International Institute for Applied Systems Analysis
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science for global insight

# Quantifying uncertainties influencing the long-term impacts of oil prices on energy markets and carbon emissions

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***David McCollum***, *Volker Krey, Jessica Jewell, Keywan Riahi (IIASA)*

*Morgan Bazilian, Marianne Fay (World Bank)*

# Acknowledgements

D. McCollum, J. Jewell, V. Krey, K. Riahi

M. Bazilian, M. Fay

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# The roller coaster of oil prices


**The last 5 years**

# The roller coaster of oil prices


?

**The last 16 years**

# Oil prices and climate change: what folks are saying…


http://www.theguardian.com/commentisfree/2015/dec/11/cheap-oil-climate-change-fossil-fuel-extraction-tar-sands

December 11, 2015
Brent crude @ 37 US$/bbl

January11, 2016
Brent crude @ 29 US$/bbl


https://www.newscientist.com/article/dn28750-oil-price-plunge-will-be-bad-news-for-climate-efforts/

# Research questions

1. What are the *broader* energy *systems* and *net* emissions impacts of diverging oil price futures over the next several decades to 2050?

2. Which future (energy-related) unknowns do these impacts depend on, and to what extent?

# What we do *not* do in this study

- We do *not* try to forecast future oil prices or make any guess at the likelihood of how high or low prices might be going forward.

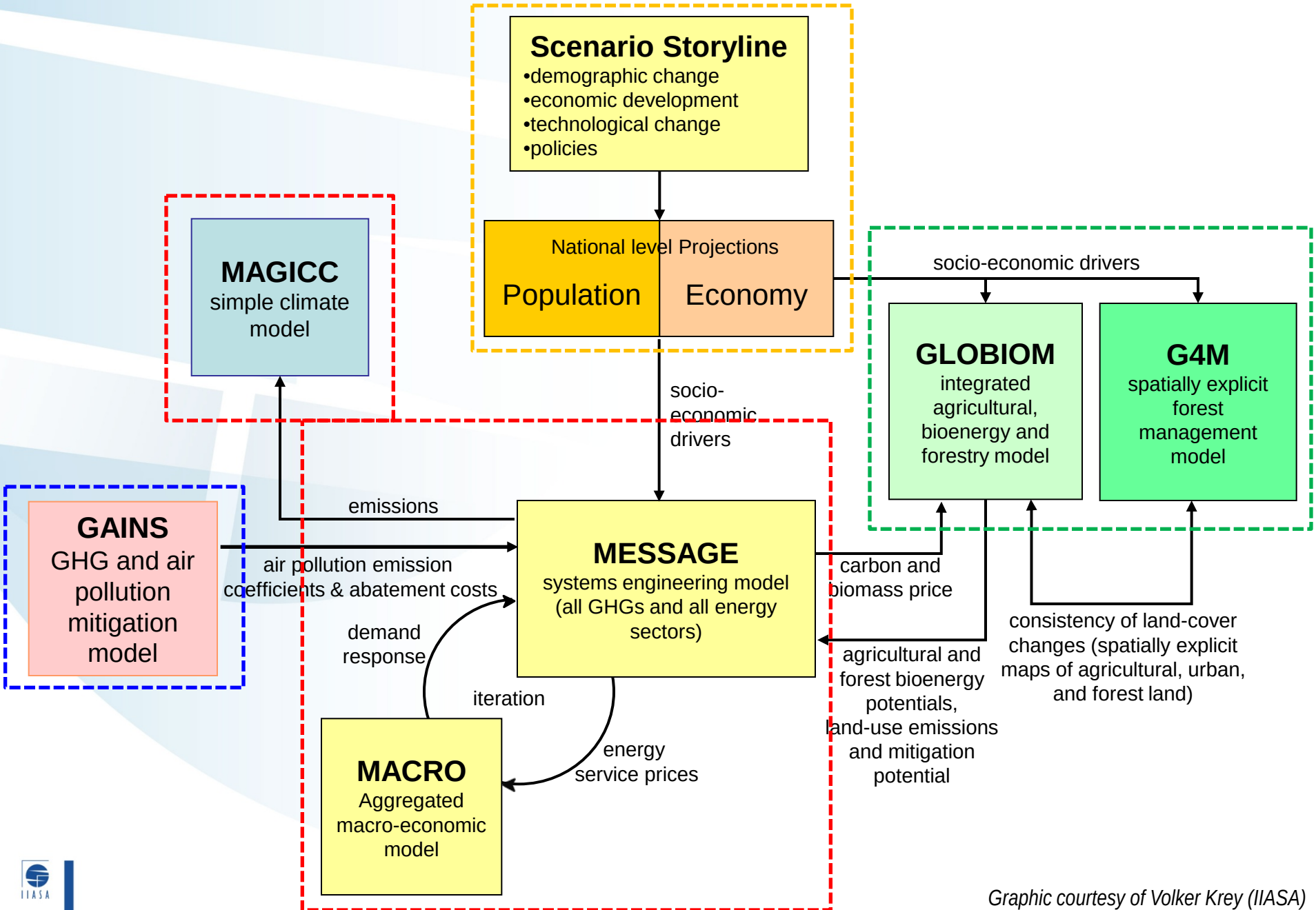
- We do *not* try to model short-term oil price volatility and market dynamics and particularities (e.g., using game-theoretic or agent-based modeling to represent the strategic behavior of individual producers or national oil companies).

