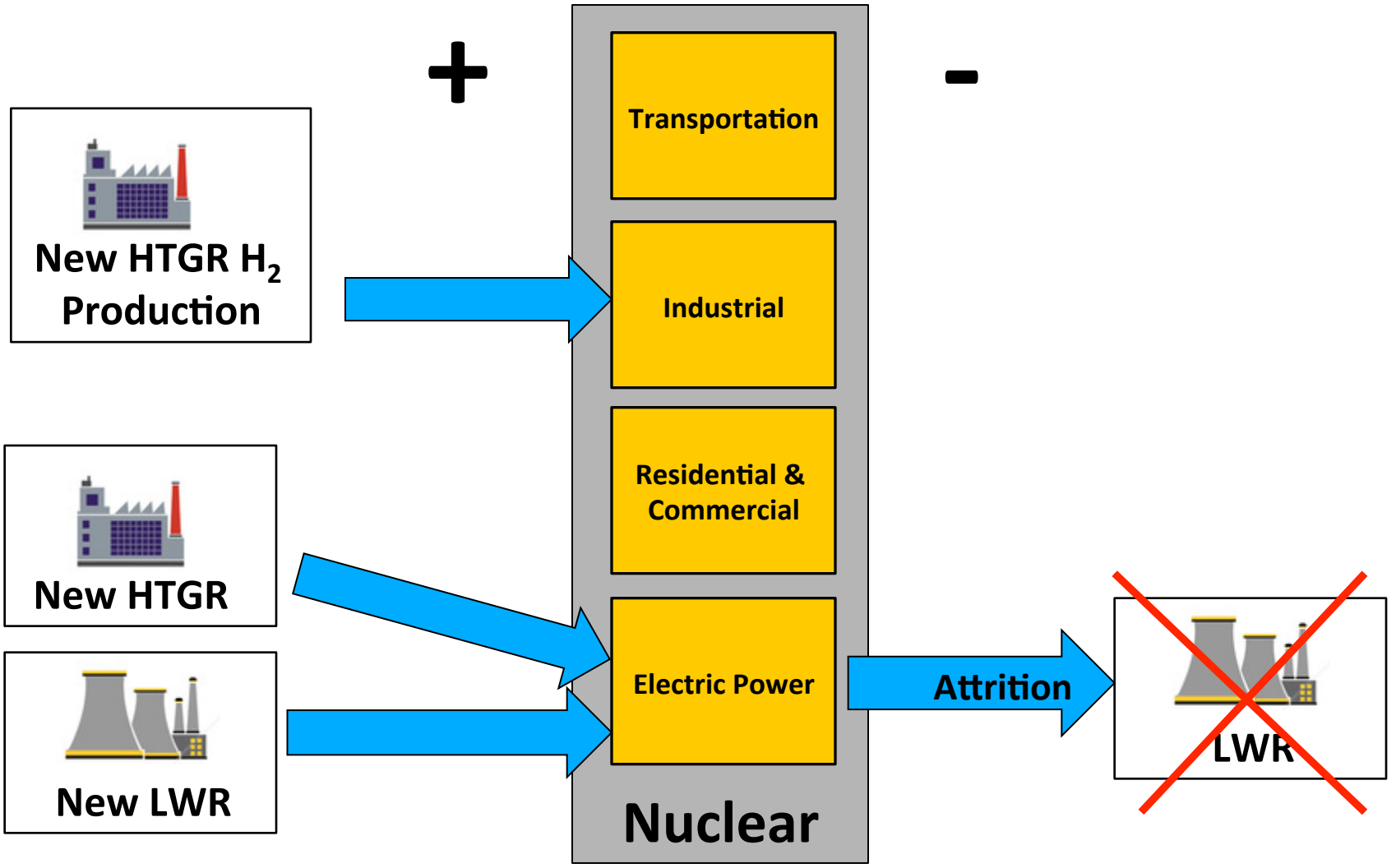
Systems Engineering Process

- Customer Requirements
  - Foreign Oil Dependence
  - Greenhouse Gas Emissions
  - Price Volatility
  - Jobs
- Software Requirements
- Alternative Evaluation
- System Design
- System Verification and Validation

