2050
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2050 Simulator 中国

Simulating the evolution of the Chinese energy system

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Disclaimer

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The 2050 simulator is a simplified model of reality.

The objective of this exercise is simply to convey, in a intuitive and educational form, the key variables of the energy sector and the way to reach its sustainability.

As a consequence, the simulator's results should not be interpreted as exact estimations, and they do not necessarily represent EDP's vision regarding the Energy Policy options that should be taken in the 2050 timeframe.

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Agenda

Brief overview of the Chinese energy system

EDP’s 2050 Simulator for China

China's energy outlook: Three scenarios

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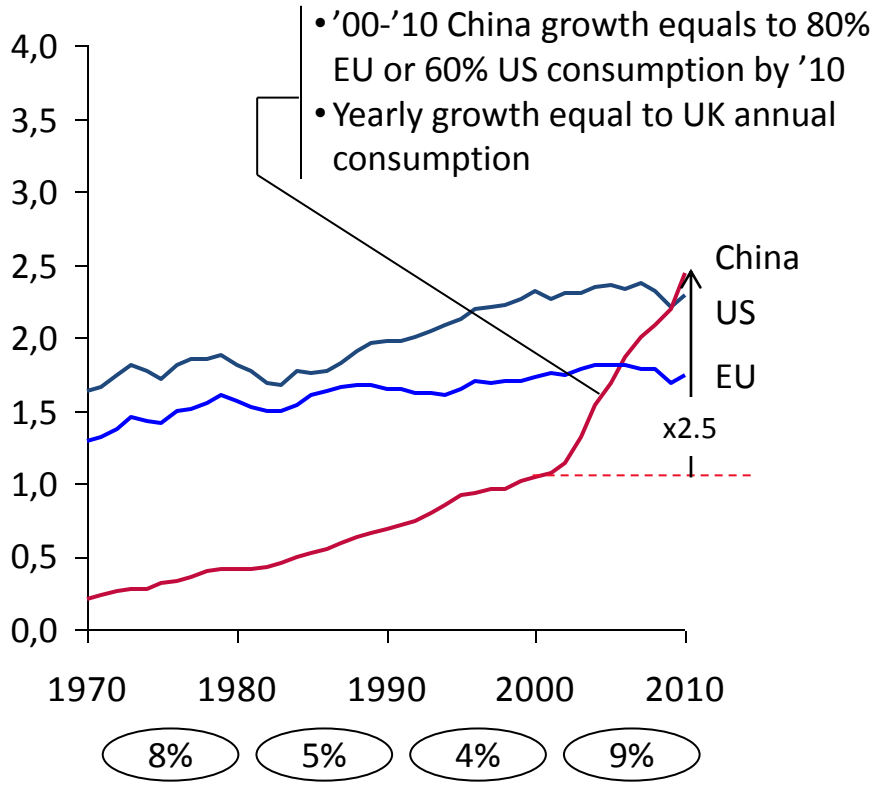
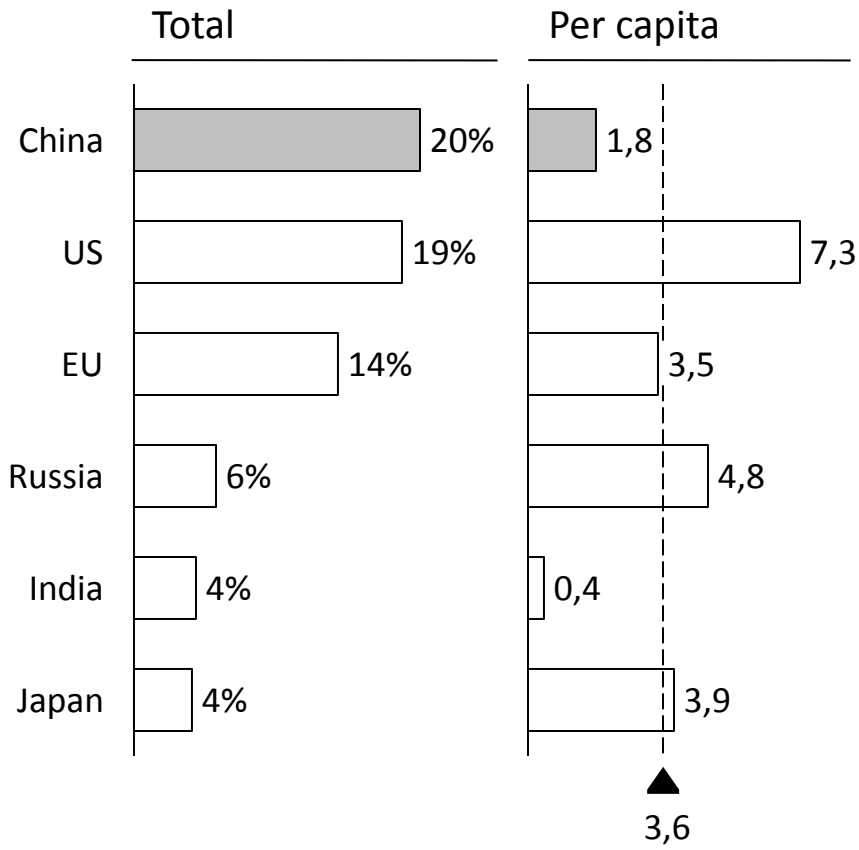
China is already the top energy consumer in the world, despite still having low levels per capita

Primary energy demand
Gtoe, 1970-2010



Primary energy consumption top countries
% total cons. and toe/cap, 2010



X% China 10 years CAGR

Source: BP Statistical Review of World Energy (Jun'11) and IEA World Energy Outlook 2011

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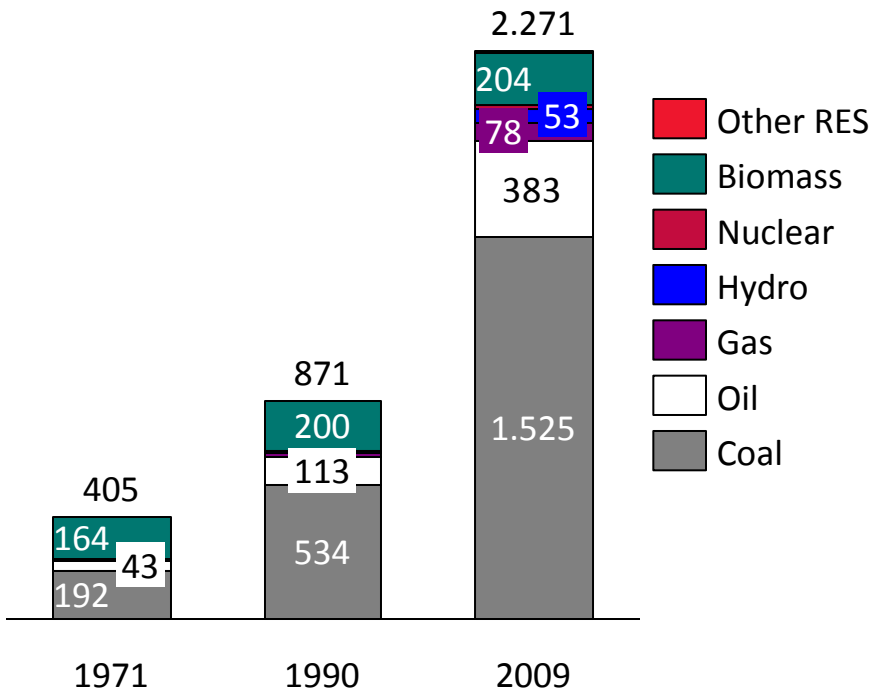
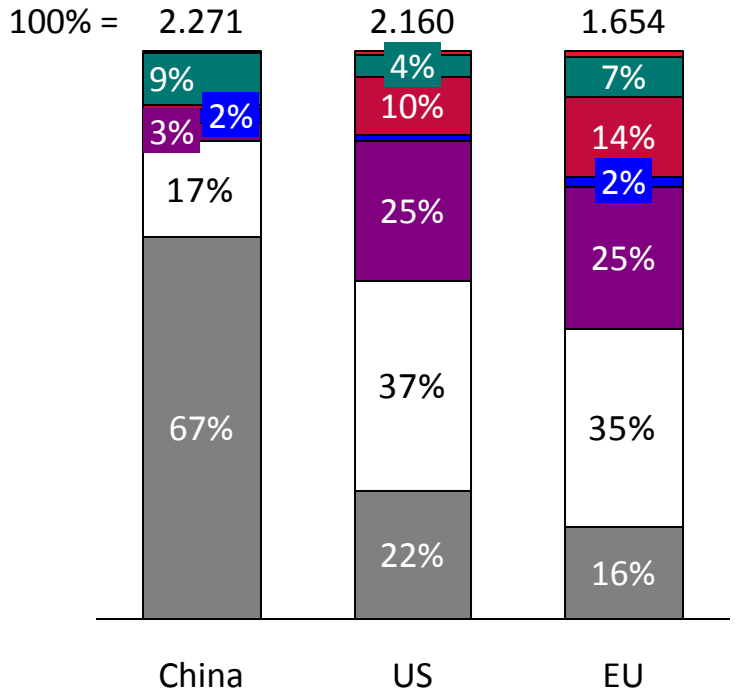
Chinese primary energy mix is mainly focused on coal, while the US and EU are much more dependent on oil and gas