# Main insights from study

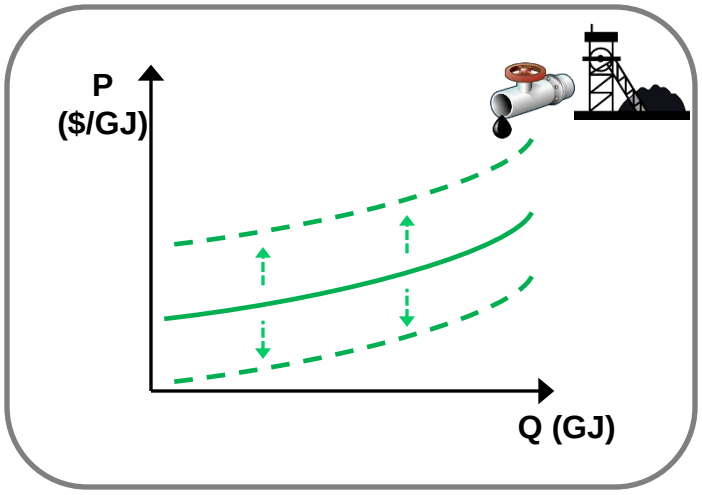
- Sustained low or high oil prices could have a major impact on the global *energy mix* between now and 2050.

- The potential impacts of sustained low or high oil prices on *$CO_2$ emissions* could be significant, depending on how the fuel substitution dynamics play out.

