

Energy Scenarios: The Value and Limits of Scenario Analysis



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Major Energy Outlooks

Types of Energy Scenarios

Tools for Scenario Development

Accuracy of Projections: Prices and Quantities

Emerging Technology Projections

Longer-term Scenarios

Concluding Remarks

Major Annual Global Energy Outlooks

Total Global Primary Energy Projections by Type

ExxonMobil (up to 2040)

BP (up to 2035)

IEA – New Policies (up to 2040)

IEA – Current Policies (up to 2040)

IEA – 450 (up to 2040)

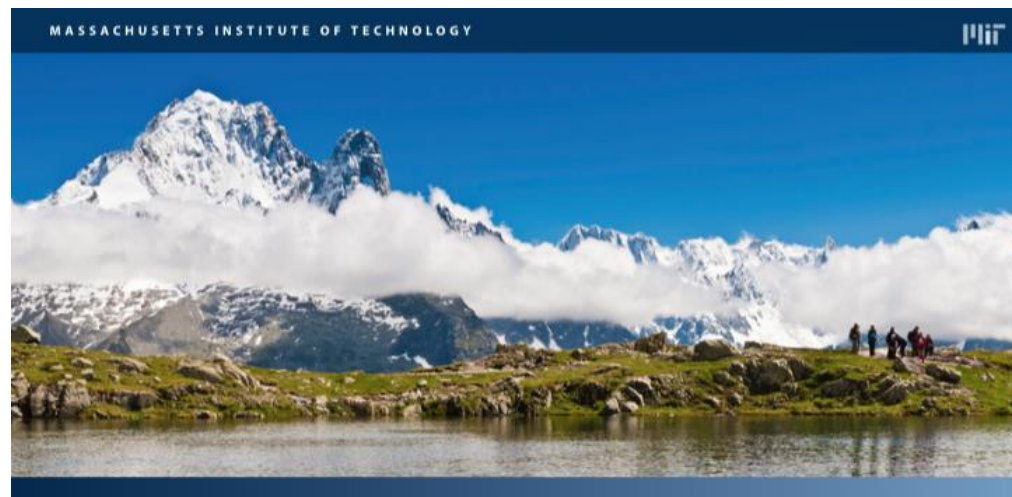
MIT Joint Program – Outlook (up to 2100)

(<http://globalchange.mit.edu/research/publications/other/special/2015Outlook>)

MIT Joint Program – 2C (up to 2100)

(Note: ExxonMobil and IEA include traditional biomass)

MIT Joint Program Energy and Climate Outlook



MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

ENERGY & CLIMATE OUTLOOK

PERSPECTIVES FROM 2015

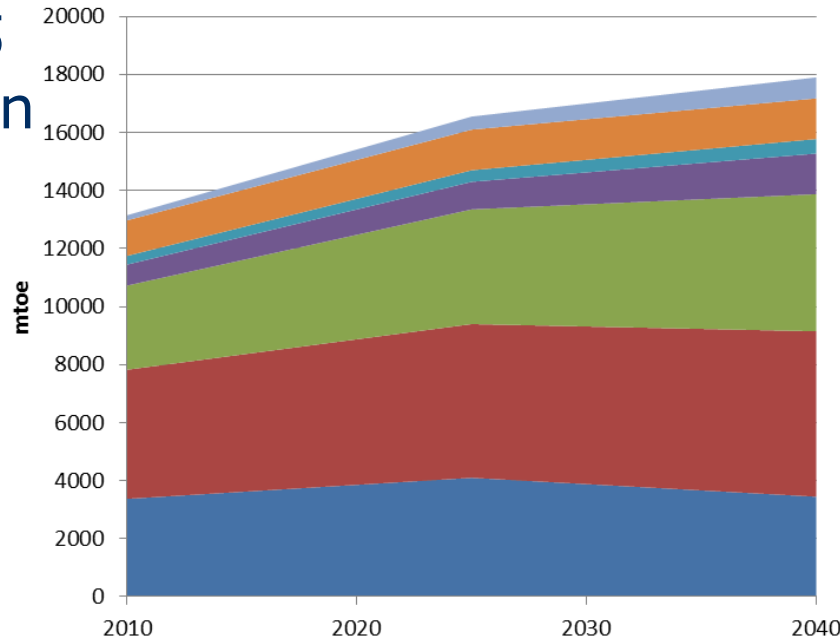
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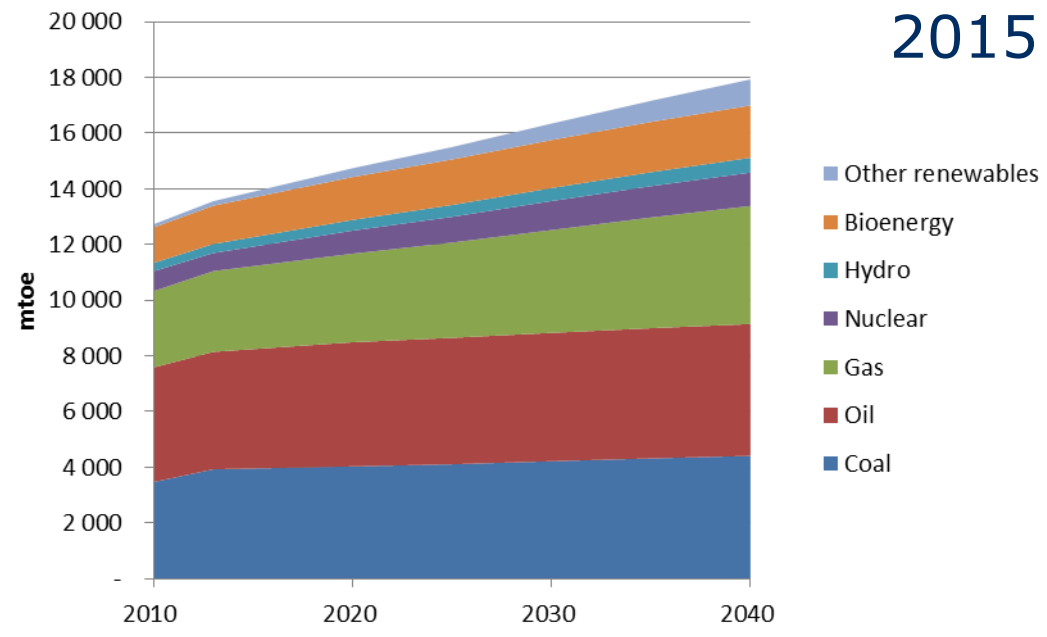


“Best guesses” – ExxonMobil, BP, “New Policies” – IEA, “Outlook” – MIT Joint Program