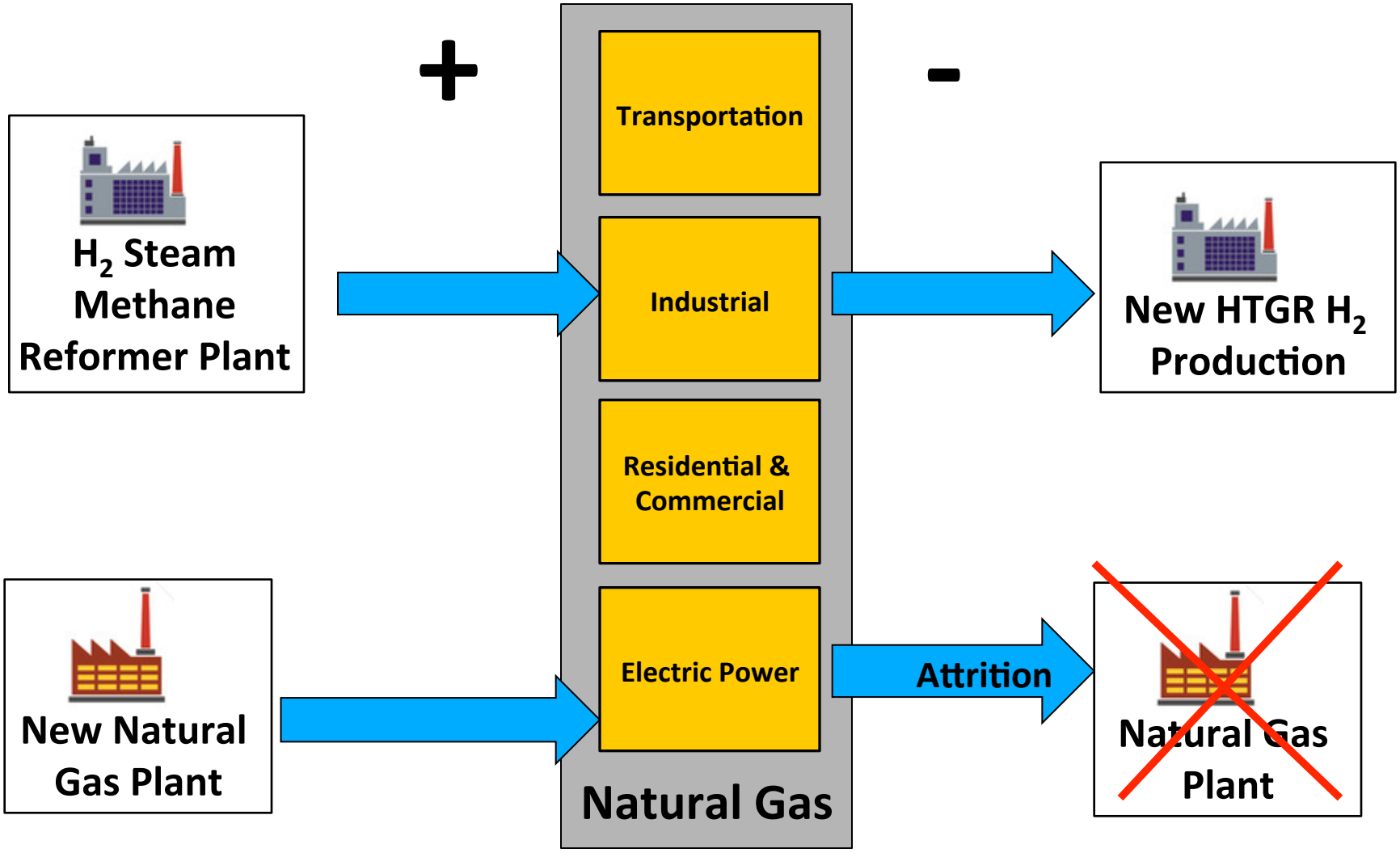
Energy Production and Consumption in U.S.



Energy Balance



Energy Balance



Model Verification

- The model (software) should conform to its specification
- Primary objective was to discover errors or defects (bugs) in software
- Wrote a detailed verification plan to implement verification
- Plan was implemented by independent person who was not associated with software development

Model Validation

- Demonstration to customer
  - The software should do what the user really requires
- Demonstration/review by subject matter experts
- Comparison to other data and energy models

2050 Strategic Impact Model – Input/Output Screen

Energy Demand

Future Energy Demand: Baseline
Conservation: Baseline
Efficiency: Baseline

Electricity

New Nuclear: LWR

2050 Electricity Mix

Nuclear	22.0%
Renewable	11.0%
Coal	48.0%
Natural Gas	18.0%
Petroleum	1.0%
Total:	100.0%