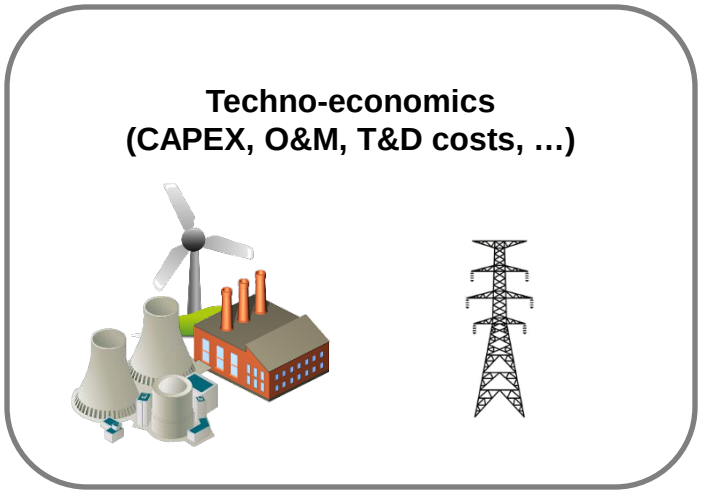
# IIASA Integrated Assessment Framework




*Graphic courtesy of Volker Krey (IIASA)*

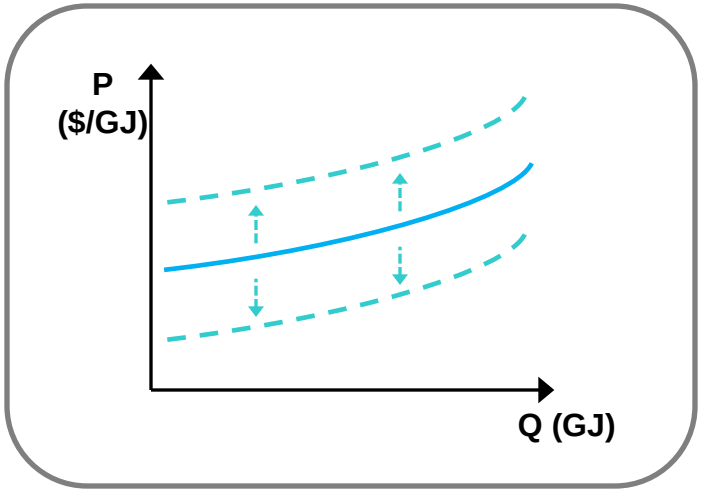



*Primary Energy (Resource) Level*




*Primary - Secondary - Final Levels*

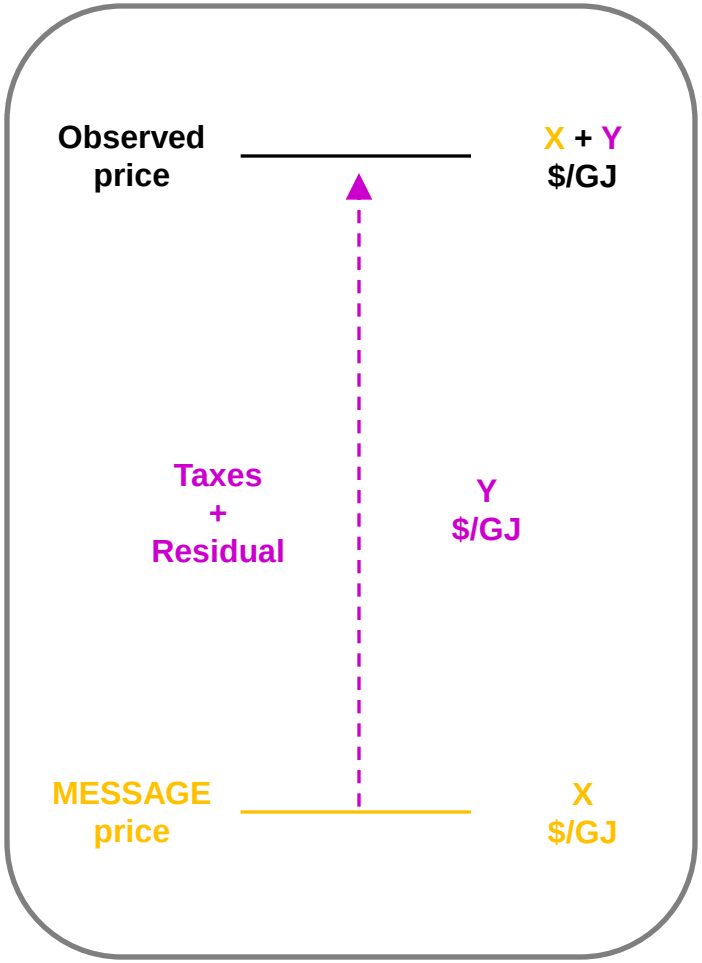
Prices by …
- Fuel (f)
- Sector (s)
- Region (r)
- Year (t)