Chinese primary energy demand
Mtoe, 1971-2009



Primary energy demand per fuel
Mtoe and %, 2009



Source: IEA World Energy Outlooks 2004 and 2011

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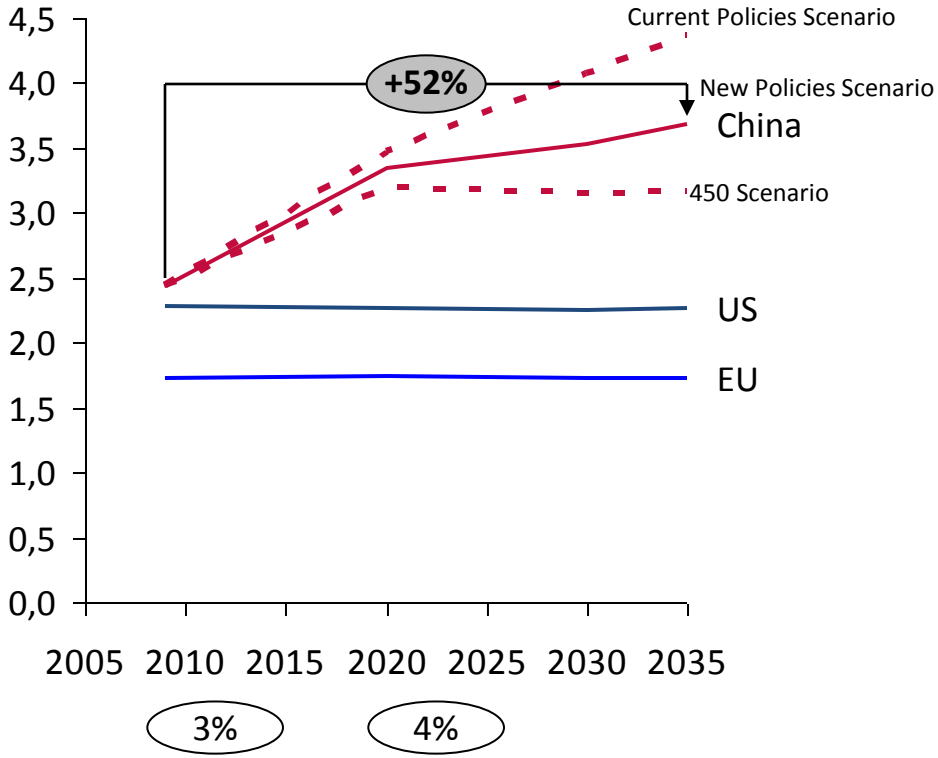
China is expected to remain the major energy consumer in the forthcoming years, reducing the share of coal in the energy mix

X% China 10 years CAGR

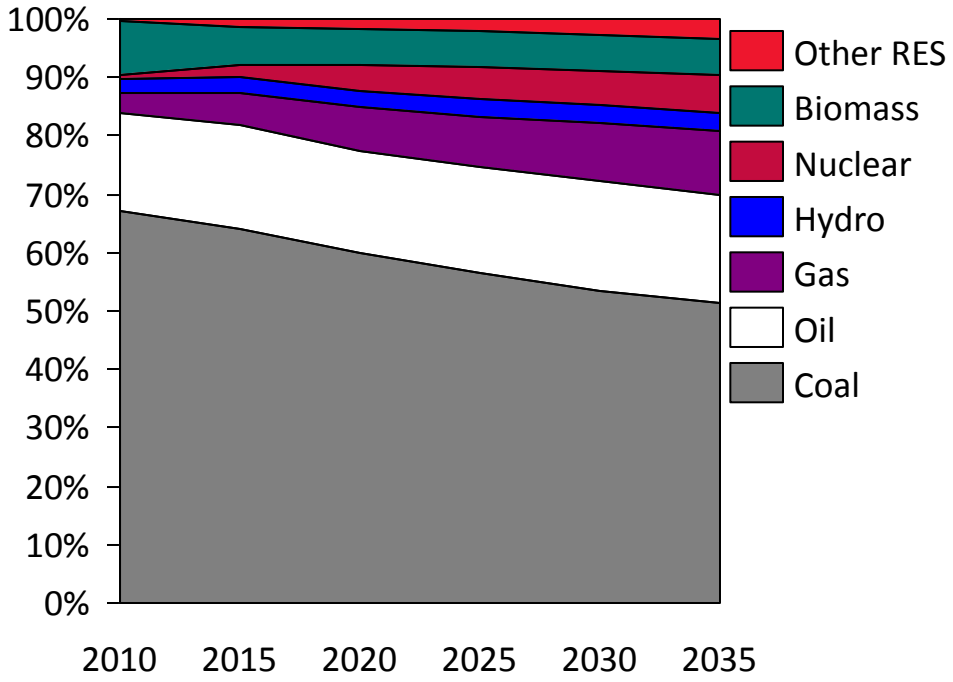
Primary energy demand forecast

Gtoe, 2010-2035



Chinese primary energy demand forecast per fuel

%, 2010-2035



What could alternative scenarios for the future evolution of the Chinese energy sector look like?

Source: IEA World Energy Outlook 2011

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China energy roadmap – drawn in Five-Year Plans (FYP) – already points to challenging objectives on efficiency, emissions and RES

Key energy and climate policy goals and indicators
China, 2006-2020

	11TH FYP (2006-2010) (TARGET)	11TH FYP (ACTUAL)	**12TH FYP (2011-2015) (TARGET)**	13TH FYP (2016-2020) (TARGET)
INDICATORS				
ENERGY INTENSITY (% REDUCTION IN FIVE YEARS)	20%	19.1%	**16%**	NOT SET
CARBON INTENSITY (% REDUCTION IN FIVE YEARS)	NOT SET		**17%**	40-45% VS 2005
NEW ENERGY (% OF PRIMARY ENERGY)	10%	9.6%[1]	**11.4%**	15%
GROWTH RATES				
PRIMARY ENERGY CONSUMPTION (ANNUAL GROWTH)	4%	6.3%	**3.75-5%***	–
ELECTRICITY ENERGY CONSUMPTION (ANNUAL GROWTH)	–	11%	**8.5%***	(5.5%)*
ELECTRICITY GENERATING CAPACITY (ANNUAL GROWTH)	8.4%[2,3]	13.2%[4]	**8.5%***	(5.6%)*
GDP (ANNUAL GROWTH)	7.5%	10.6%	**7%**	–

ASTERISKED NUMBERS INDICATE ESTIMATES MADE BY GOVERNMENT THAT ARE NOT FORMAL TARGETS. BOLD NUMBERS ARE NEW TARGETS.

Source: HSBC - Delivering Low Carbon Growth, A Guide to China's 12th Five Year Plan (Mar'11)