Transportation

Efficiency: Baseline
2050 MPG: Baseline
% Electric cars in 2050: Baseline

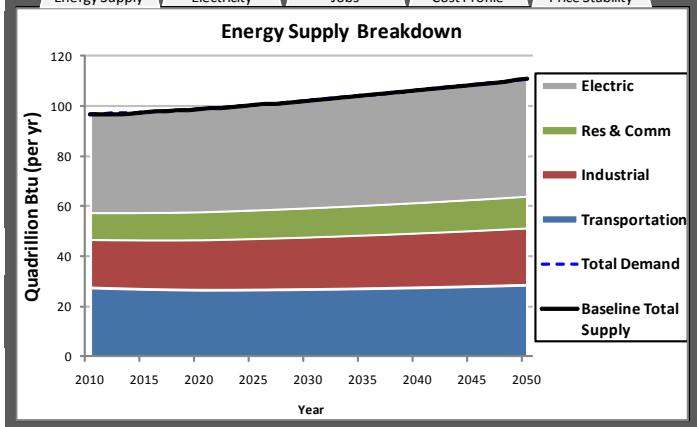
Industrial

	# of Plants
HTGR Hydrogen Production:	0
HTGR Ammonia Production:	0
HTGR Assist Coal to NG:	0
HTGR Assist NG to Diesel:	0
HTGR Assist Coal to Diesel:	0
HTGR Assist NG to Gasoline:	0
HTGR Assist Coal to Gasoline:	0
HTGR Assist SAGD:	0
HTGR Assist Oil Shale Extraction:	0
HTGR Co-generation:	0

Calculate
Reset
Scenarios
-Select Scenario-
Calculate

Results

Energy Supply | Electricity | Jobs | Cost Profile | Price Stability



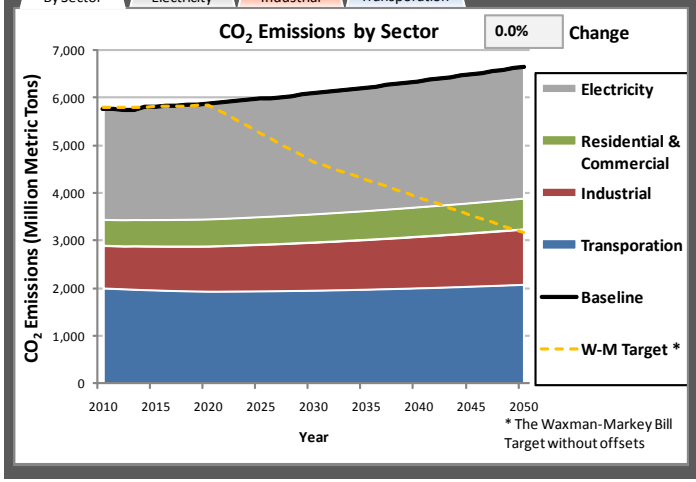
	# Plants	MWe	MWe	Cost ($B)	Change
HTGRs for Elec:	0	0	0	$0	0
LWRs:	86	116,100	104,490	$670	0
SMRs:	0	0	0	$0	0
Wind Farms:	754	37,700	14,062	$95	0
Solar Plants:	116	11,600	4,327	$56	0
Geothermal Plants:	232	11,600	9,744	$50	0
Coal Plants:	828	455,400	387,090	$2,056	0
Natural Gas Plants:	780	312,000	271,440	$369	0
H_2 Steam Reformer Units:	98			$27	0
		Capacity	Actual		

	# Plants	MWt	MWt	
HTGRs for Industrial:	0	0	0	$0

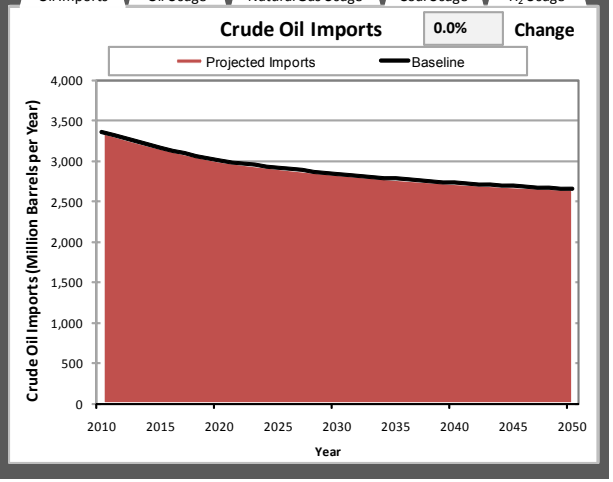
Total Capital Cost: $3,863 Billion
Average Capital Cost: $94 Billion/yr