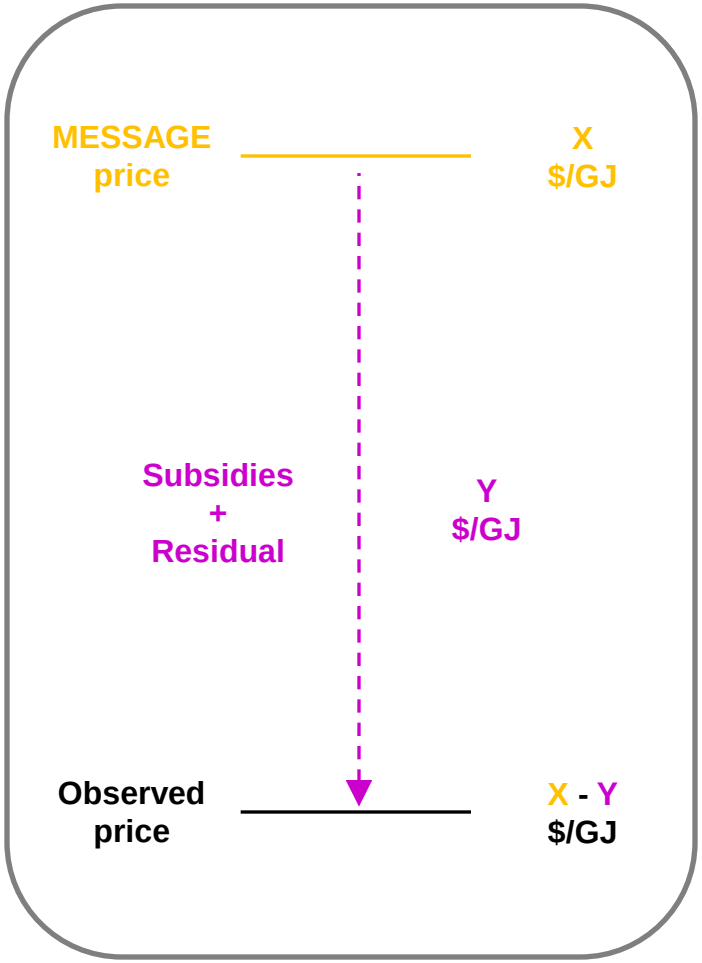

*Final Energy (End-Use) Level*

# Illustrative examples

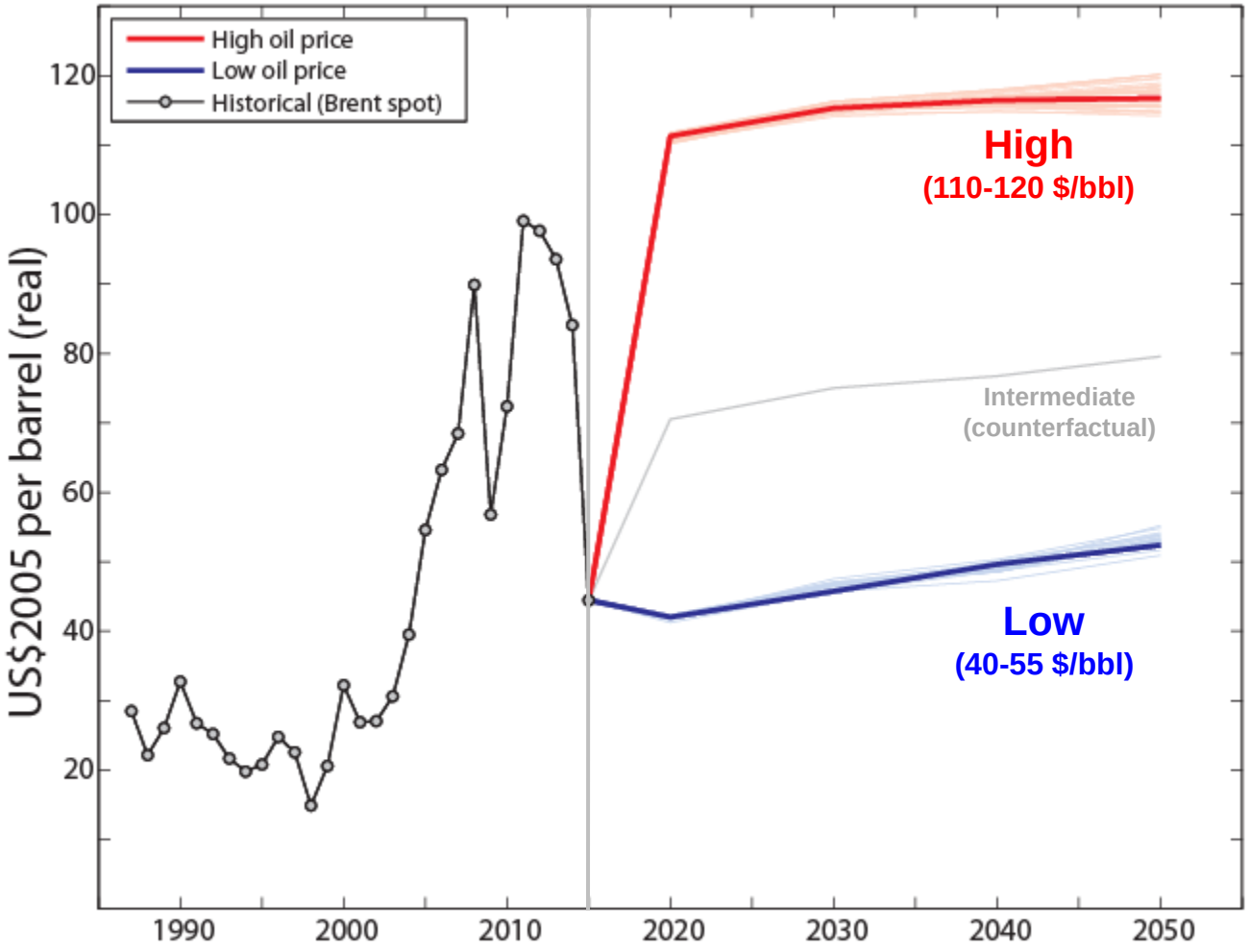
*Oil products - Transport*
*Western Europe*