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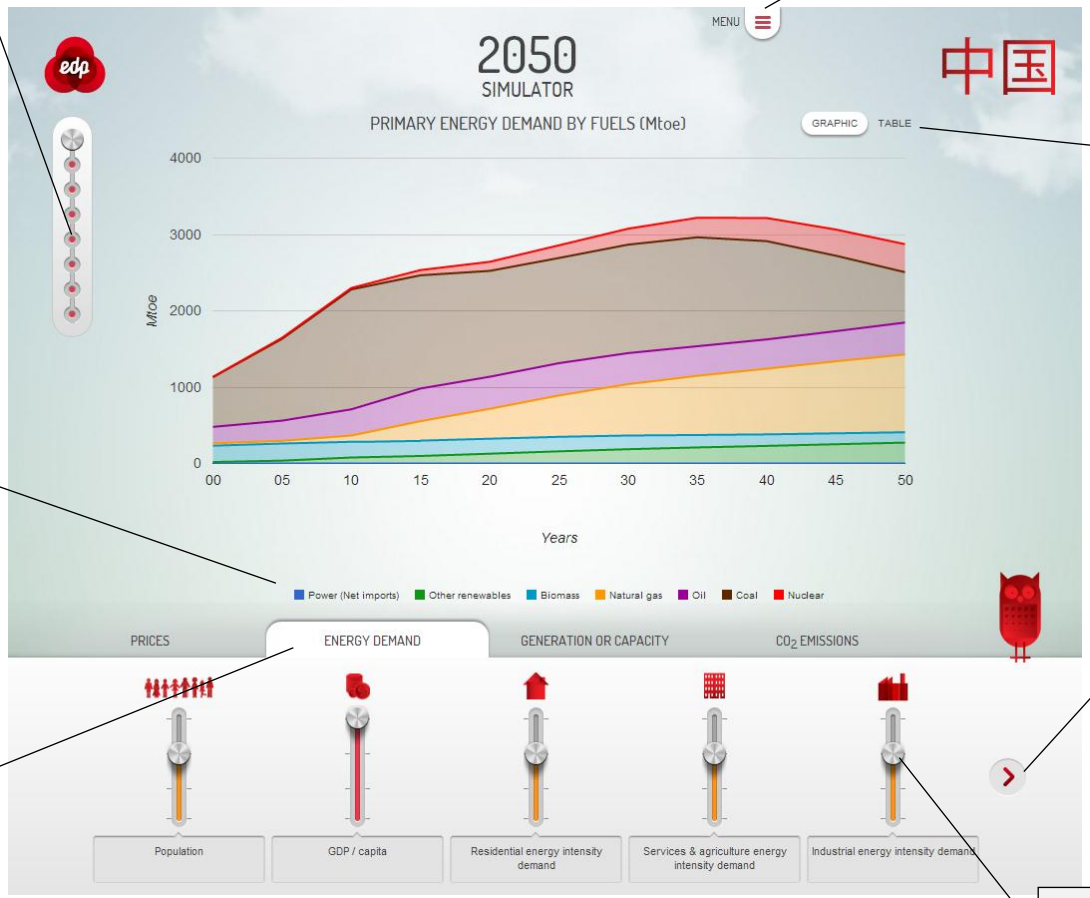
The 2050 simulator allows users to view the energy sector's evolution given their forecast about future technology adoption and consumption behaviors

Outputs selector (charts/tables)

Menu



Output charts/tables

Chart legend

Question categories selector (Prices, Demand, Generation and Emissions)

Horizontal scroll for additional questions

Answer switch (Bottom – BaU Top - disruptive)

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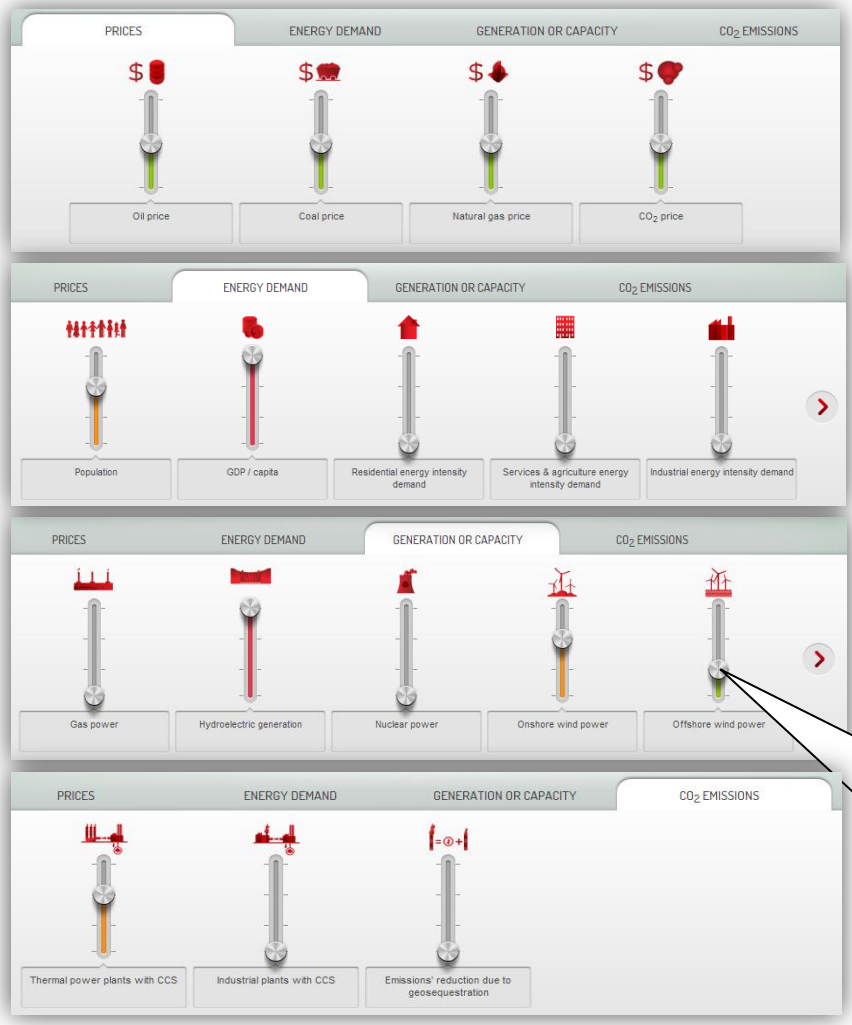
By answering 32 questions about energy prices, demand and supply evolution, and GHG emissions, the user defines an energy path

Prices

Energy Demand

Generation or Capacity

CO_2 Emissions



32 questions divided into 4 groups

Multiple choice answers:

1. Business as Usual scenario
2. Minor transformations required
3. Medium transformations necessary
4. Scenario involving major transformations (without breaking the laws of physics!)

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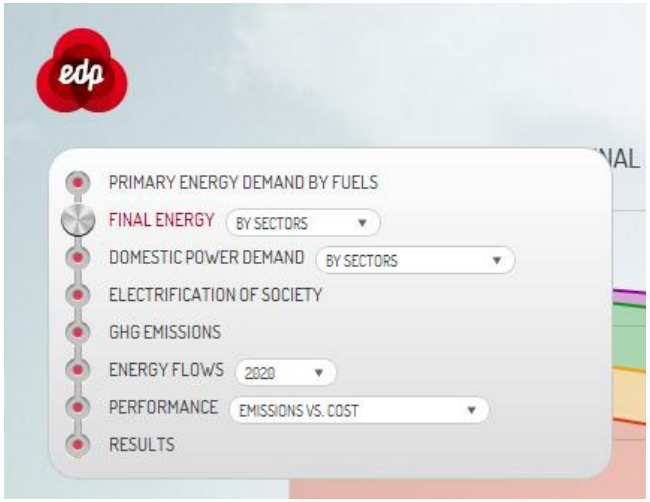
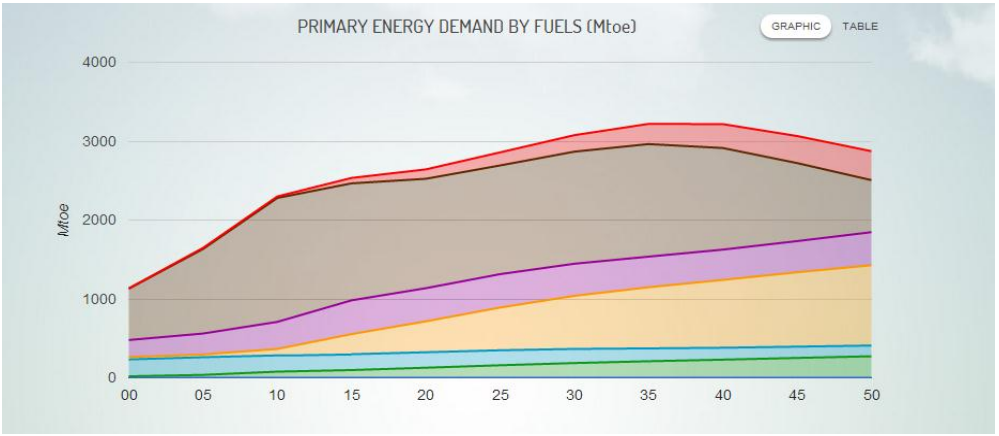
The simulator allows for immediate visualization of the path impacts along several dimensions in graph or numeric format

2050 Outputs



Graphic impact of resulting pathway



Numerical impact of resulting pathway

PRIMARY ENERGY DEMAND BY FUELS (Mtoe) GRAPHIC TABLE

	00	05	10	15	20	25	30	35	40	45	50
Primary Energy by fuels	1136	1647	2299	2533	2642	2857	3075	3219	3215	3065	2873
Nuclear	4	14	19	69	119	166	209	256	303	343	367
Coal	651	1072	1571	1483	1387	1378	1421	1427	1288	989	660
Oil	216	265	343	428	420	423	407	388	384	395	419
Natural gas	30	35	82	255	392	542	673	775	860	943	1018
Biomass	214	224	206	201	196	190	179	163	151	143	136
Other renewables	19	37	78	97	127	158	186	209	230	252	273
Power (Net imports)	0	0	0	1	1	1	1	1	0	0	0