$Billions Not Spent on Oil Imports:	$39 Low	$150 Mid	$398 High

By Sector | Electricity | Industrial | Transporation



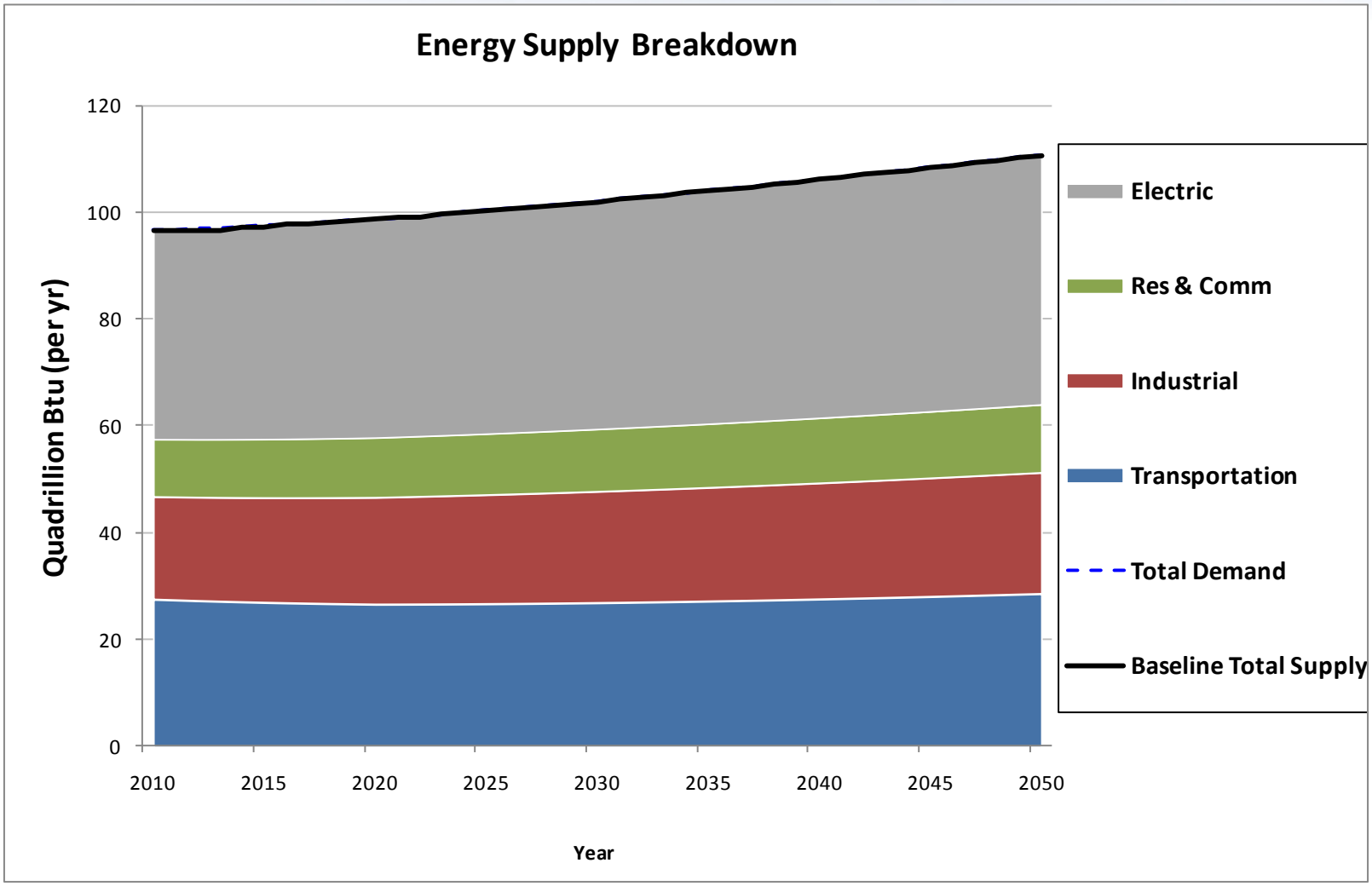
Oil Imports | Oil Usage | Natural Gas Usage | Coal Usage | H_2 Usage