2015
Exxon



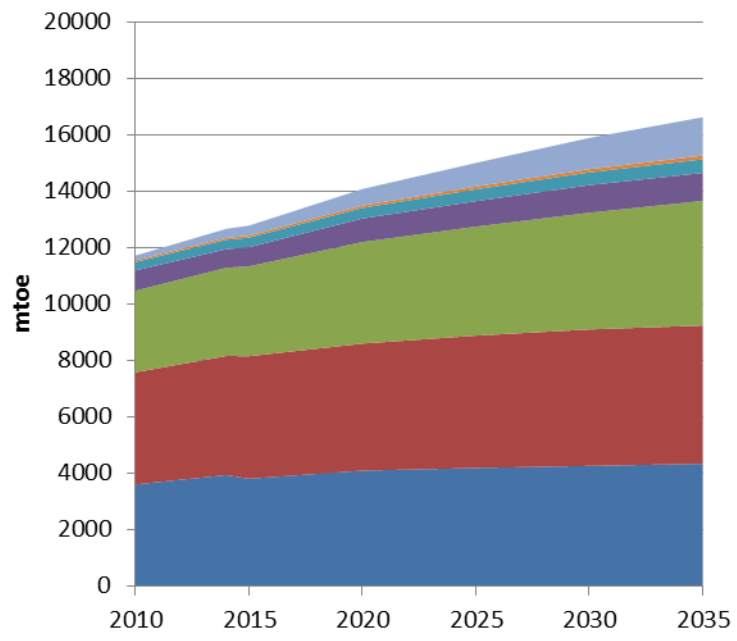
2015
IEA



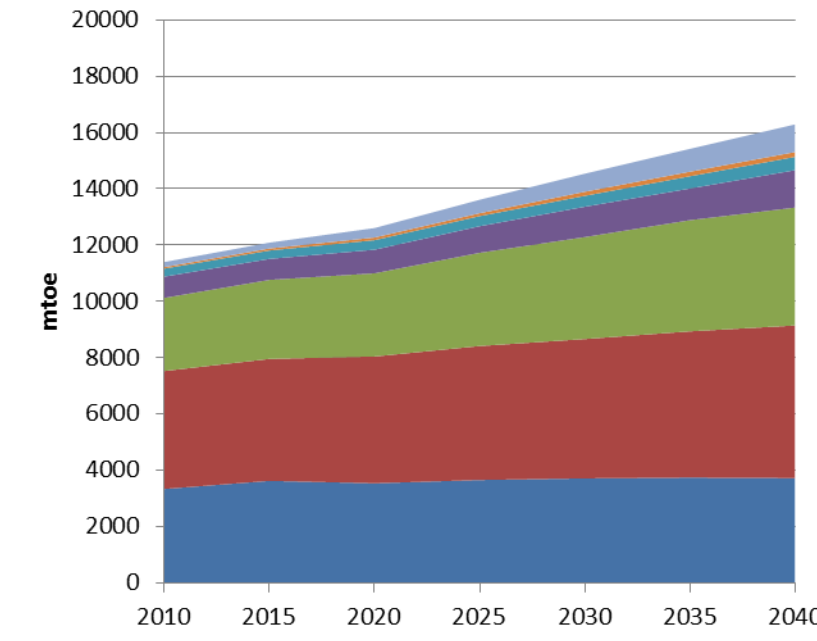
2015 IEA

- Other renewables
- Bioenergy
- Hydro
- Nuclear
- Gas
- Oil
- Coal

2016
BP



2015
MIT

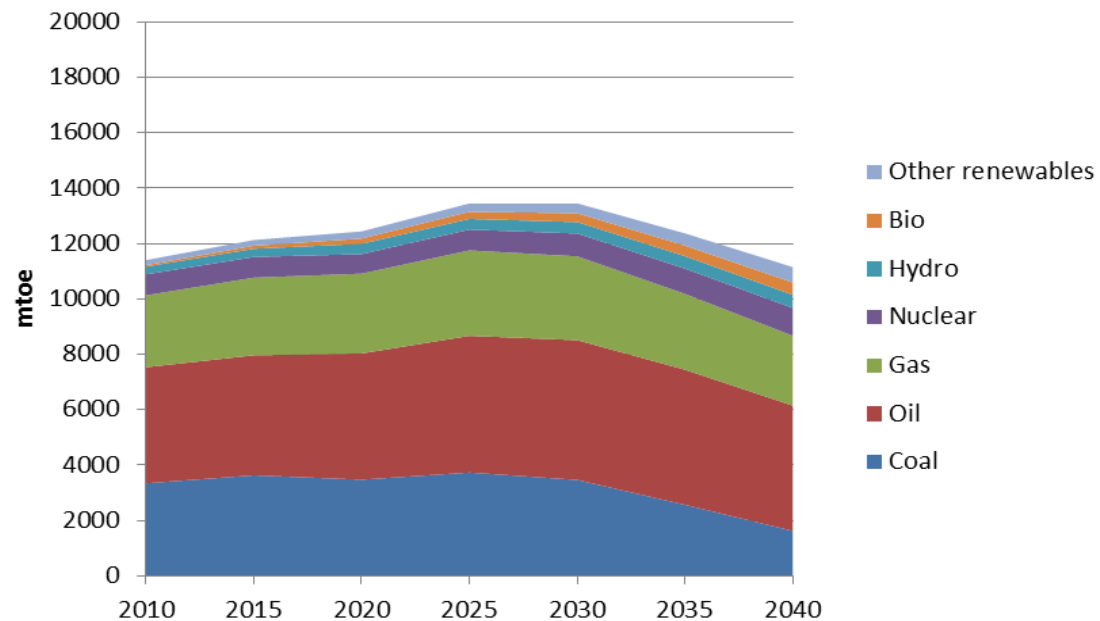
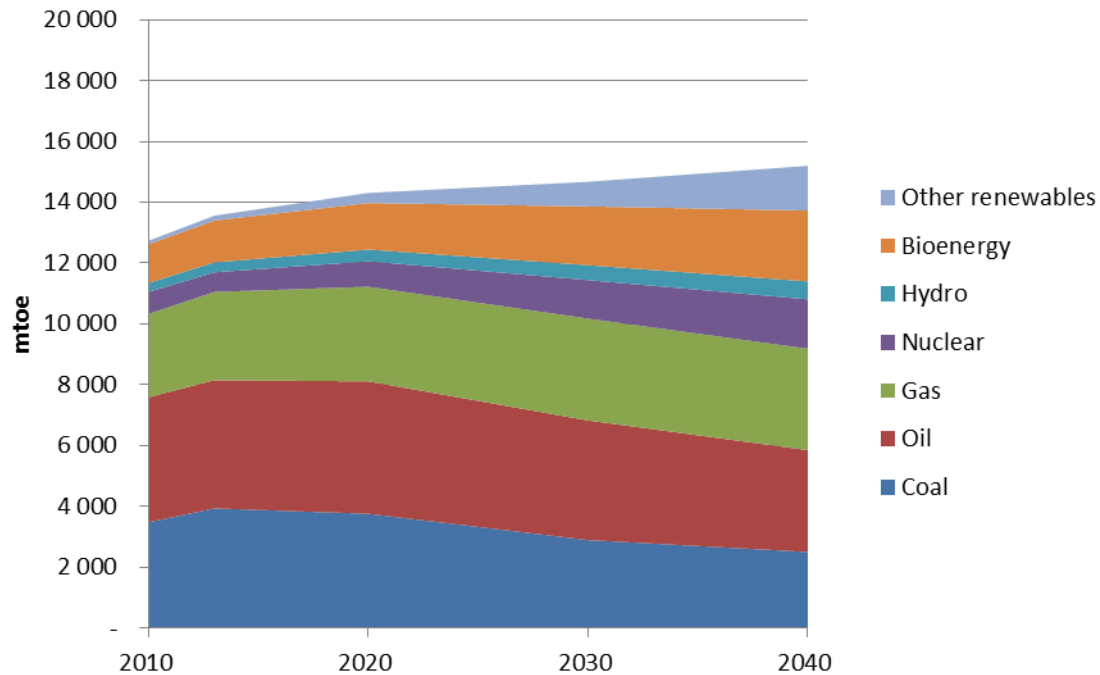


2015 MIT

- Renewables
- Bio
- Hydro
- Nuclear
- Gas
- Oil
- Coal



“450” – IEA, “2C” – MIT Joint Program



What is a Scenario?

Scenario - a description of what could possibly happen (Google)

Scenario vs Projection vs Prediction vs Forecast vs Outlook

EPPA – Prediction vs Projection

Prediction – a (probabilistic) statement that something will happen in the future

Forecast – “best” prediction (while sometimes used in the same way as prediction – “ensemble forecasts”).

Projection – a (probabilistic) statement that something could happen under some conditions (“if-then”).

Scenario – projection of what *could* happen and not prediction of what *will* happen.

Types of Energy Scenarios

By purpose: “best guess” or “most likely” trajectory (e.g., BP, ExxonMobil) vs “Plausible future” vs “BAU-Policy Case” vs “Reference-High-Low” vs “what would it take to get to a specific goal?”.

By time-horizon: short-term, medium-term, long-term.

By sectoral coverage: industry, energy system, economy-wide.

By geographic coverage: regional, country, region, global.

By basis: model-based, expert-based, expert-based using a range of analytical tools (e.g., IEA WEO).

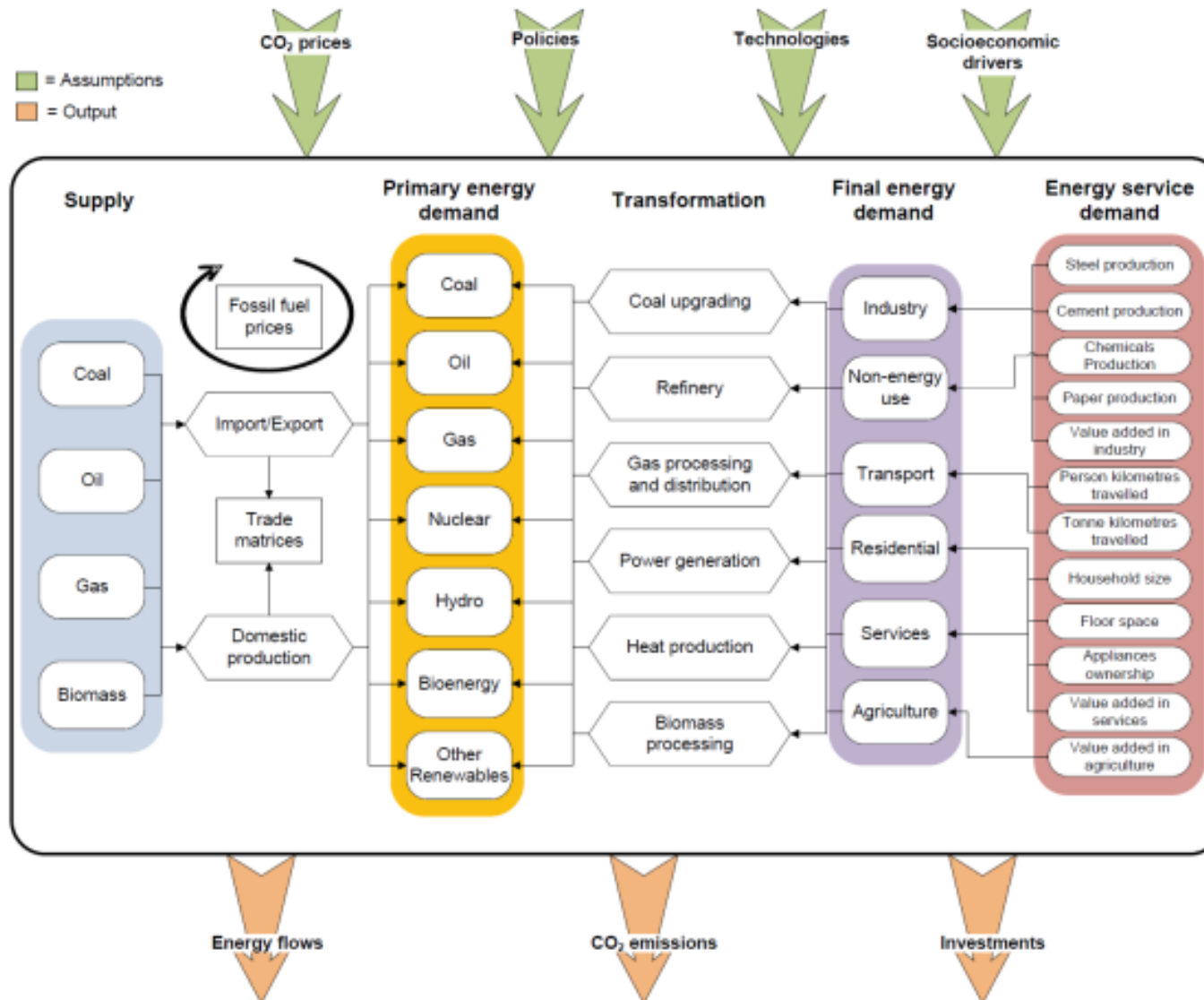
By adding “storylines”: (e.g., Shell, IPCC SRES).

By periodic updates: one-time, occasional, annual, monthly.

Note: most of the energy scenarios are NOT probabilistic.

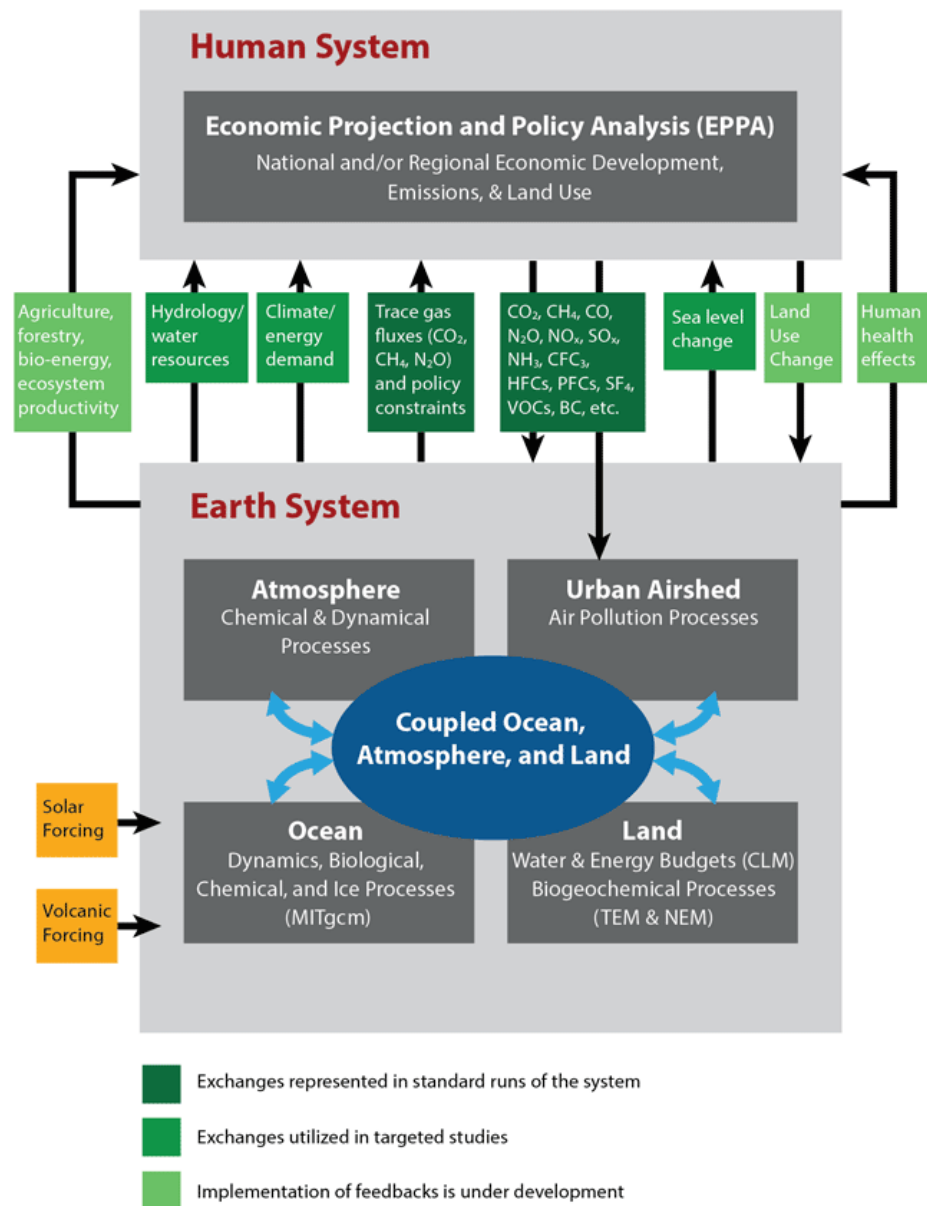
Tools for Scenario Development

Different degrees of complexity (top-down economy-wide; bottom-up engineering; hybrid)