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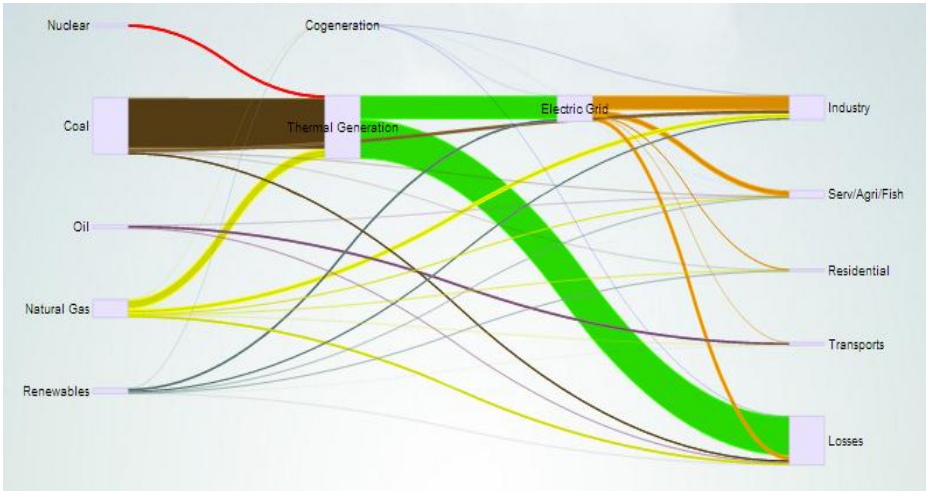
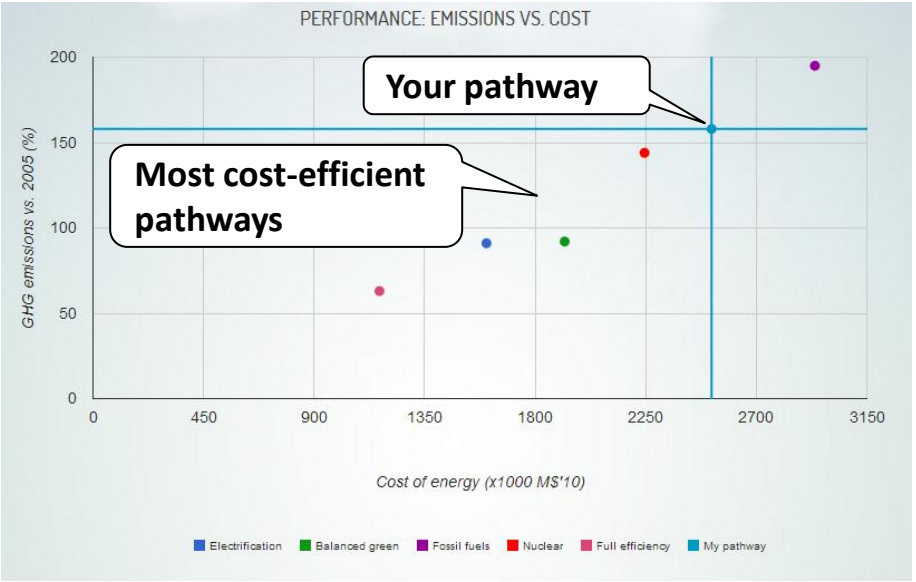
Outputs also include energy flows and performance data

Energy flows output
Sankey graphs

Primary energies → **Transformation into power** → **Final energy by sectors**



Performance output
Emissions vs. Cost



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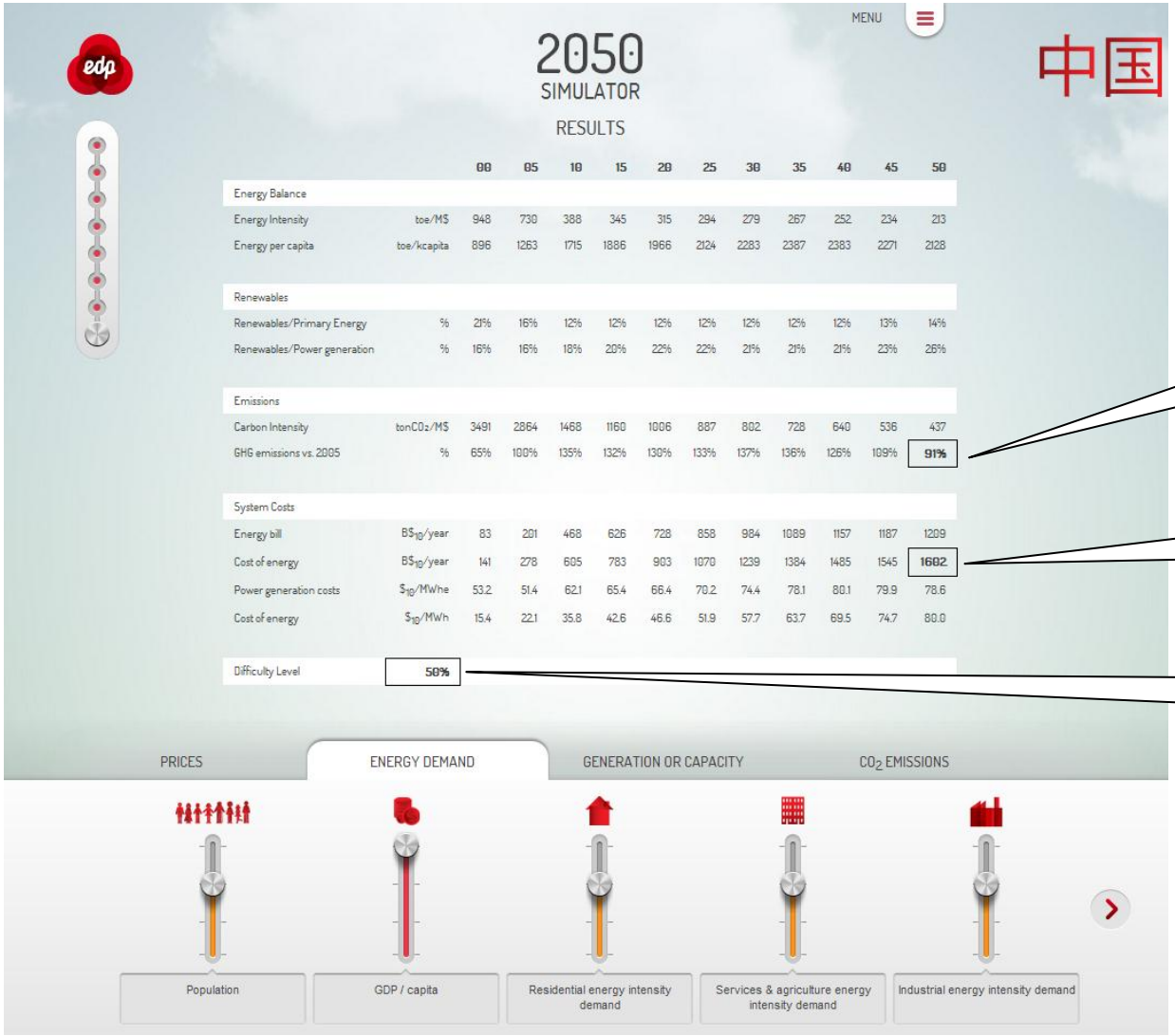
The simulator's objective function is to (1) minimize greenhouse gas emissions, (2) at the lowest cost, and (3) at the lowest difficulty level



Objectives

Minimize GHG emissions

Minimize total cost of energy

Minimize the difficulty of implementation

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What will China's future energy sector look like in the decades to come?

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Common assumptions across all scenarios

	Common assumptions for all simulated scenarios (answers from 1 to 4)
Prices	• IEA long term oil price scenario: 130 $\$_{,10}$/bbl (2) • IEA long term oil coal scenario: 110 $\$_{,10}$/ton (2) • IEA long term natural gas scenario: 11 $\$_{,10}$/Mbtu (2) • Long term CO_2 base case scenario: 50 $€_{,10}$/ton (2)
Population	• Current Chinese population by 2050: 1350 Million (3)
GDP/capita	• Double current Chinese GDP/Capita by 2050: 10 k$/capita (4)
Energy intensity	• Current Residential Chinese energy intensity level by 2050: 260 toe/kcapita (3) • Current Services, agr. & fish Chinese energy intensity level by 2050: 25 toe/M$ (2) • Double current Chinese vehicles penetration level by 2050: 400 vehicles/kcapita (3)
Power imports	• No power imports by 2050 (1)
CO_2 mitigation	• No thermal power plants with CCS (1) • No industrial plants with CCS (1) • No emissions reduction due to geosequestration (1)

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Three stylized scenarios were defined: King Coal, Shale Gas and RES & Electrification

Scenarios	Rationale	EDP's 2050 Simulator answers (different from 1)
1 King Coal	• Business as Usual • Coal keeps its leading high market share • Low energy efficiency levels	• N.a.
2 Shale Gas	• China discovers Shale Gas • Power system shifts from Coal to Gas • Low energy efficiency levels	• Transports fuel switching: 75% road and non-road transports from oil to biofuels and natural gas (4) • Power generation: gas accounts for 2,000 GW (4)