Five Energy Scenarios

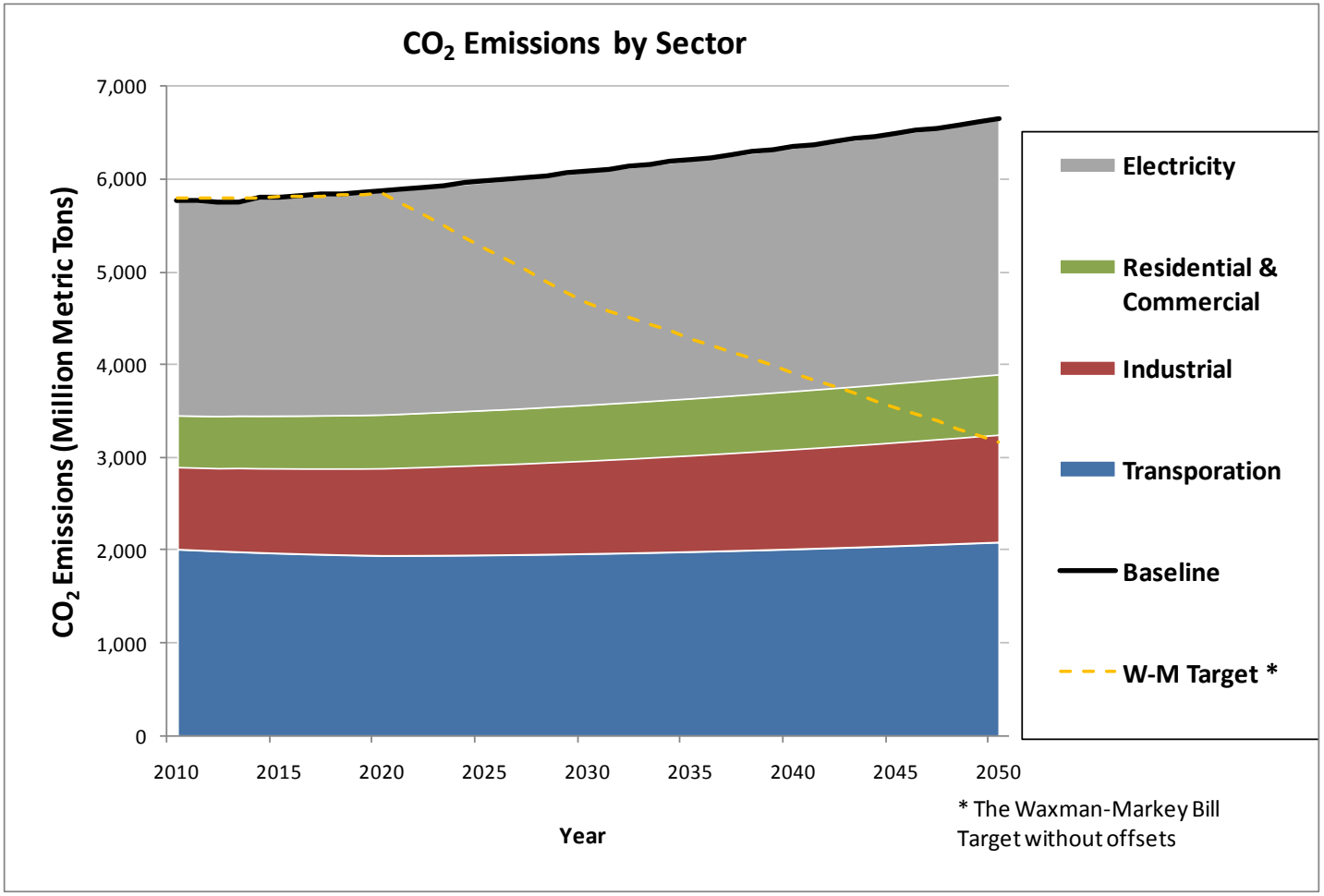
	Baseline	Scenario 1 Natural Gas	Scenario 2 Nuclear/LWR	Scenario 3 Nunes/ Simpson	Scenario 4 Market Case
Electricity	Nuclear: 22% Renew.: 11% Coal: 48% Nat. Gas: 18%	Nuclear: 22% Renew.: 11% Coal: 34% Nat. Gas: 32%	Nuclear: 35% Renew.: 11% Coal: 35% Nat. Gas: 18%	Nuclear: 52% Renew.: 12% Coal: 17% Nat. Gas: 18%	Nuclear: 35% Renew.: 17% Coal: 29% Nat. Gas: 18%
Industrial	No Change	No Change	No Change	15 HTGR industrial process plants	26 HTGR Cogeneration plants & 122 HTGR industrial process plants

Supply and Demand (Quads of Energy)