Example:
 IEA's World Energy Model

MIT Integrated Global System Modeling Framework



Developed by the MIT Joint Program on the Science and Policy of Global Change

IGSM is in development since 1995

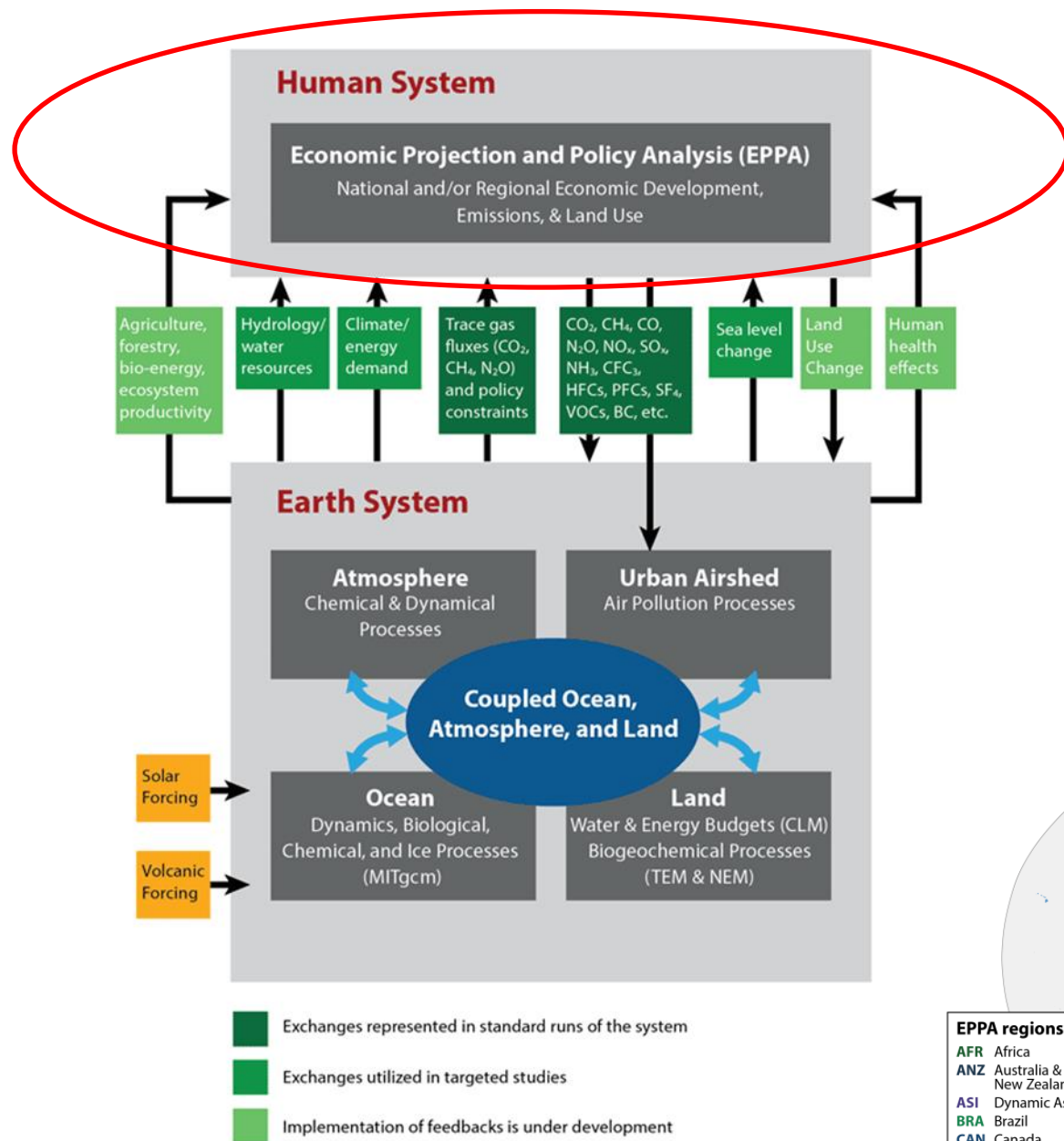
1994-2015 – 290 Joint Program Reports; a similar number of peer-reviewed articles

Report 1 – Uncertainty in Climate Change Policy Analysis (December 1994)

Report 290 – Modeling Uncertainty in Climate Change: A Multi-Model Comparison (December 2015)

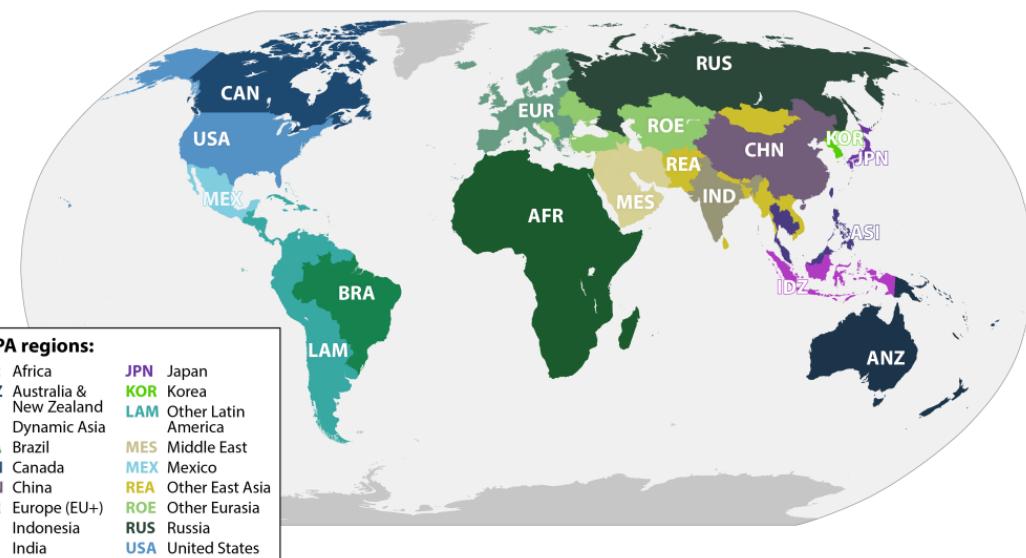


“Helping the Future Arrive”



Major goals:
Energy, economy, GHG
and air pollutants
projections.

Representation:
All sectors of economy;
Global coverage (detailed
U.S. and China models).



Market-based vs Technology Cost

General equilibrium

- Prices endogenous
- Factors driving growth
- International trade

Sacrifice technological details

- Production technology
- Aggregation of sectors
- No inefficient markets

Engineering cost

- Technical detail
- Zero-cost opportunities

Partial equilibrium

- Key prices exogenous
- Omit interactions

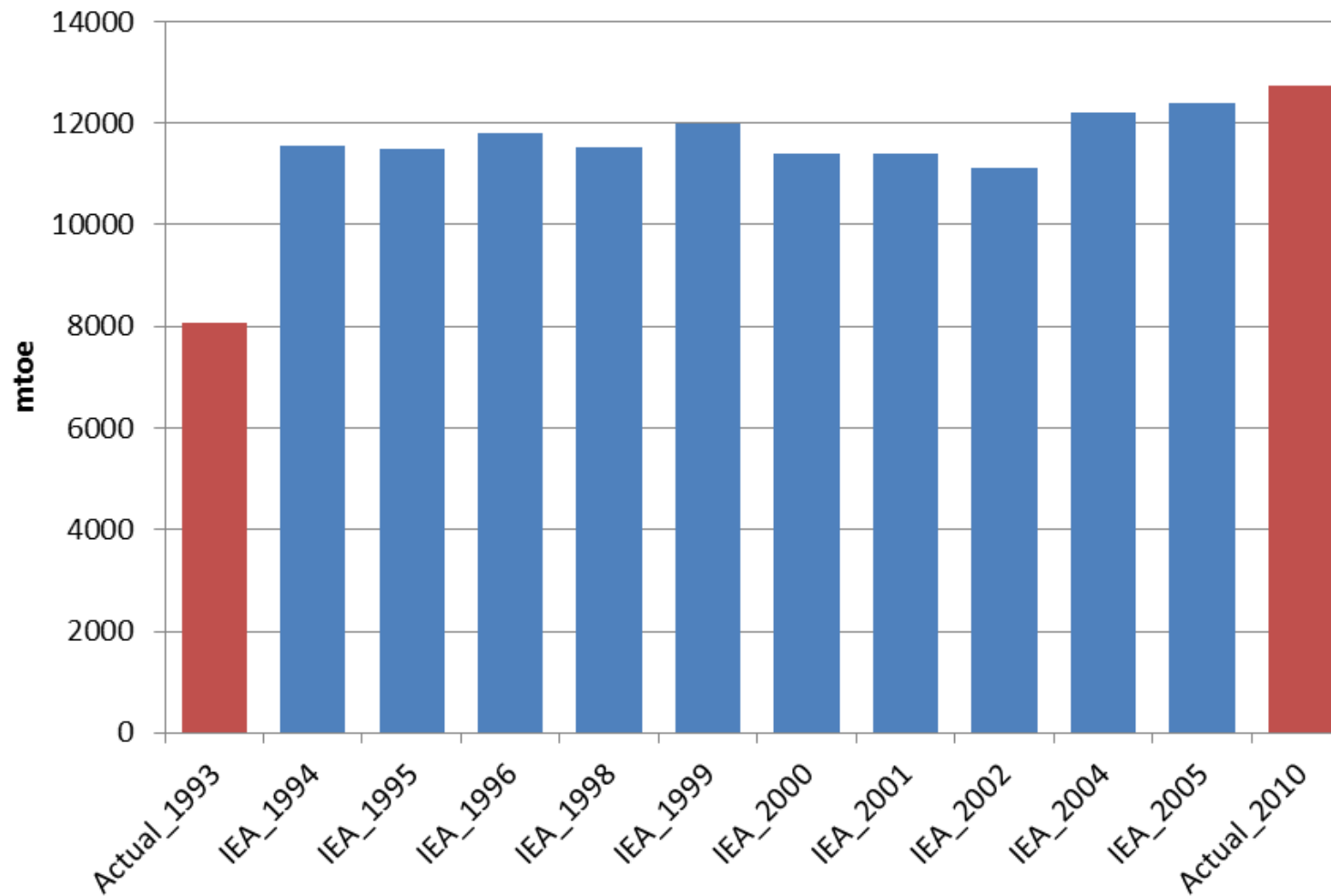
Direct costs, ignoring

- Consumer surplus loss
- Distortions

Cannot calculate GDP or welfare losses.