*Natural gas – Res. & Comm.*
*Middle East*



# Alternative oil price cases




McCollum et al. (2016) *Nature Energy*.

# Sensitivity cases run

1. Potential supplies of sustainable bio-energy
2. Biofuels production costs and availability/scalability
3. Fossil synfuels production costs and availability/scalability
4. Biofuels and fossil synfuels production costs and availability/scalability
5. Coupling between crude oil and natural gas prices

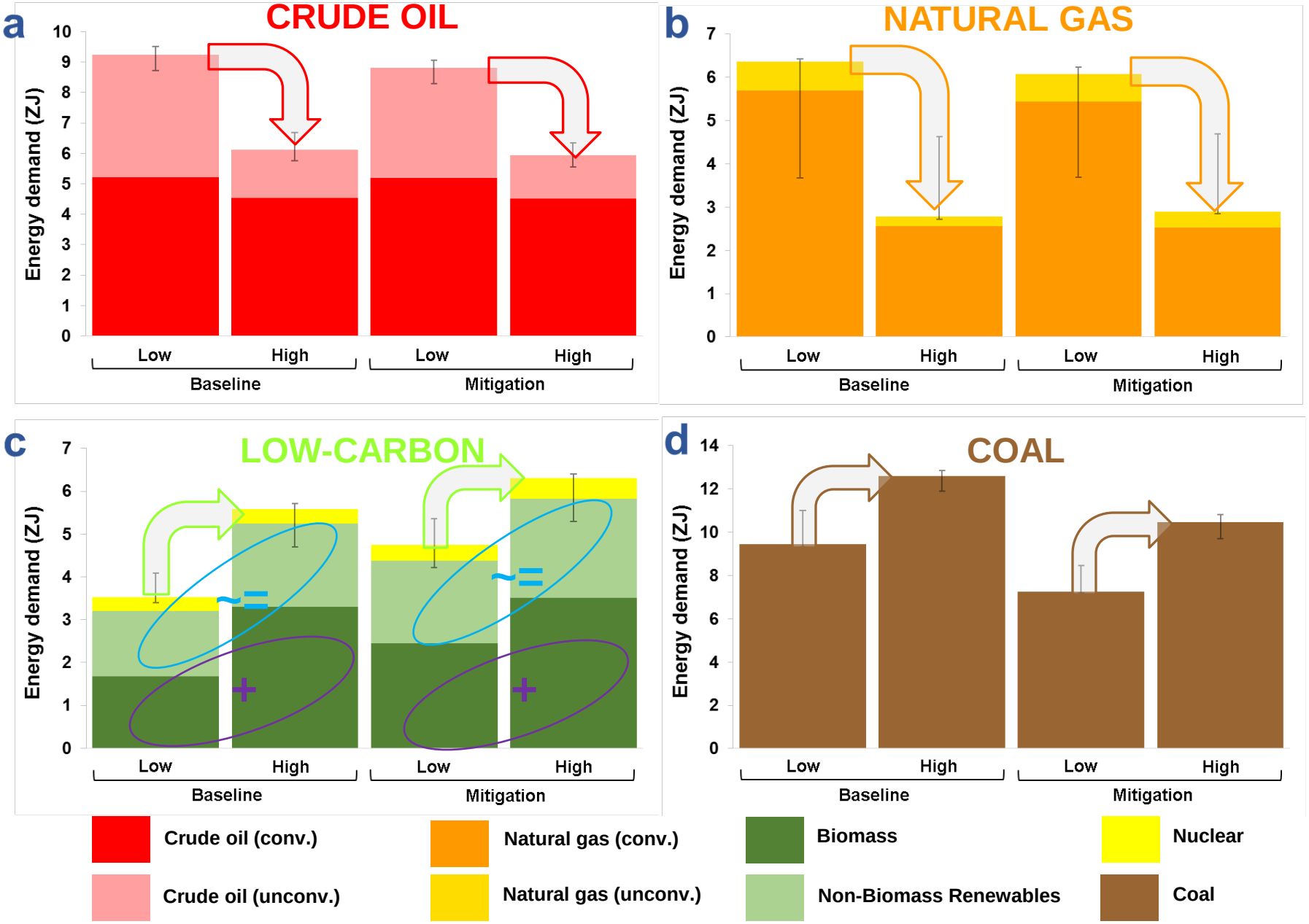
*Upstream (Supply)*

6. Electric vehicle costs and availability/scalability
7. Natural gas vehicle costs and availability/scalability
8. Hydrogen vehicle costs and availability/scalability

*Downstream (Demand)*

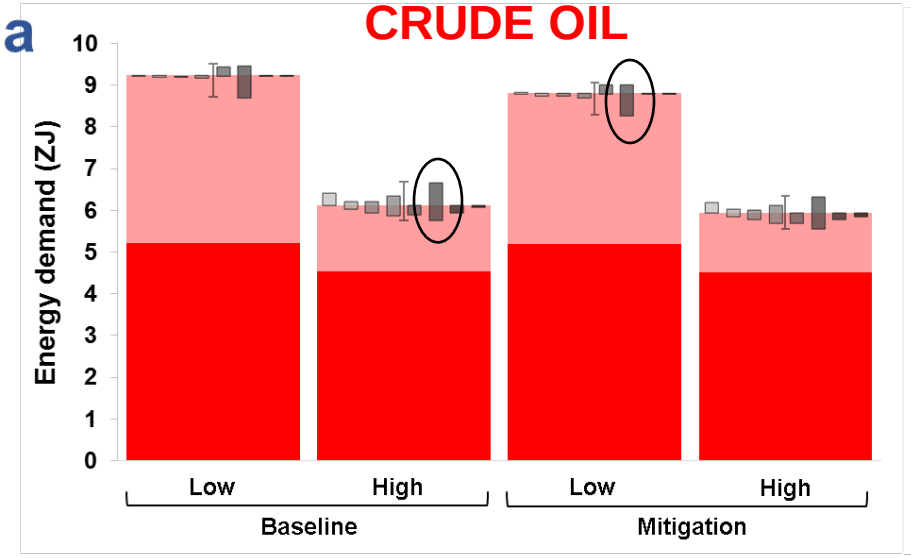
9. Climate policy

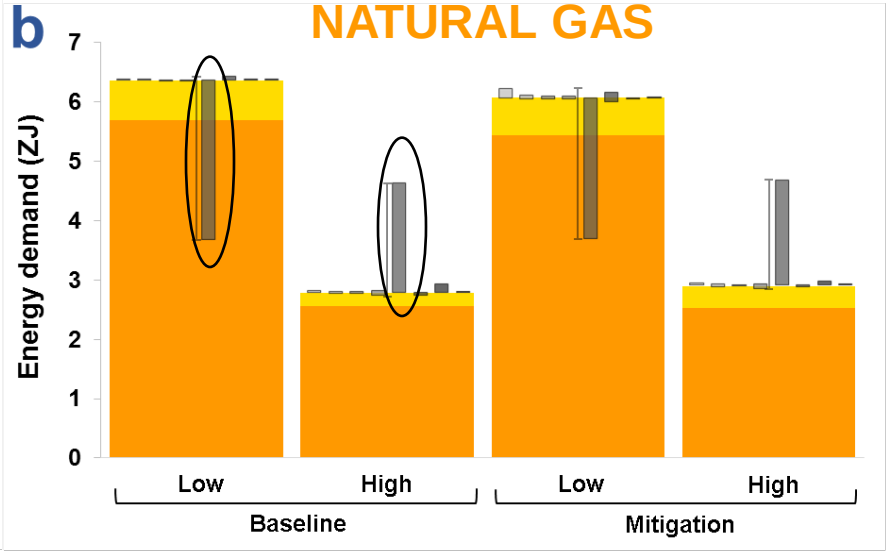
# Energy demand by type (cum., 2010-50), low vs. high oil prices