3 RES & Electrification	• Focus on electrification and energy efficiency
	• Clean power generation (Nuclear and Renewables)
		• Industry: 40% current intensity level to 50 toe/M$ (3)
		• Demand electrification:
		  • Residential, services and industry electrification (3)
		  • Transports: 50% road and 30% non-road electrification (3)
		• Power generation: focus on nuclear and RES (3)

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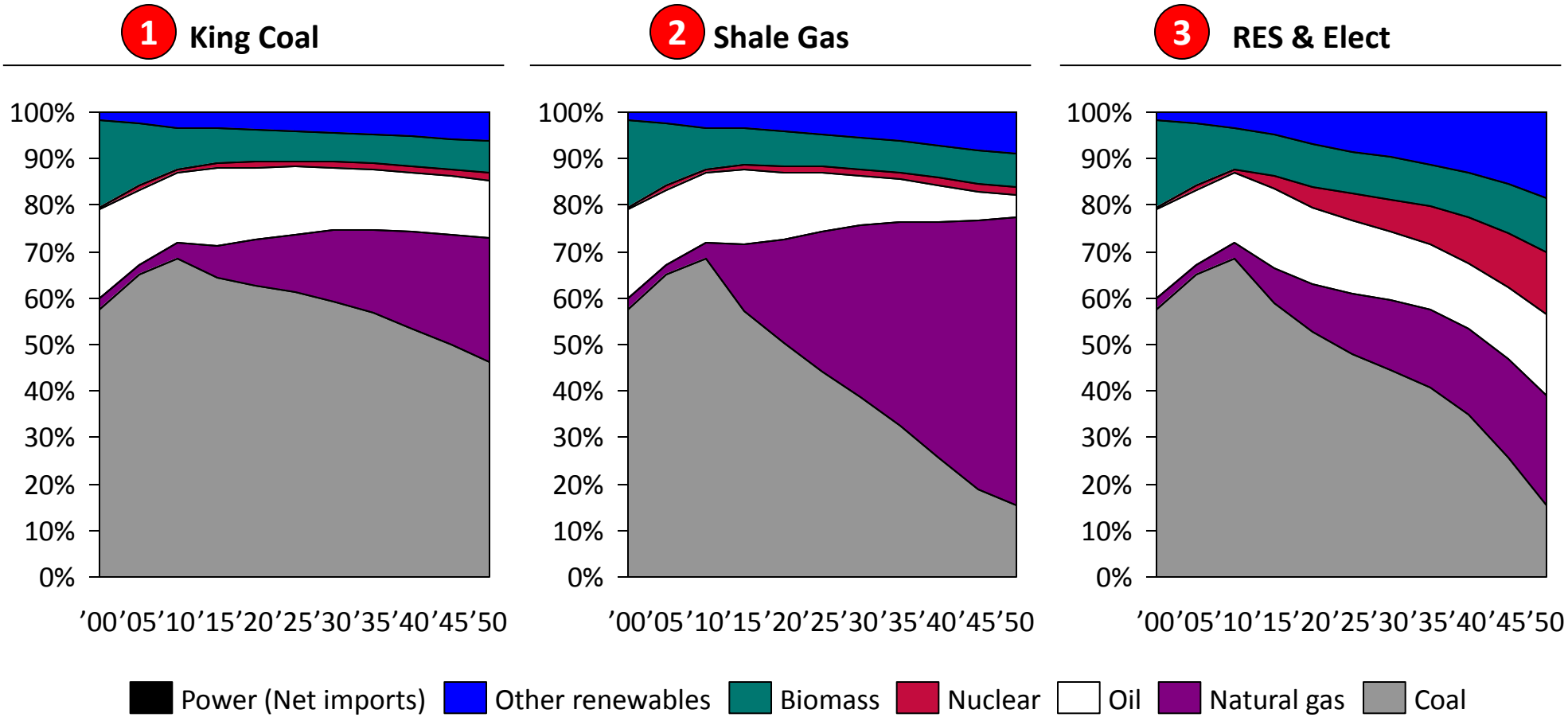
These 3 scenarios imply very different energy mixes…

Share of primary energy demand evolution by fuels
%, 2000-2050



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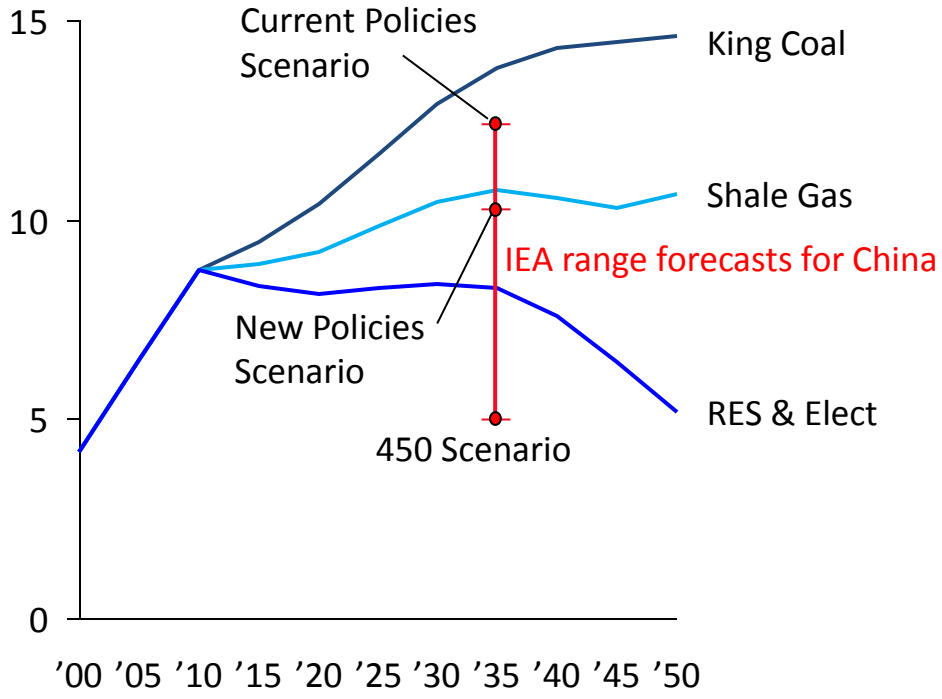
…leading to substantially different GHG emissions

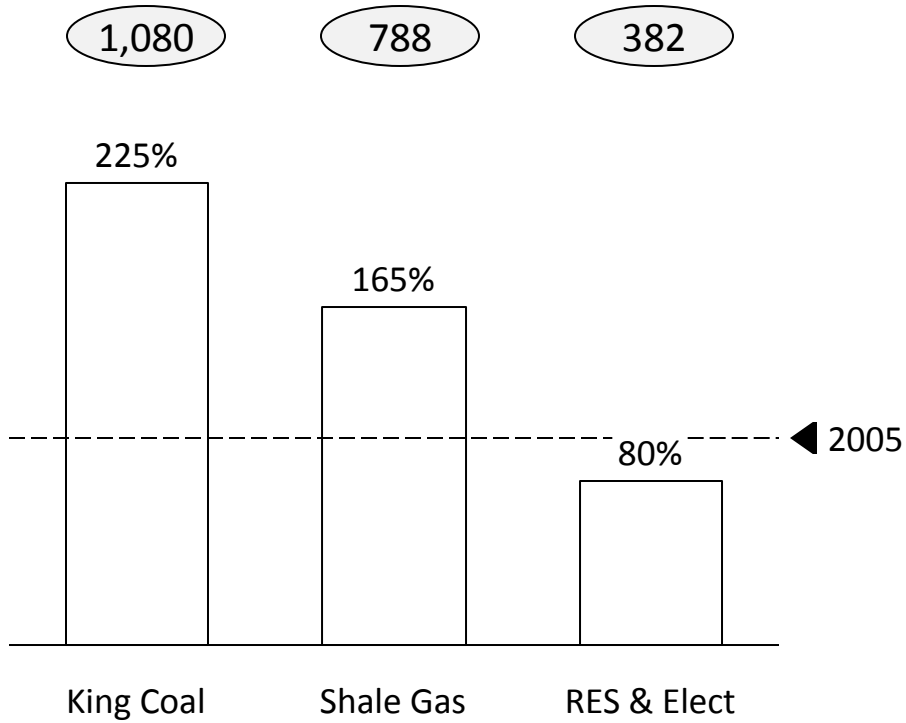
GHG emission evolution

$GTonCO_{2eq}$, 2000-2050



2050 GHG emissions vs. 2005

%, 2050



Source: IEA, World Energy Outlook 2012

Note: As benchmark, according to IEA, current carbon intensity for US = 400 and for EU = 240 (2011)

xxx Carbon intensity [$tonCO_2/M\$$]