Hybrids

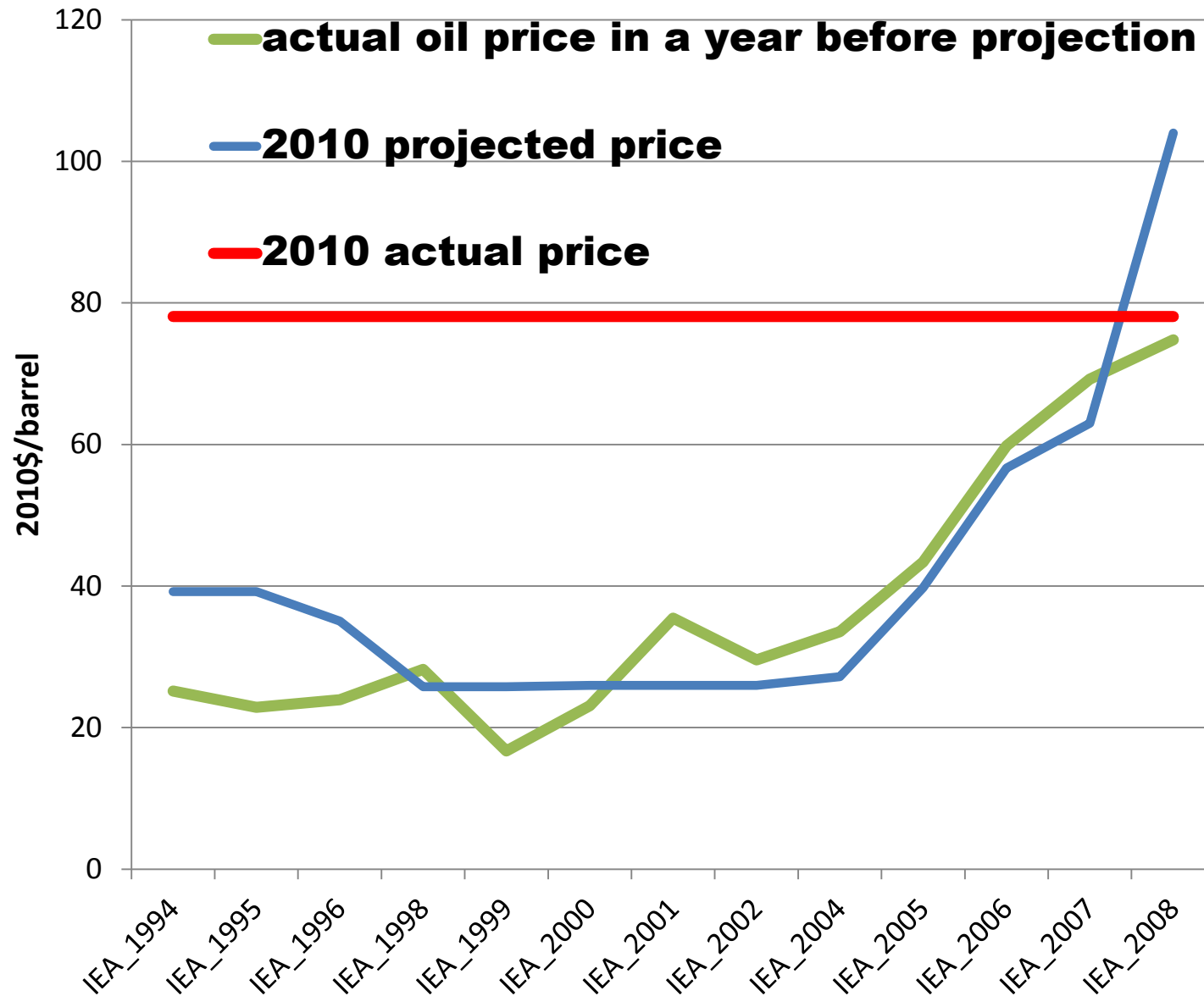
IEA projections from different years for 2010 global energy use



Even 16
year old
forecast is
not quite
bad

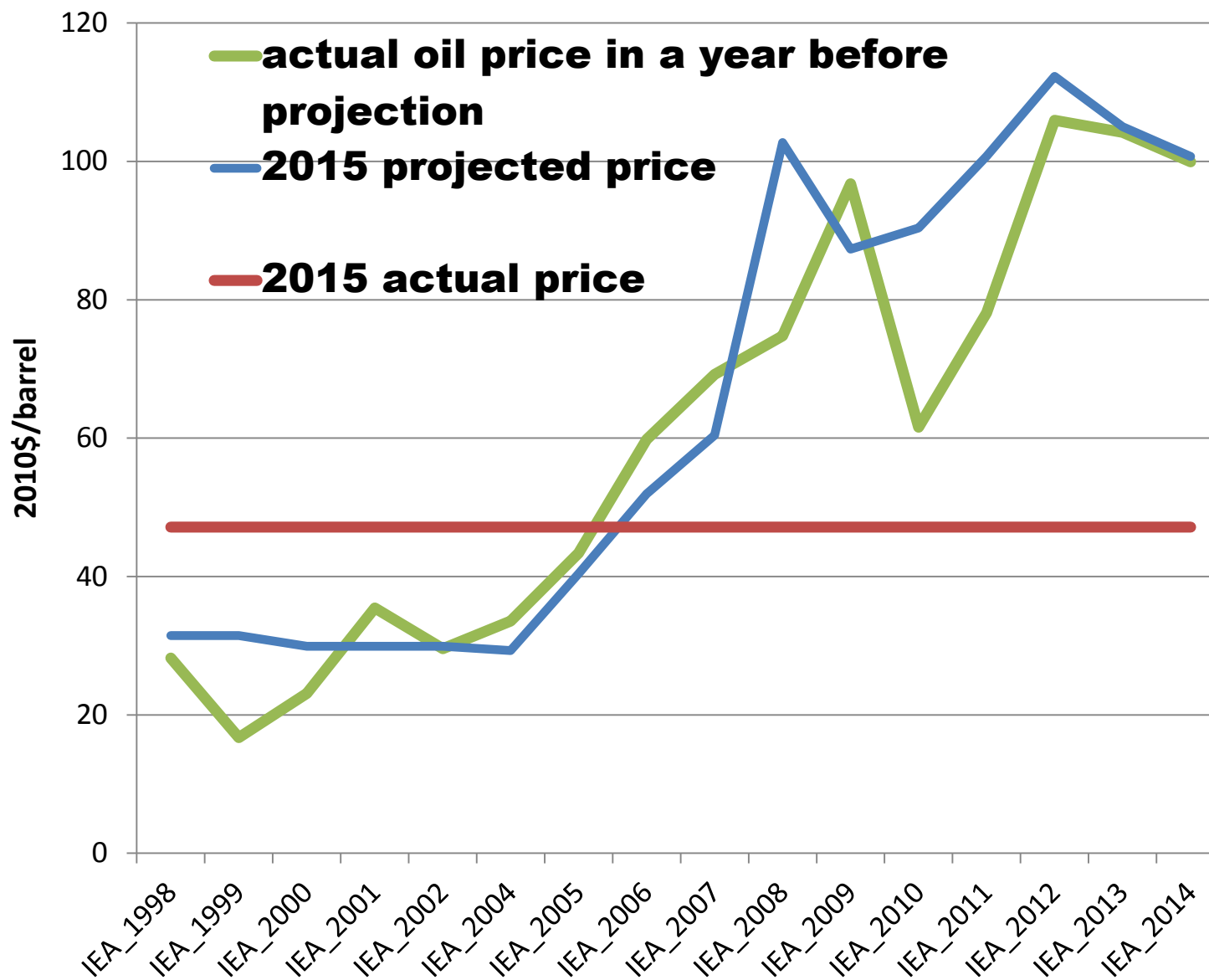
while
very
different
China,
USSR

IEA projections from different years for 2010 oil price



Price forecast is not that good

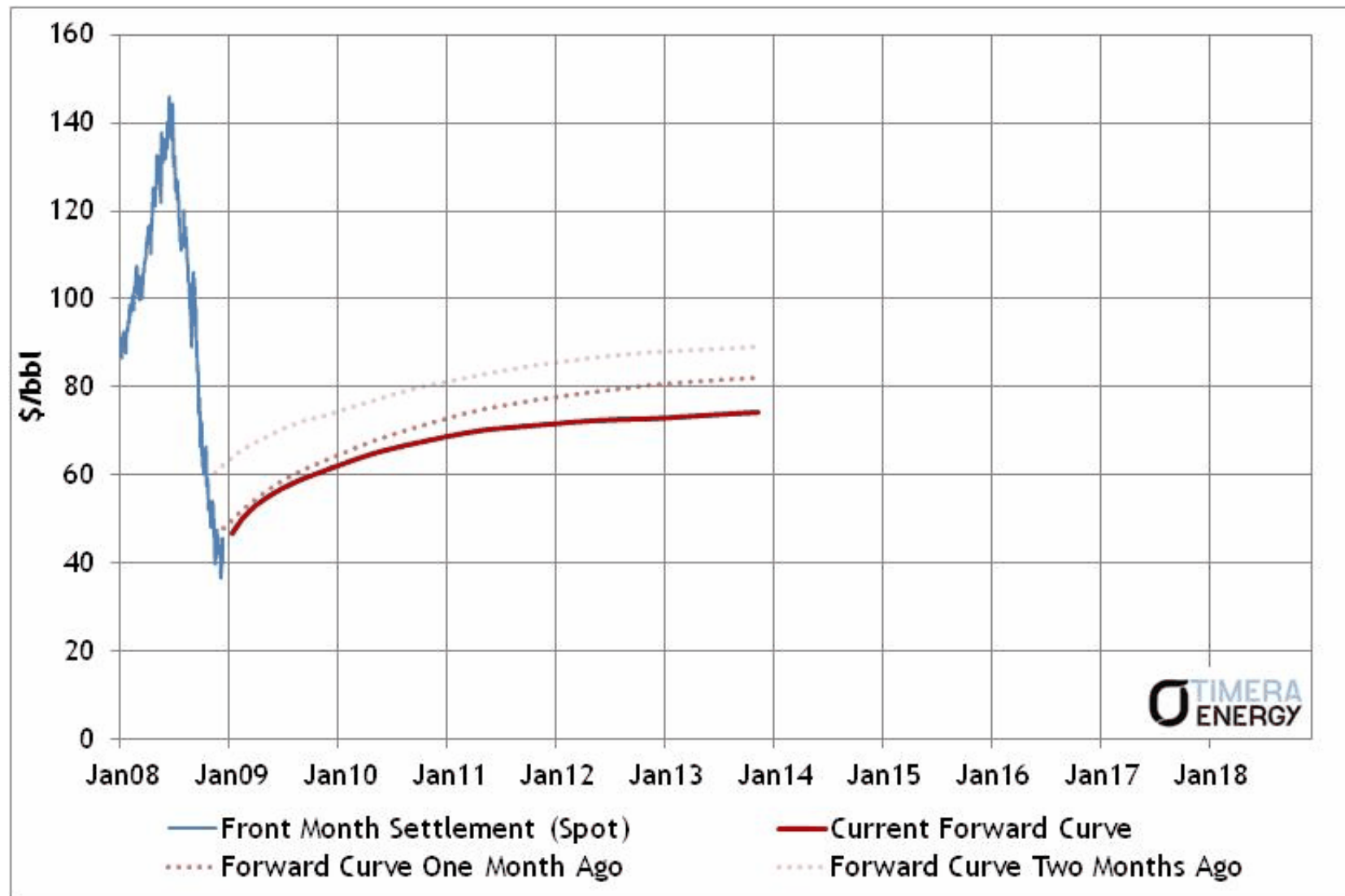
IEA projections from different years for 2015 oil price