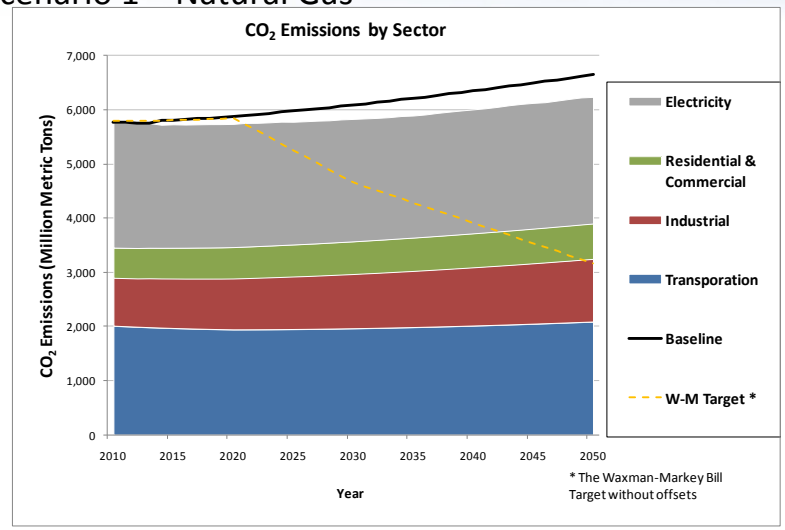
Baseline Scenario: 2010 CO_2 Emissions by Sector

Baseline Scenario - Default ("As - Is")