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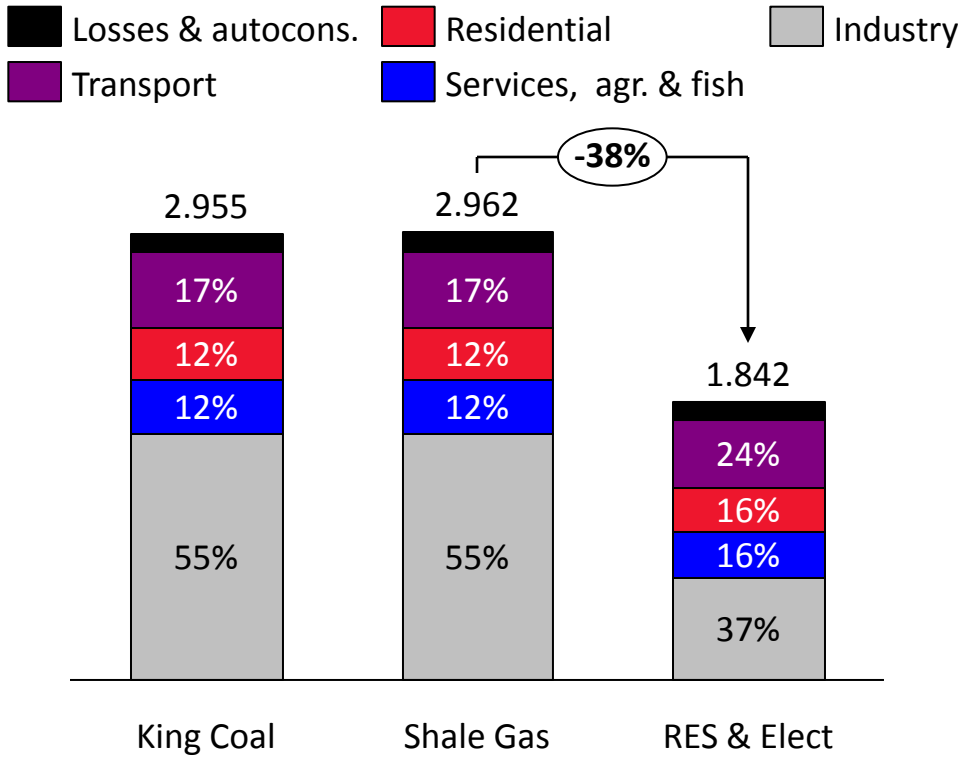
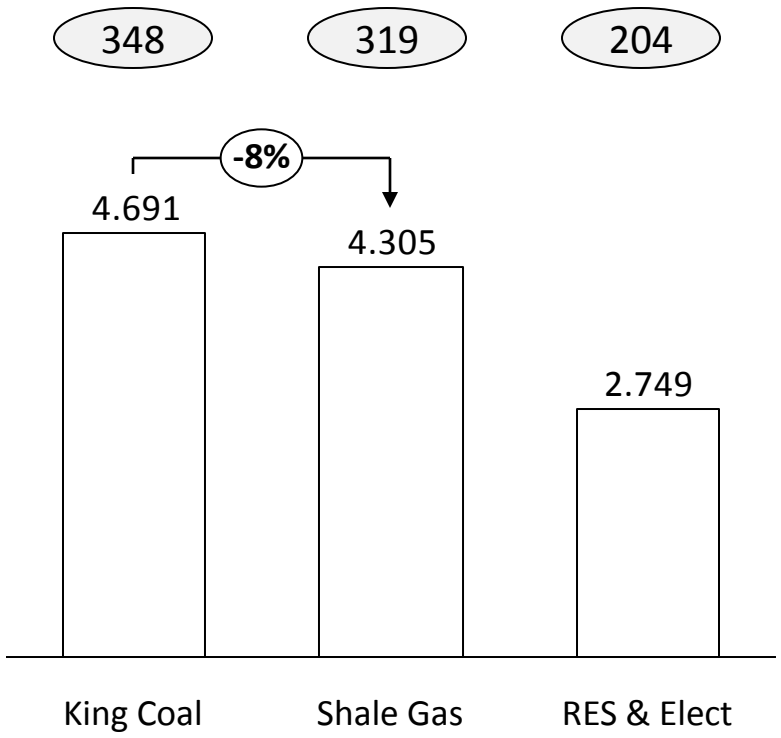
The higher energy efficiency level of the RES & Electrification scenario has a huge impact on energy consumption…

Final energy demand by sectors
Mtoe, 2050



Energy efficiency may reduce significantly final energy demand

Primary energy demand
Mtoe, 2050



Higher efficiency of CCGT vs. Coal-fired reduces primary energy demand

Note: As benchmark, according to IEA, current energy intensity for US = 170 and for EU = 110 (2011)

xxx Energy intensity [toe/M$]

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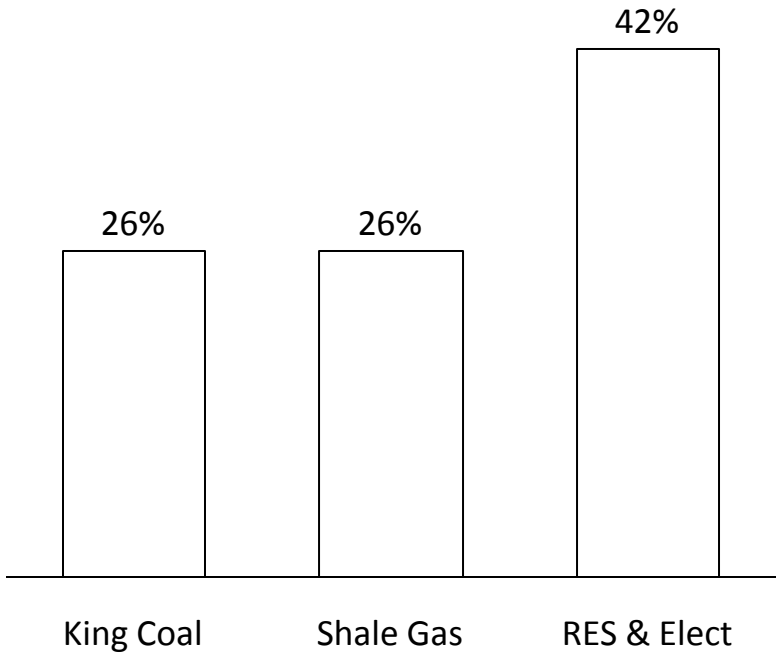
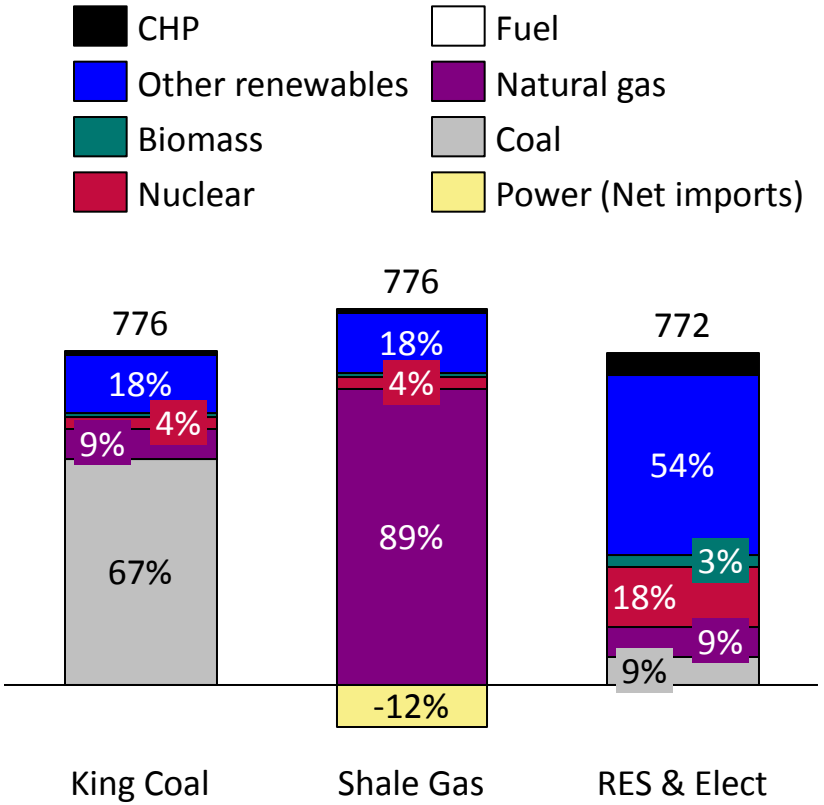
…which, even with higher levels of electrification, leads to similar needs of power generation than that of the King Coal and Shale Gas scenarios