Only two sources, who are brave enough to show their historic forecasts: IEA and EIA

Price forecasts are not that good

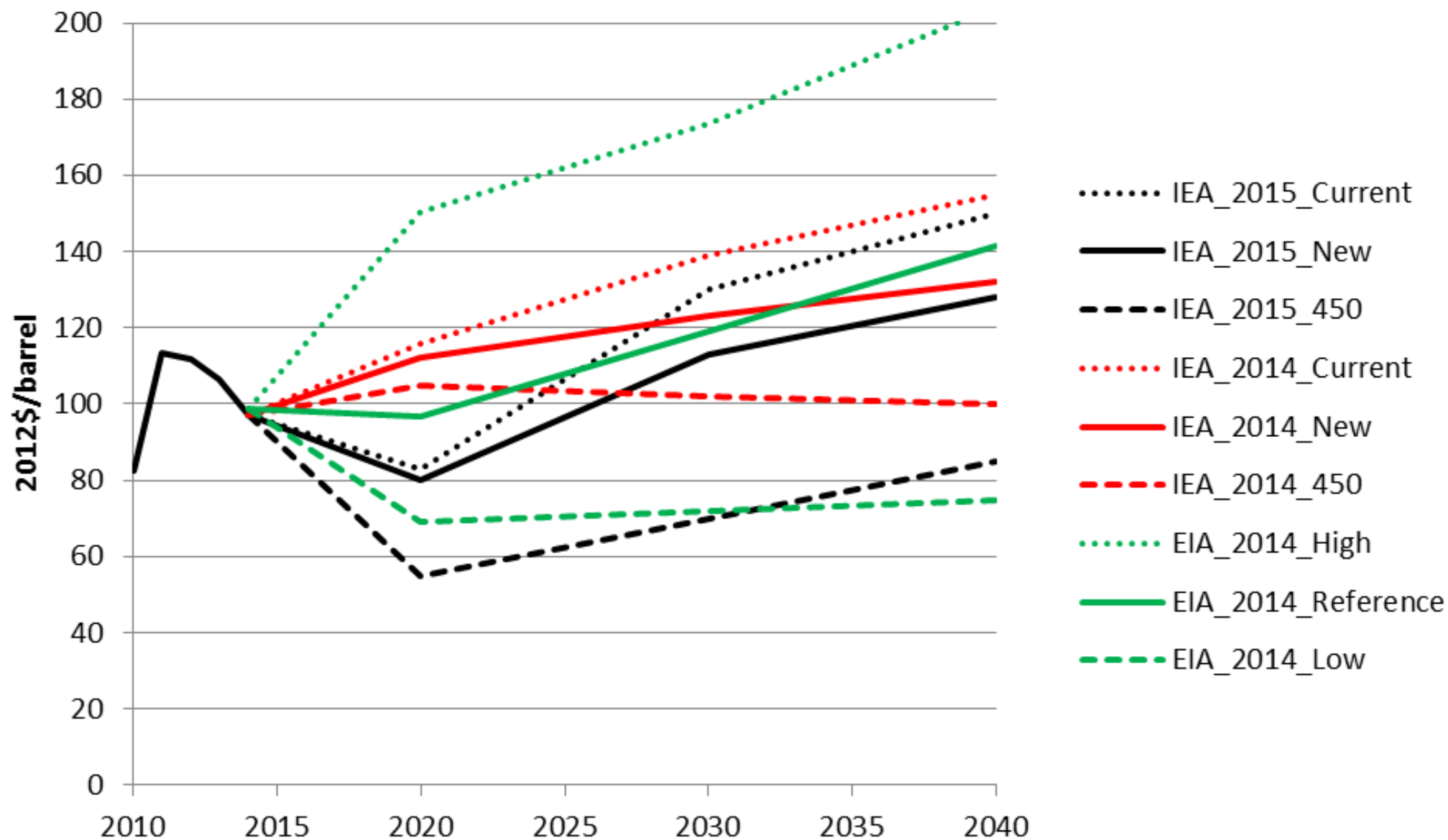
Oil Price Projections – ICE Brent Futures



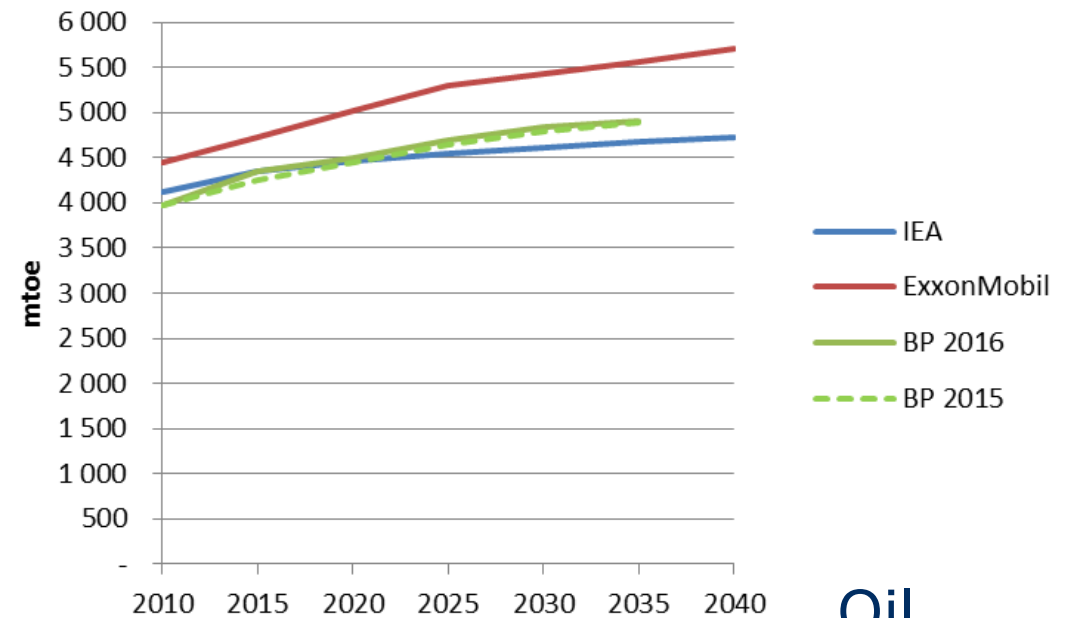
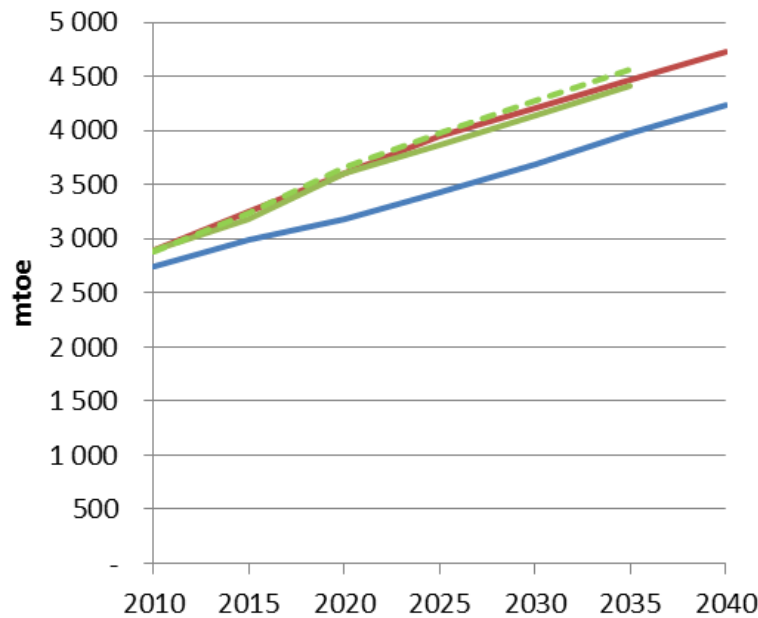
Source:

<http://www.timera-energy.com/the-dangers-of-mixing-forecasts-and-forward-curves/>