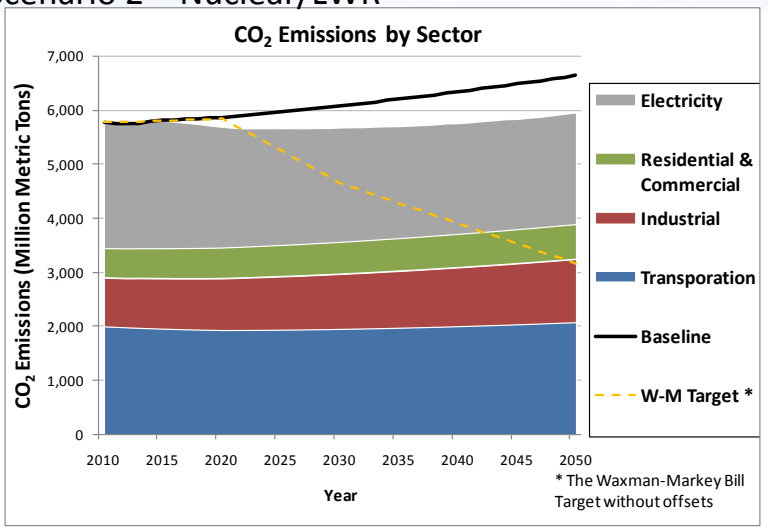


Scenarios 1-4: CO_2 Emissions

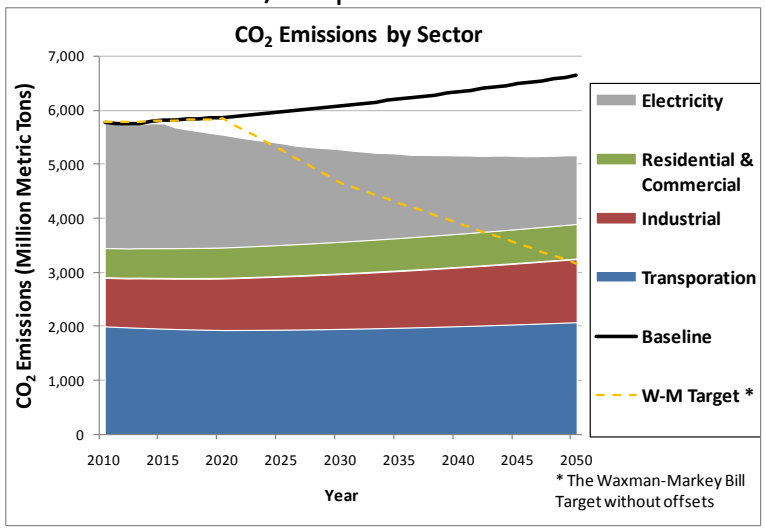
Scenario 1 – Natural Gas



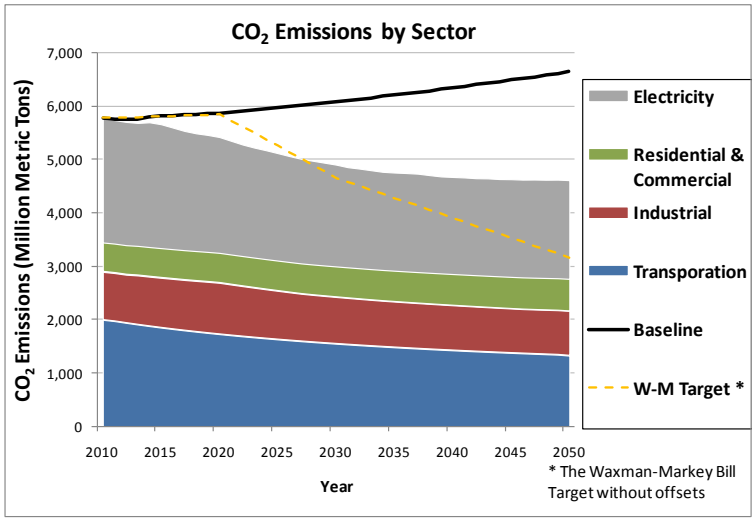
Scenario 2 – Nuclear/LWR



Scenario 3 – Nunes/Simpson

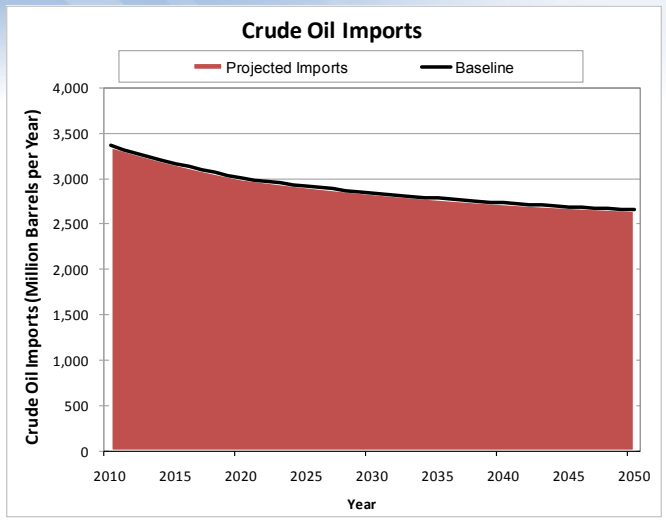


Scenario 4 – Market Case

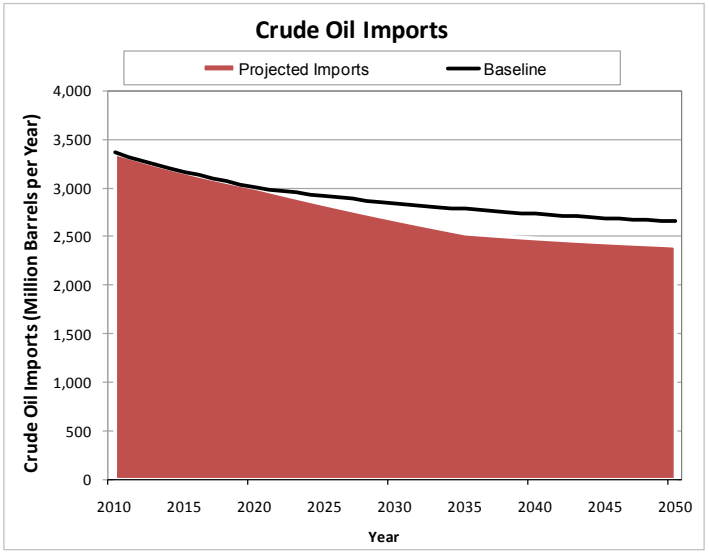


Crude Oil Imports

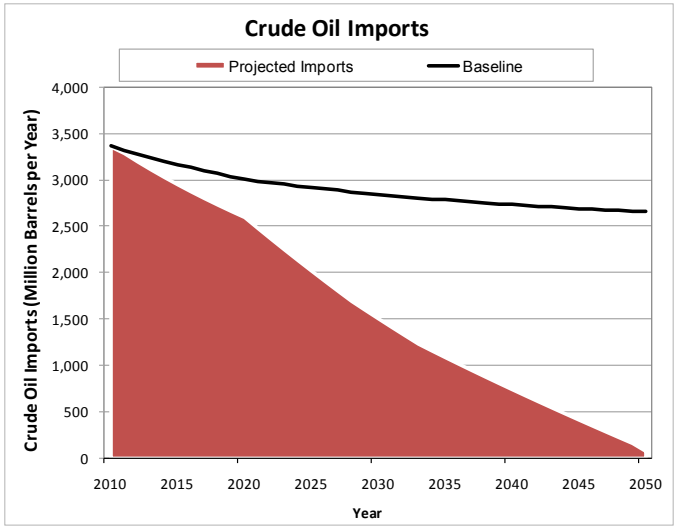
Baseline Scenario - Default ("As - Is")