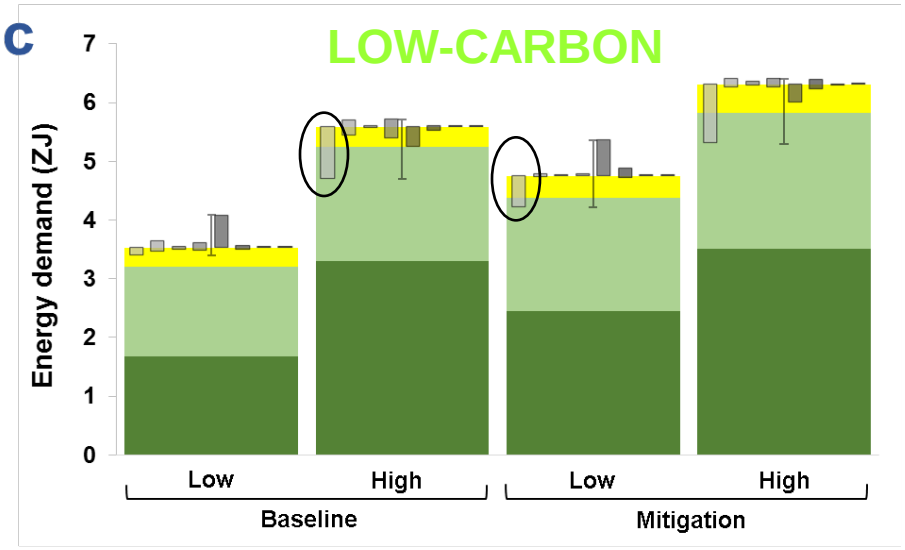


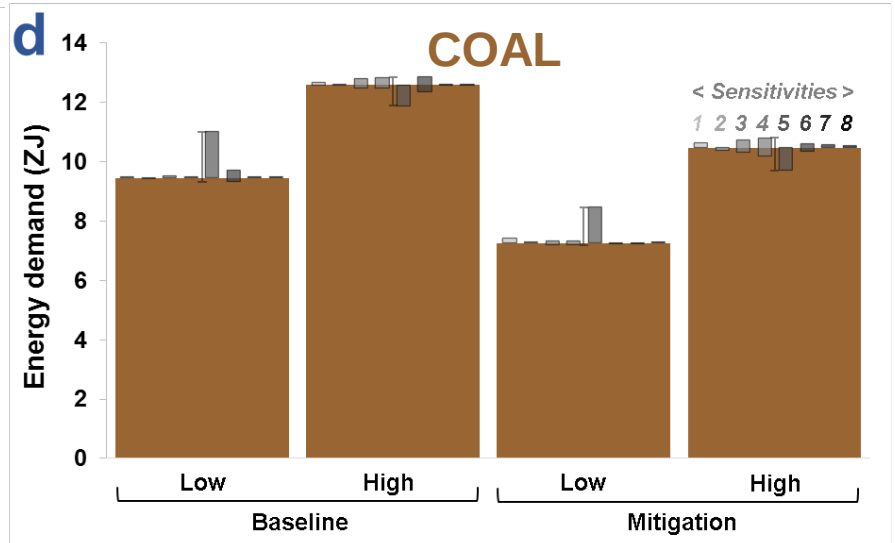

McCollum et al. (2016) *Nature Energy*.