IEA and EIA oil price projections

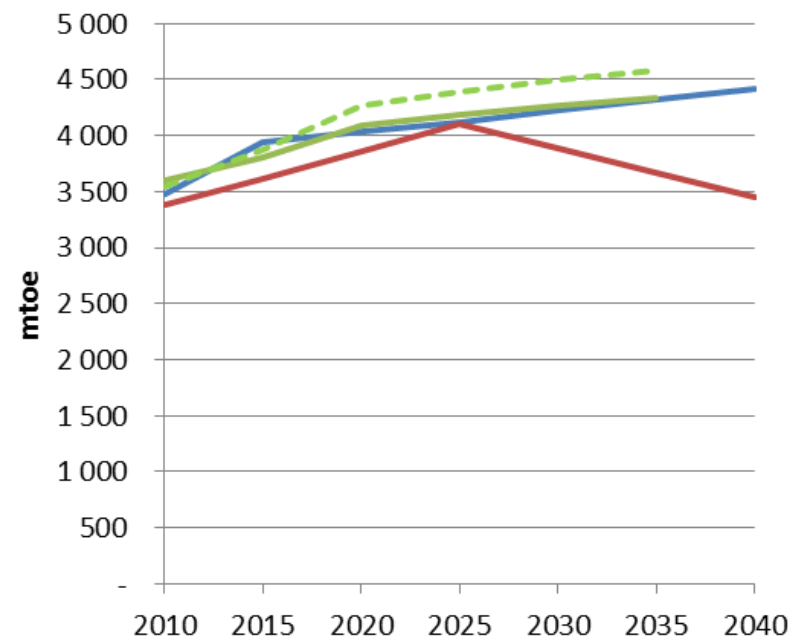


Quantity projections



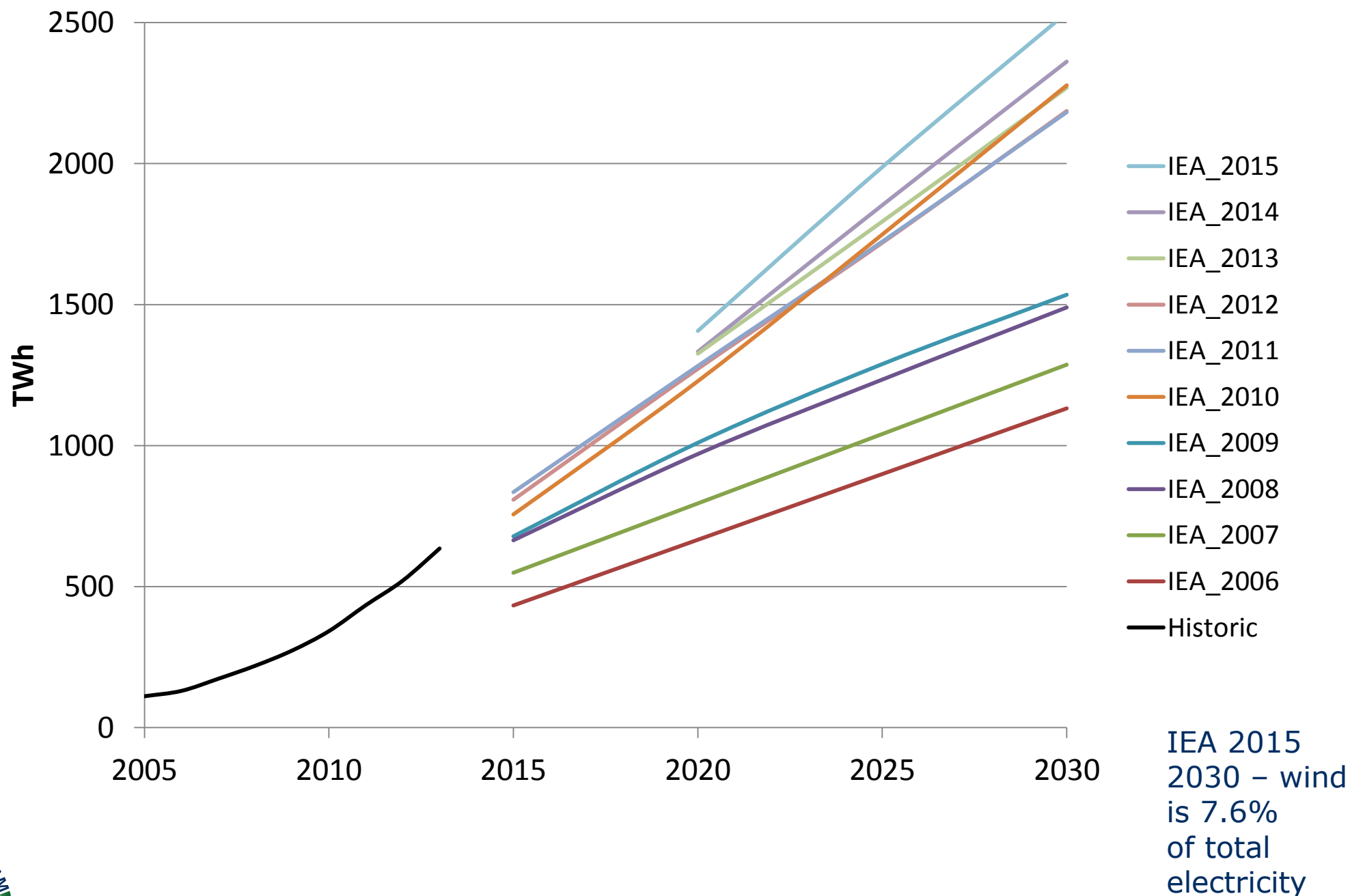
Oil

Natural gas

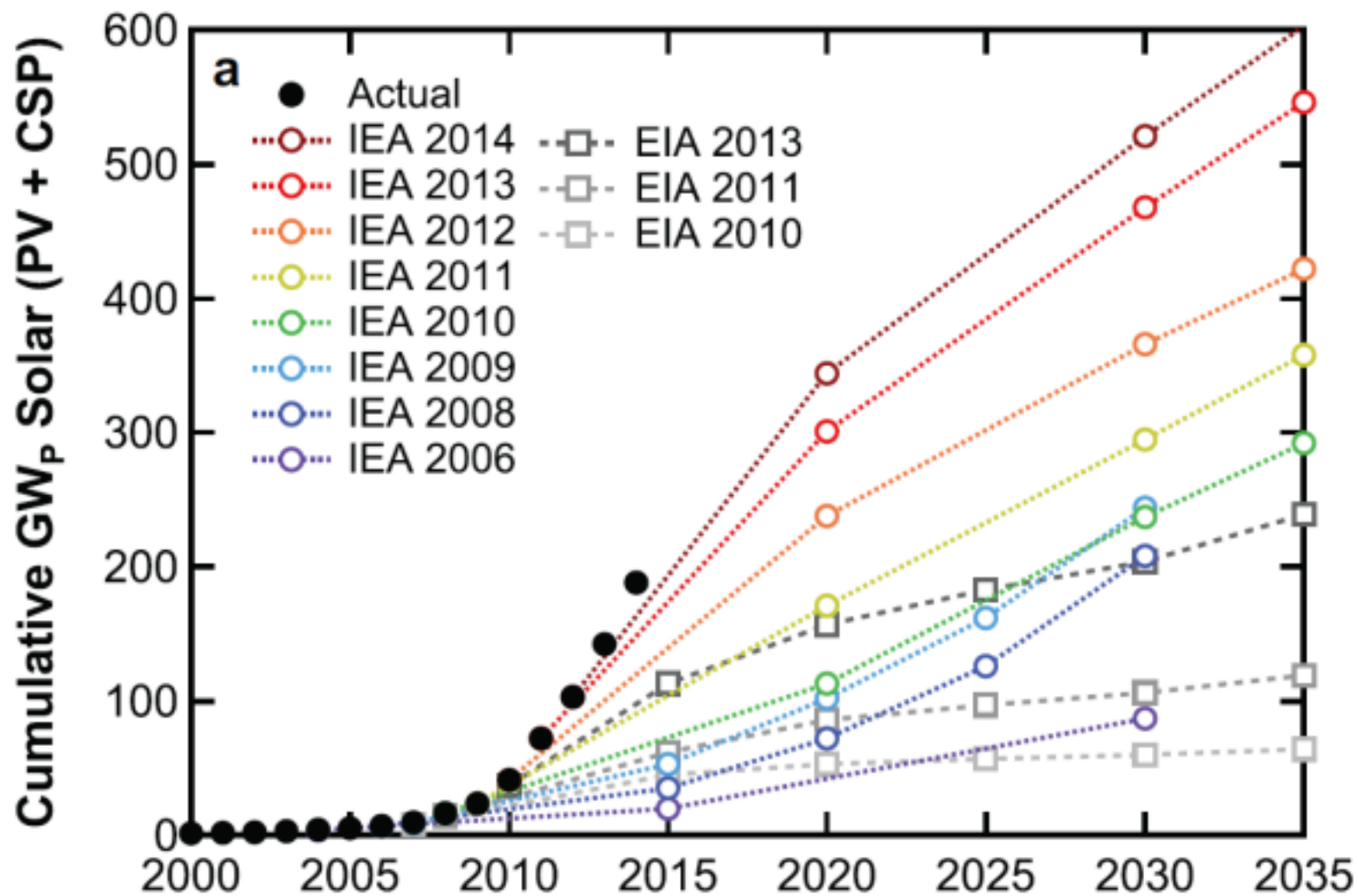


Coal

Global Wind Power Generation Projections

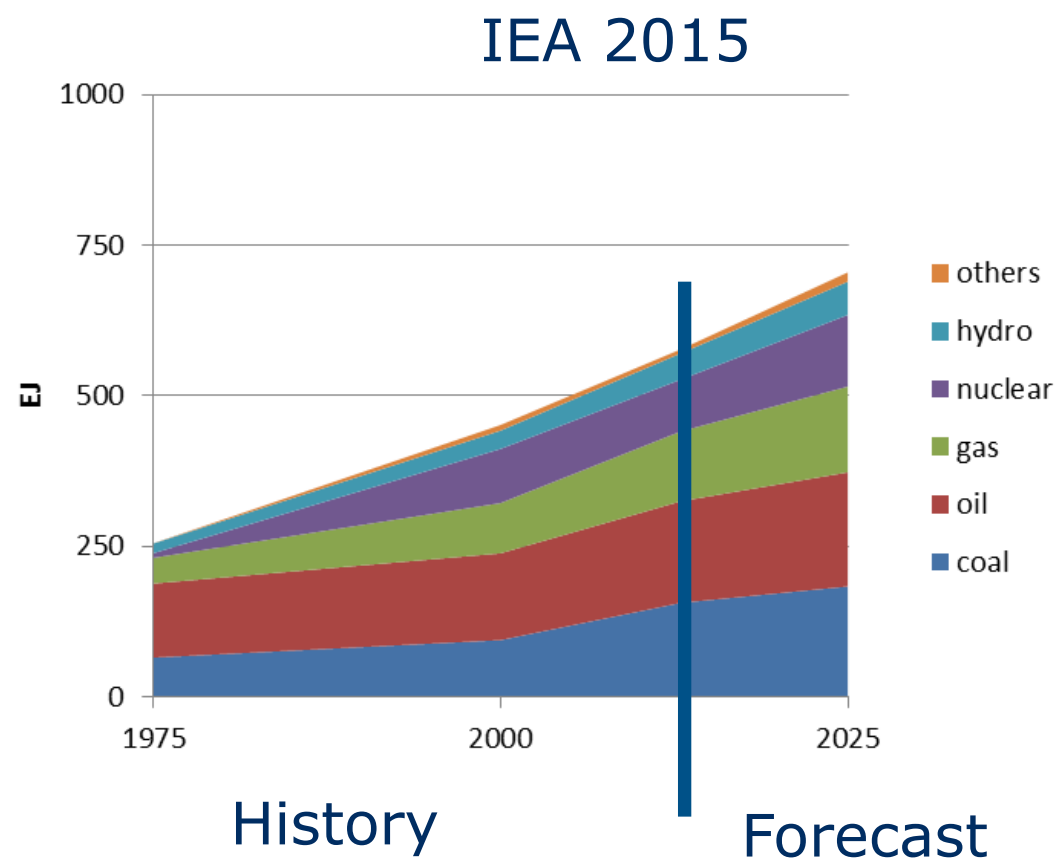
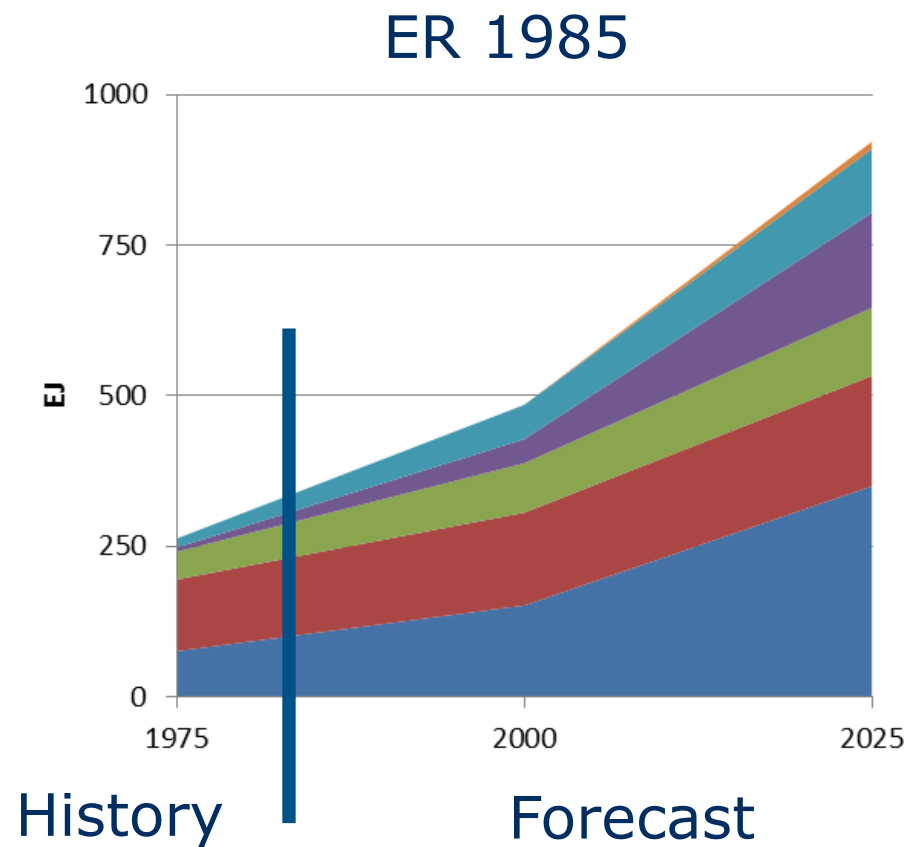