Scenario 3 - Nunes/Simpson

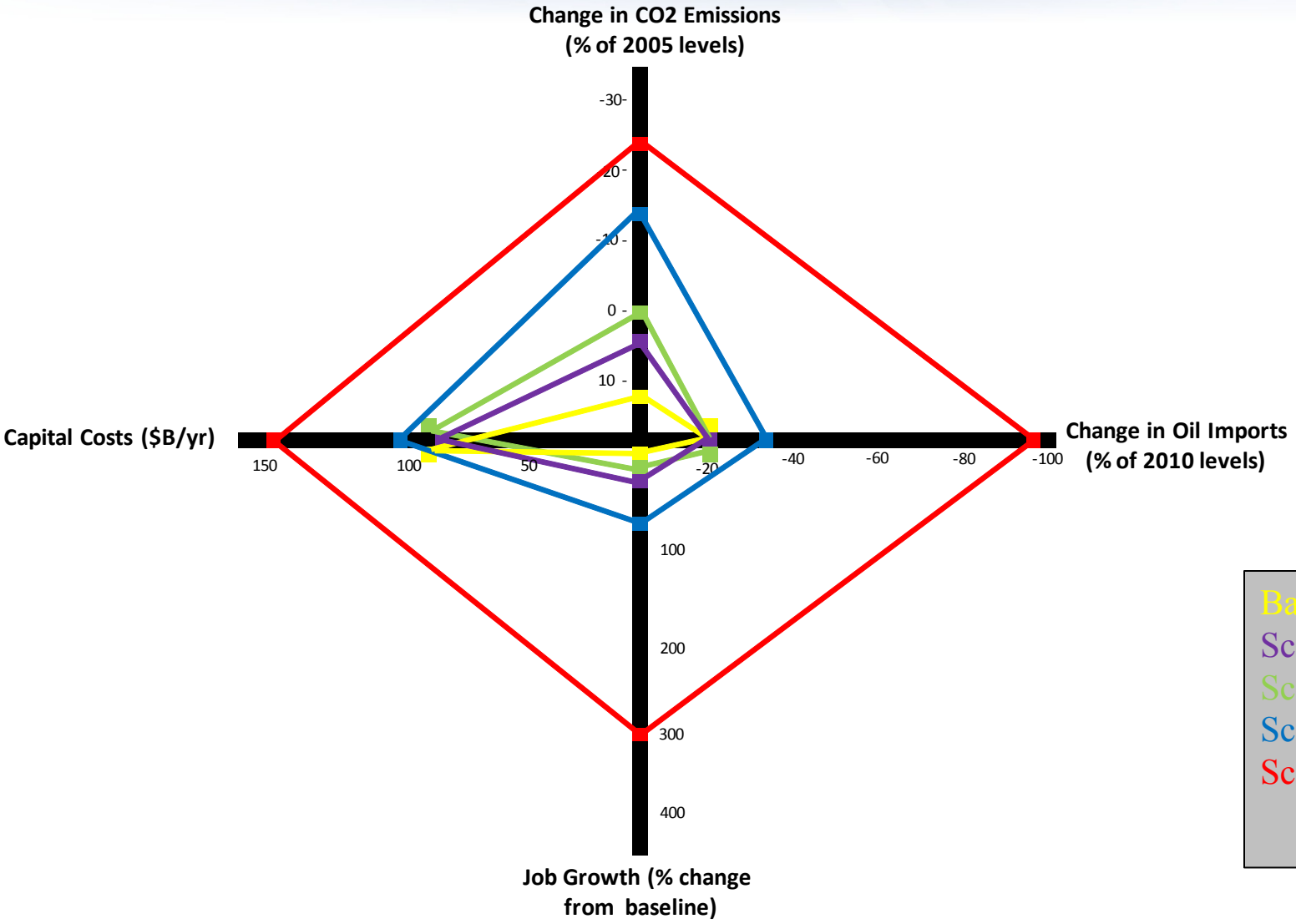


Scenario 4- Market Case



Decrease in imports results from HTGRs and Large LWRs

Scenario Comparison



Monte Carlo run of electricity generation