Electrification of society
%, 2050



Electricity generation by technology
Mtoe, 2050



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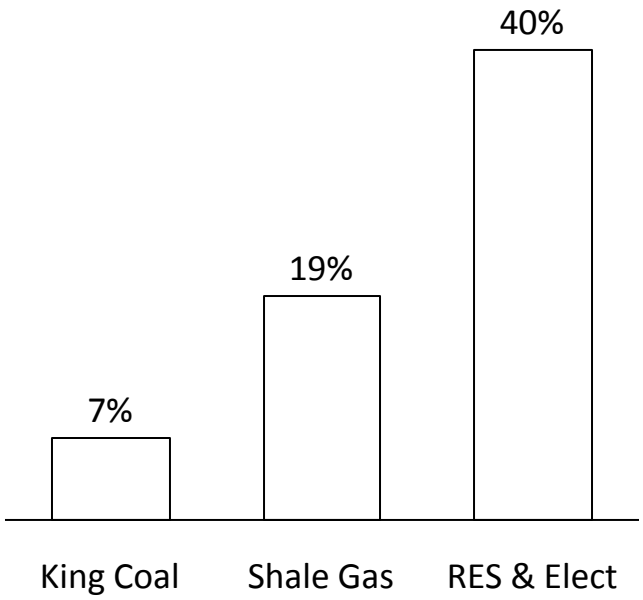
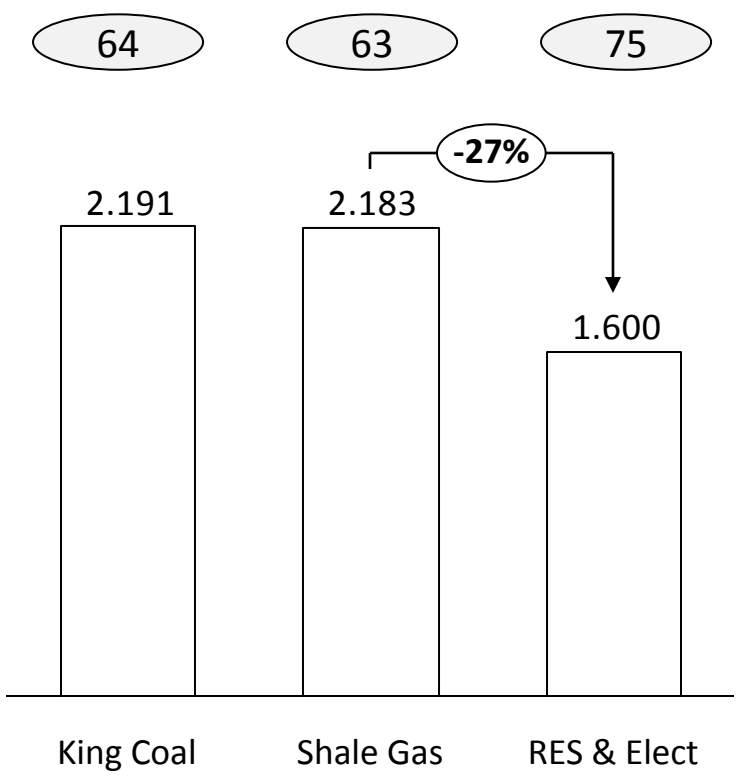
Although the RES & Elect scenario has higher unit costs of energy and seems to be more difficult to implement, it leads to lower total energy costs

Difficulty level (of implementation)
%, 2000-2050



Total cost of energy
B$'10/year, 2050



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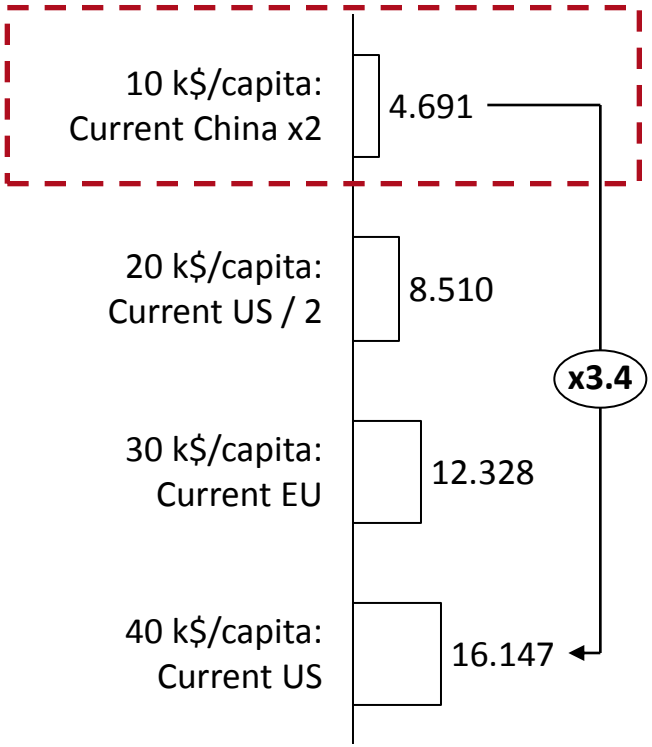
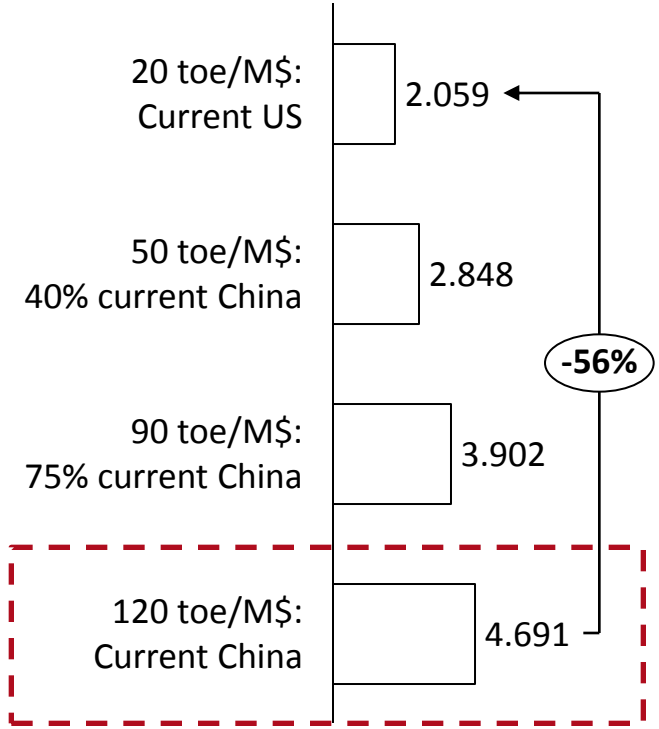
If China increases its GDP/Cap by 2050 to current US values primary energy demand would increase by 3.4x to 16 Gtoe

1 King Coal

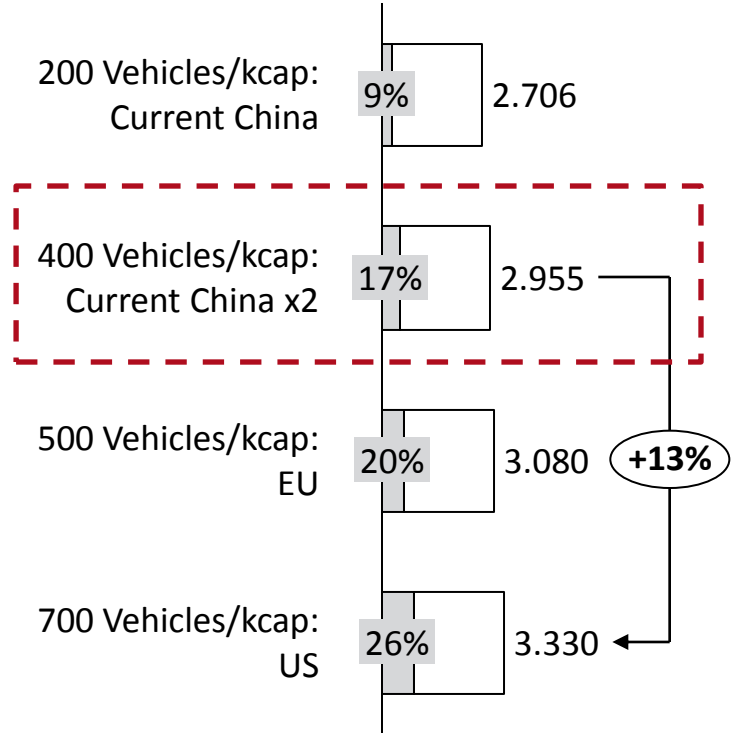
Primary energy vs. **GDP/capita**
Mtoe, 2050