Solar Generation Capacity Projections



Source: MIT Future of Solar

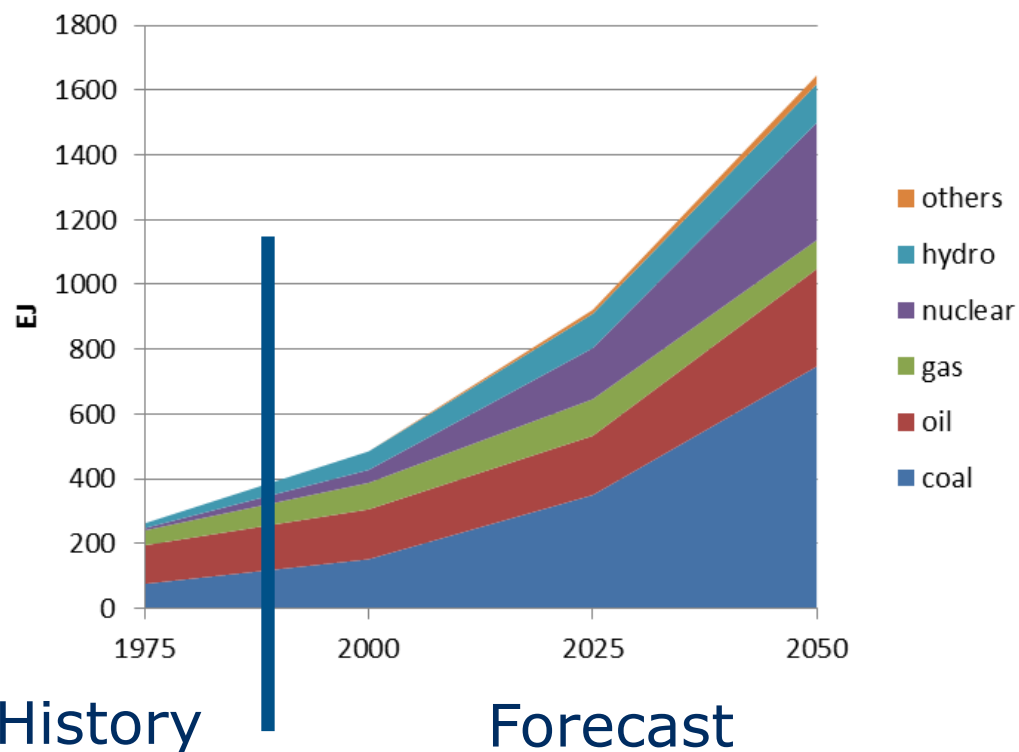
Earlier Forecasts: Edmonds-Reilly (1985)



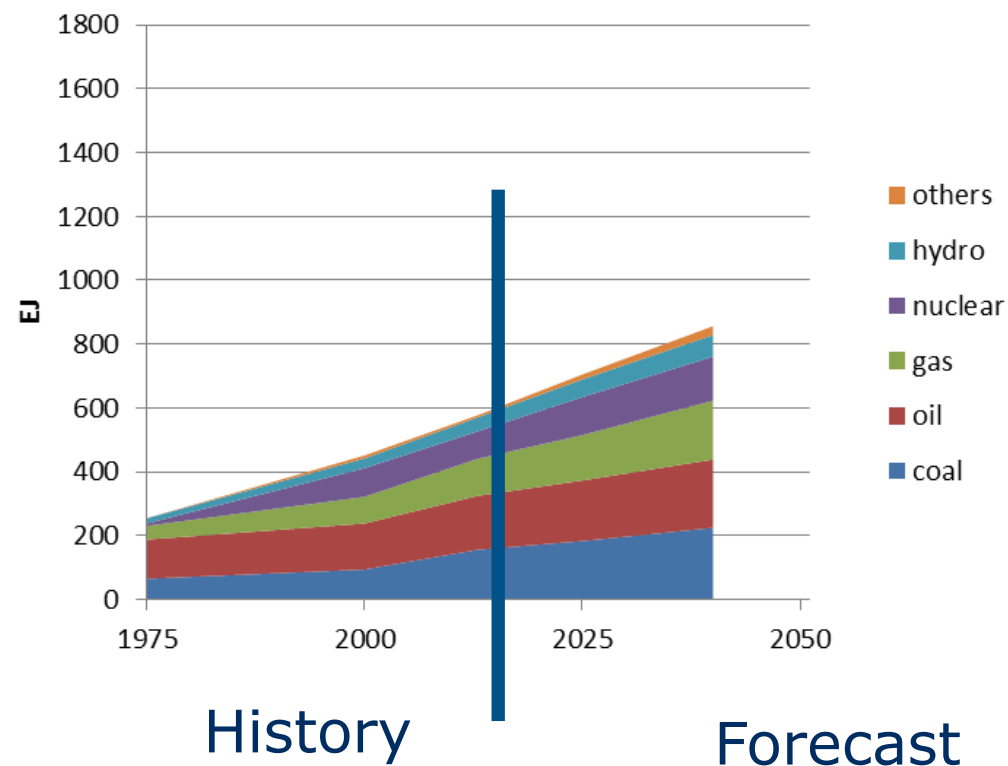
Up to 2025

Earlier Forecasts: Edmonds-Reilly (1985)

ER 1985

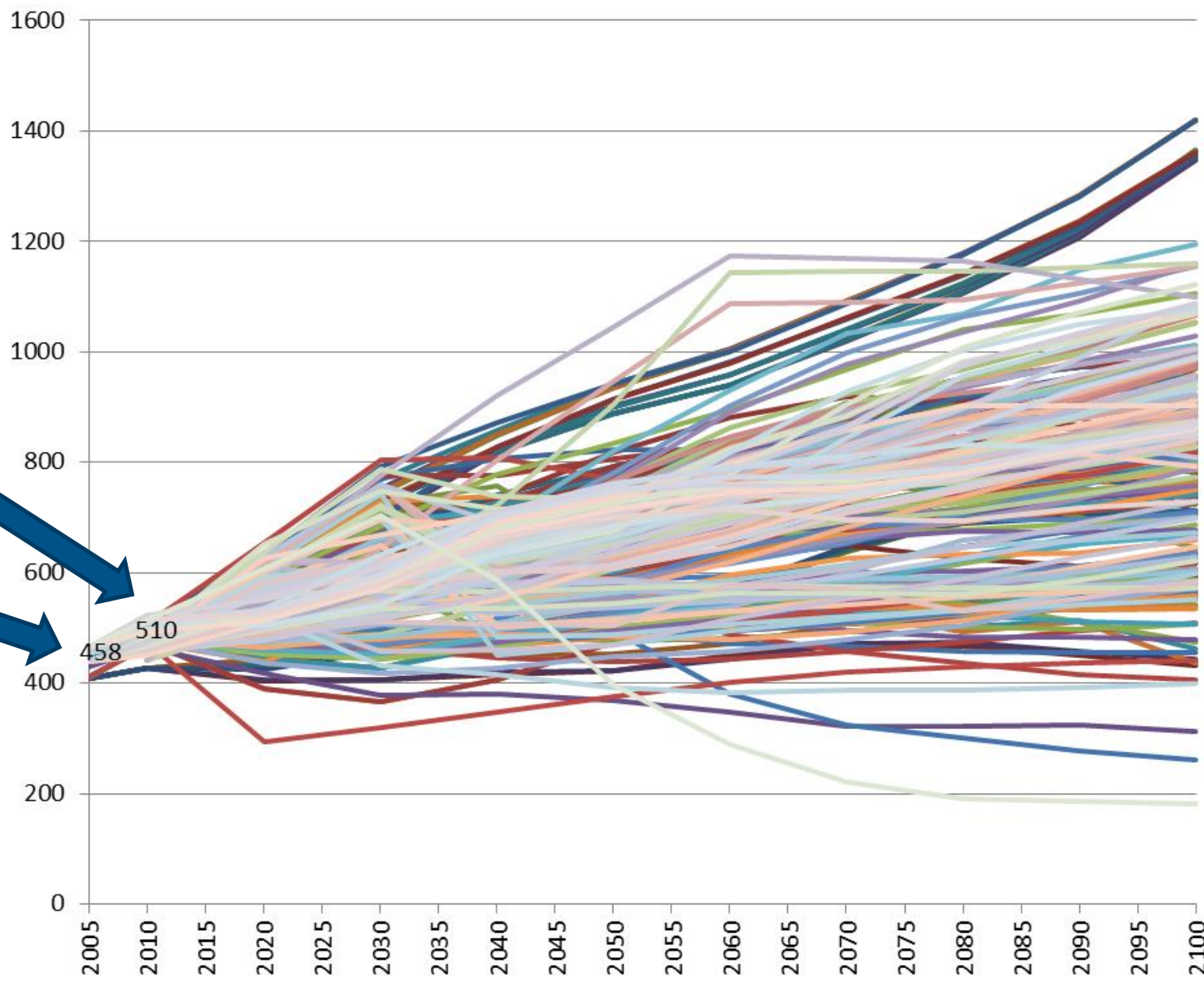


IEA 2015



Up to 2050 (2040 for IEA)

2C Scenarios from IPCC AR5: Global Primary Energy



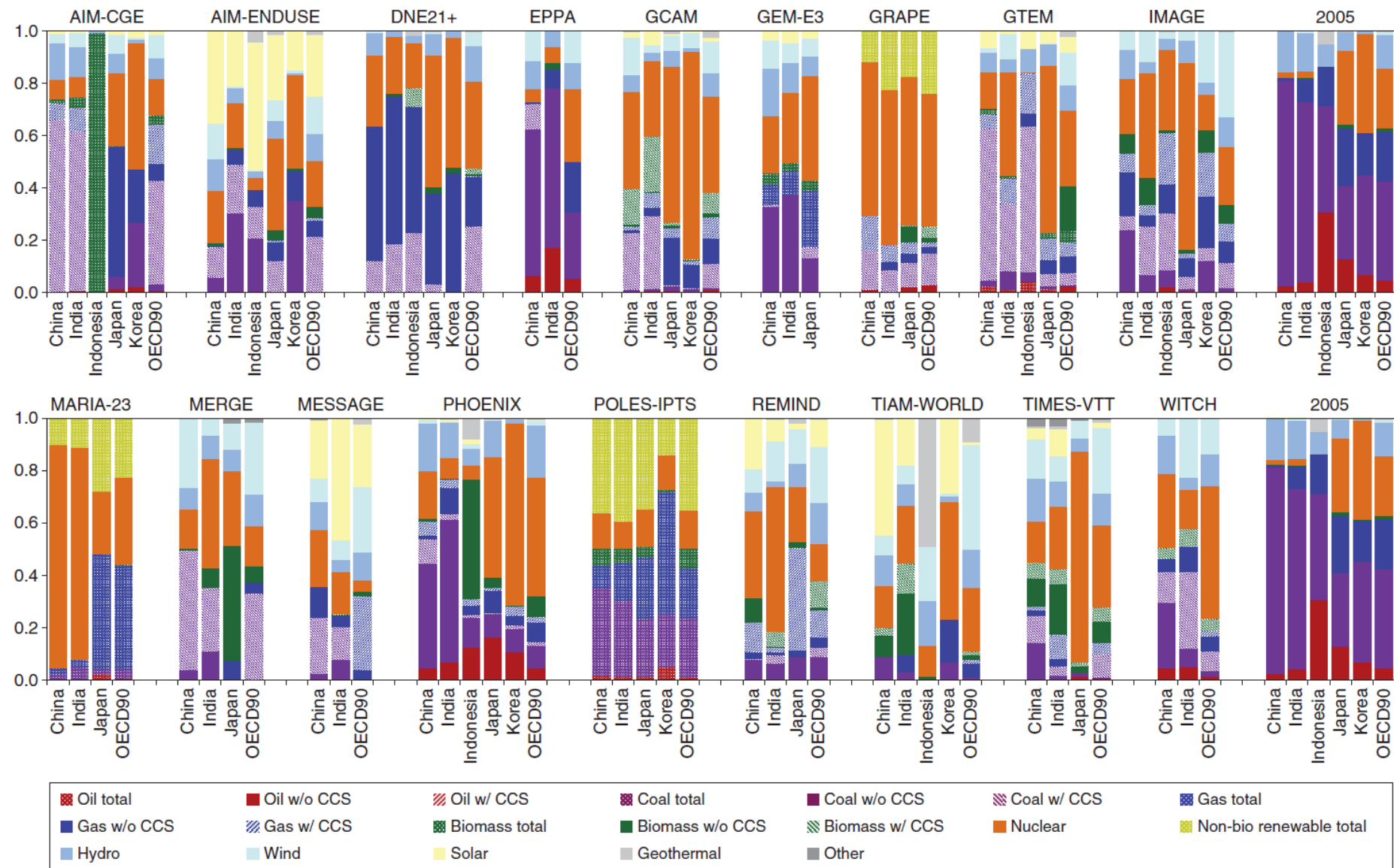
Combining scenarios from different groups