Primary energy vs. **Industry energy intensity**
Mtoe, 2050



Final energy vs. **Road transport penetration**
Mtoe, 2050



King Coal scenario

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1

King Coal

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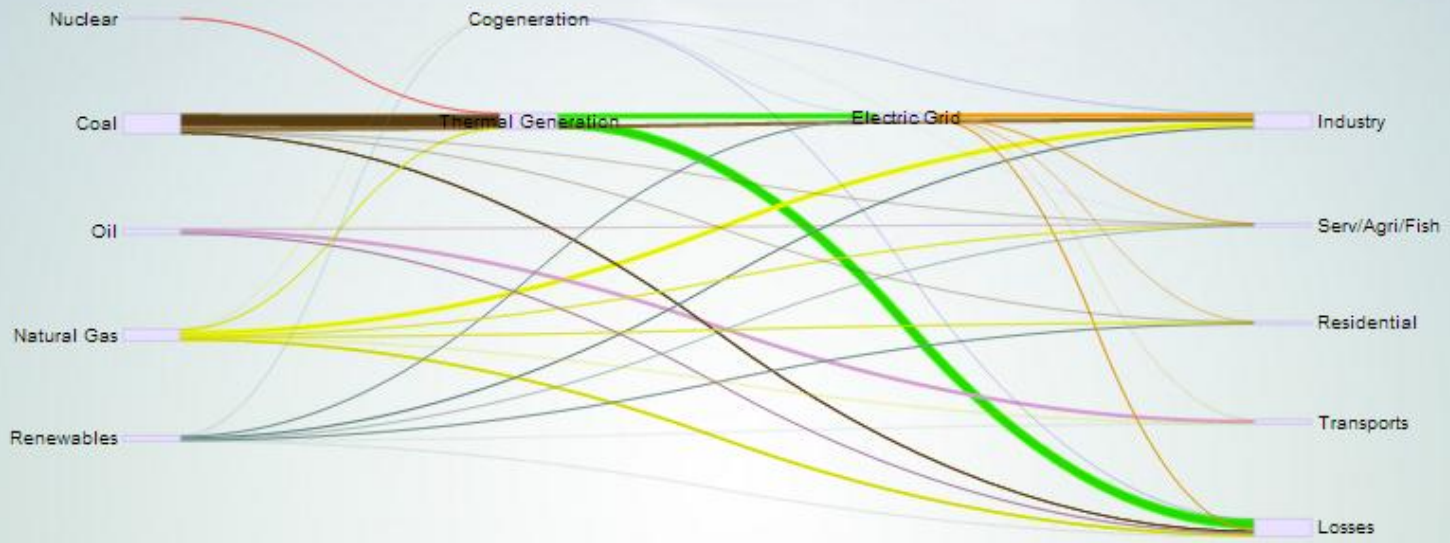
ENERGY FLOWS 2050 (Mtoe)



PRICES | ENERGY DEMAND | GENERATION OR CAPACITY | CO_2 EMISSIONS

Gas power | Hydroelectric generation | Nuclear power | Onshore wind power | Offshore wind power

2

Shale Gas

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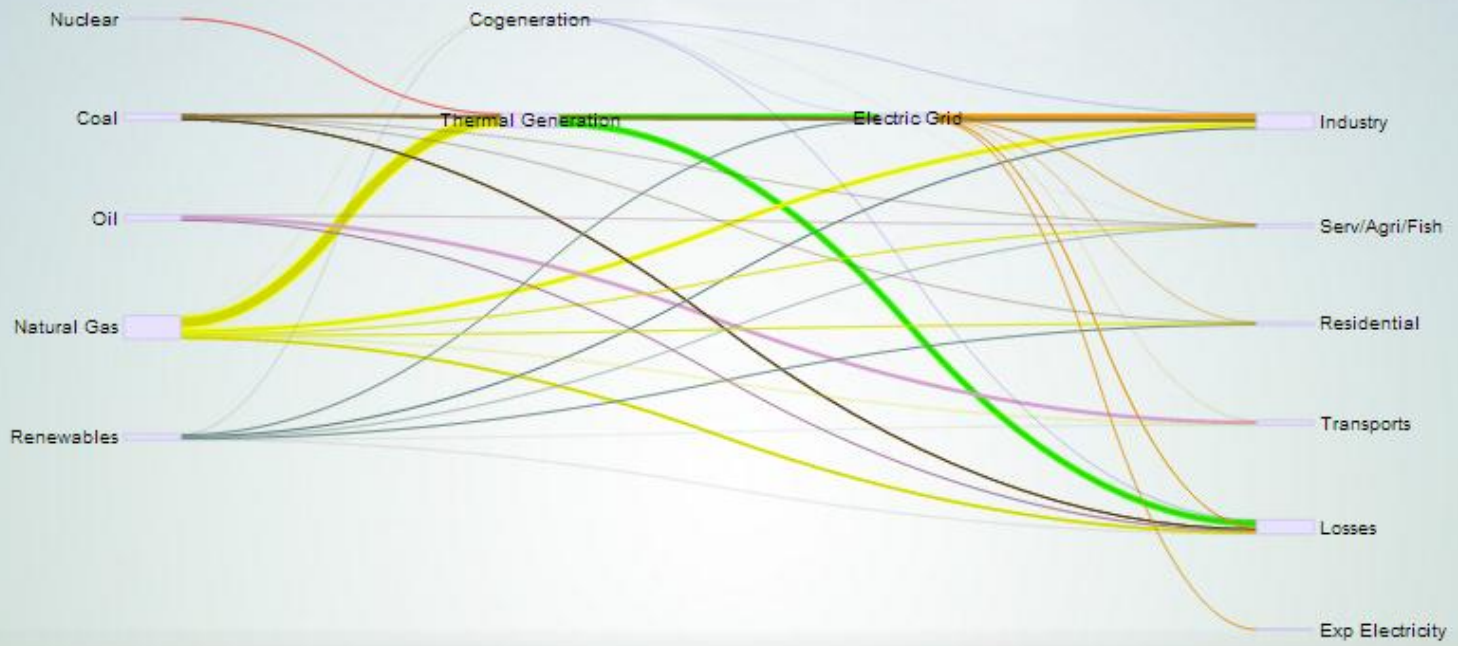
ENERGY FLOWS 2050 (Mtoe)



PRICES | ENERGY DEMAND | GENERATION OR CAPACITY | CO_2 EMISSIONS

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3

RES & Elect

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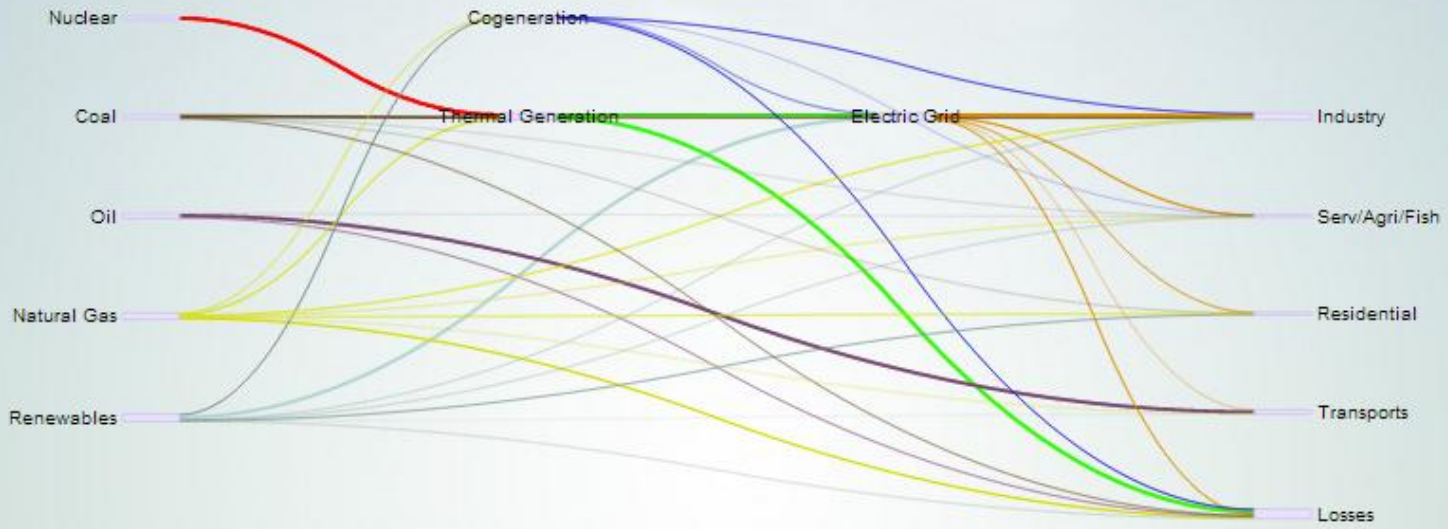
ENERGY FLOWS 2050 (Mtoe)



PRICES | ENERGY DEMAND | GENERATION OR CAPACITY | CO_2 EMISSIONS

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