392 of 2C scenarios out of 1,184 total scenarios in AR5

"spaghetti diagram"



Asia Modeling in 2050: Electricity Generation by Type (\$30/5%)



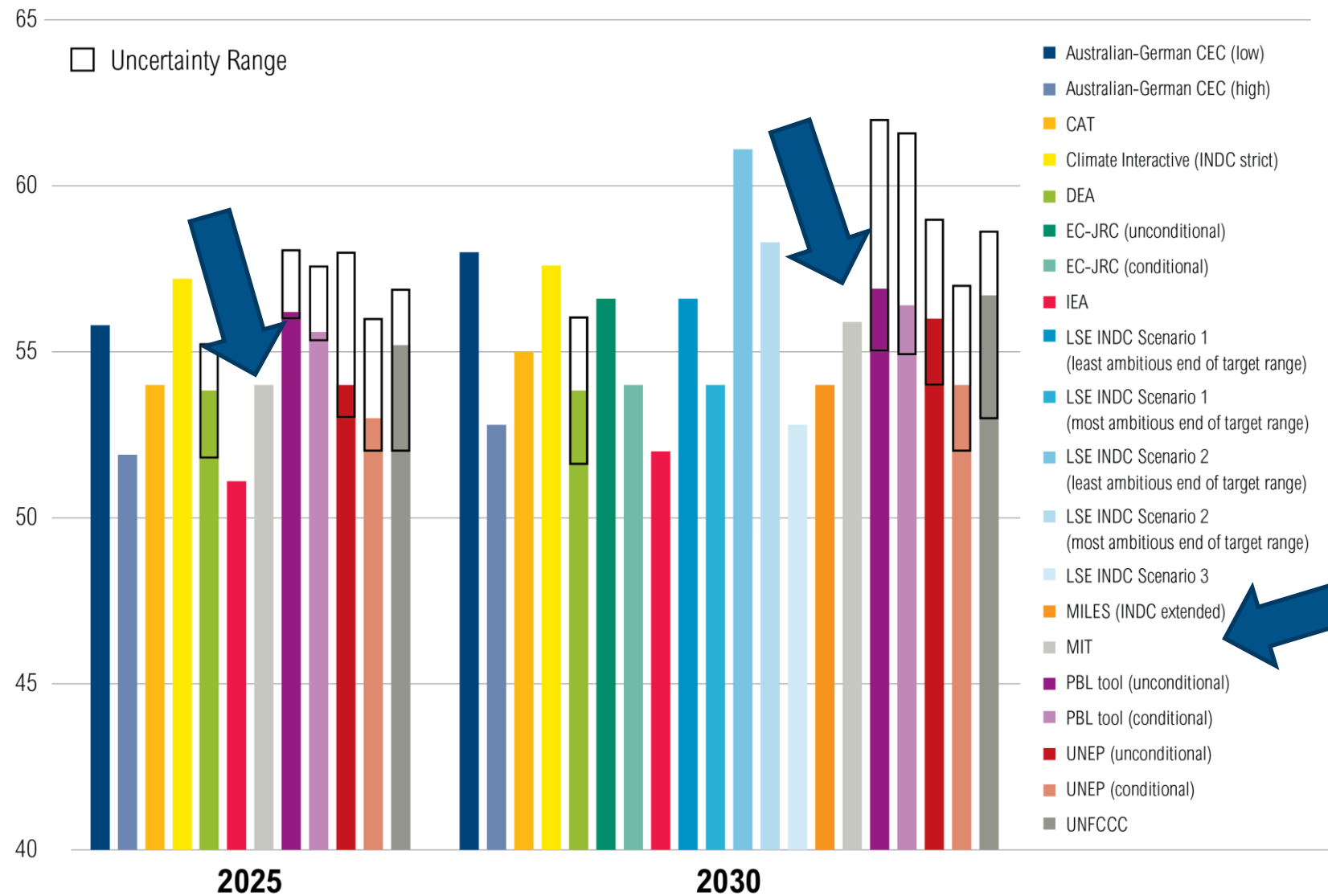
Source: Krey (2014) WIREs Energy and Environment



GHG Emissions from Proposals for COP-21

Consistent with 2C goal?

Emissions levels in 2025 and 2030 with INDCs



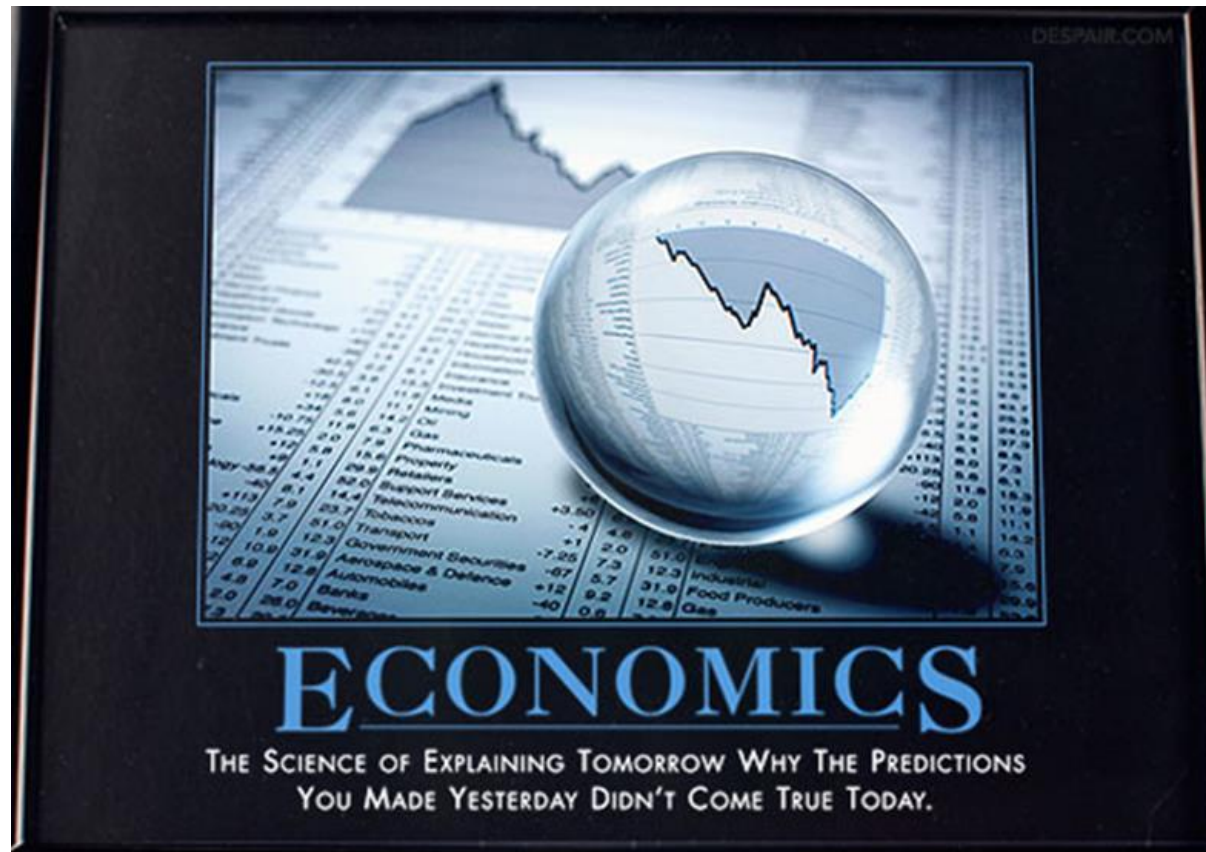
<http://bit.ly/indc-temp>

 WORLD RESOURCES INSTITUTE



<http://globalchange.mit.edu/>

“Watch Out for Our Invisible Hands”



“Economists make predictions not because they know, but because they are asked” (J.K Galbraith)

“Q: How has French revolution affected world economic growth?
A: Too early to say.”
(attributed to IIASA workshop presentation)

Limits and Values of Energy Scenarios

Indeed we know very little to provide the exact number (or specific forecast). The scenarios are unlikely to be successful at producing precisely definitive estimates.

But practically

Decisions have to be made.

Scenarios are *decision-support* tools.

Scenarios are *not decision-making* tools.

When one has a model to make a scenario – an argument can be made about improvement, simplification, or bringing additional details.

When one has just tea leaves – there is no tool to advance the knowledge – you are stuck with drinking (tea).

Warnings: “averaging”, “herd mentality”, “outliers”.

No alternative: *Even a limited knowledge is better than no knowledge.*

Values of Energy Scenarios

Use of scenarios:

Explore vulnerabilities, assess risks, seek robust strategies.

Energy scenarios:

Assess the scale of the necessary investments and transformation.

Lesson:

Aggressive climate stabilization targets require drastic changes in energy mix.

Future costs and the resulting technology mixes are uncertain.

Policy: Target emissions reductions from any source, rather than focus on boosting certain kinds of renewable energy.

Use scenarios as decision-support tools.



Values of Model-Based Energy Scenarios

Help to understand complex systems.

Focus on important drivers.

"There are three kinds of lies: lies, damned lies, and statistics."
(Mark Twain, he attributed the phrase to Disraeli)

Main strength: models do not allow to lie very easily.

Test your initial intuition:

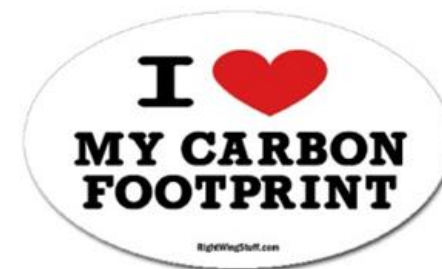
A model-based scenario will not provide all the answers to researchers and policy-makers (who do not rely on just one model, hopefully), but it is a good basis to start a dialog and quantify the trade-offs.

Scenario modelers: need to provide appropriate warnings to the users of scenarios (e.g., confidence intervals).

Thank you

Questions or comments?

Please contact Sergey Paltsev at paltsev@mit.edu.



<http://globalchange.mit.edu/>