# Energy demand by type (cum., 2010-50), low vs. high oil prices



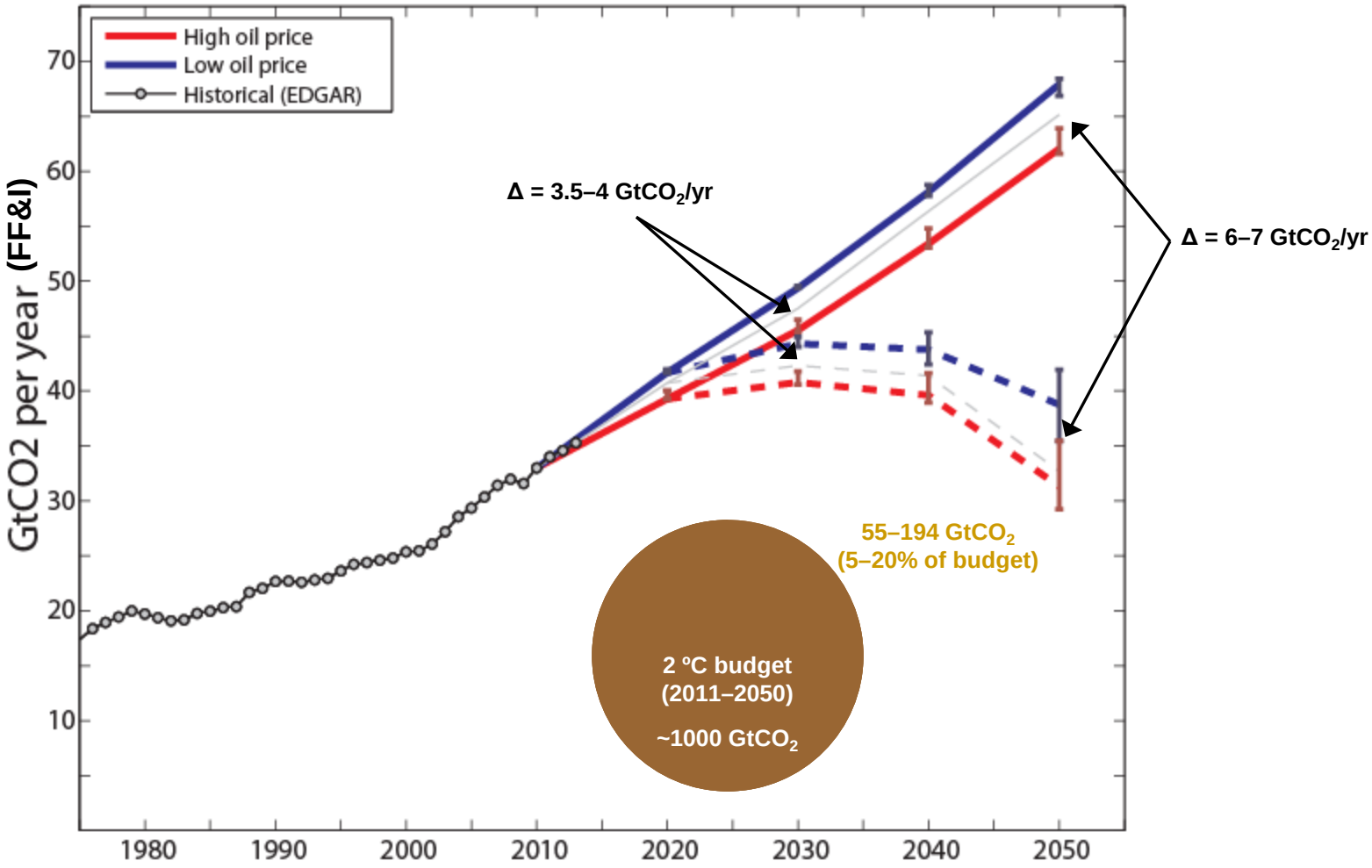




Legend for sensitivities

| | | | |
|---|---|---|---|
| (1) Bio-energy supply | (2) Biofuels prod. cost | (3) Fossil synfuels prod. cost | (4) Bio. & foss. synf. prod. cost |
| (5) Oil & gas price-coupling | (6) Electric vehicle cost/avail. | (7) Nat. gas vehicle cost/avail. | (8) $H_2$ vehicle cost/avail. |

McCollum et al. (2016) *Nature Energy*.

# $CO_2$ emissions (FF&I), low vs. high oil prices




McCollum et al. (2016) *Nature Energy*.

# $CO_2$ emissions impacts: behind the scenes

- Coal (carbon-intensive) and biomass (not carbon-intensive) move in parallel when oil prices are high/low; thus, benefits/consequences partially cancel out (↑↓).

- Energy efficiency and conservation efforts suffer when oil prices are low; thus, $CO_2$ emissions go up (↑).

# Conclusions and future work

- Sustained low or high oil prices could have a major impact on the global *energy mix* between now and 2050.
  - Oil-gas price coupling assumption is most important.

- The potential impacts of sustained low or high oil prices on $CO_2$ *emissions* could be significant, depending on how the fuel substitution dynamics play out.

- Single model used here => Model comparison could be fruitful (would get at structural differences across models).

- Sustained high and low oil price paths (stylized) analyzed here => Volatility in prices could lead to energy/carbon lock-in.

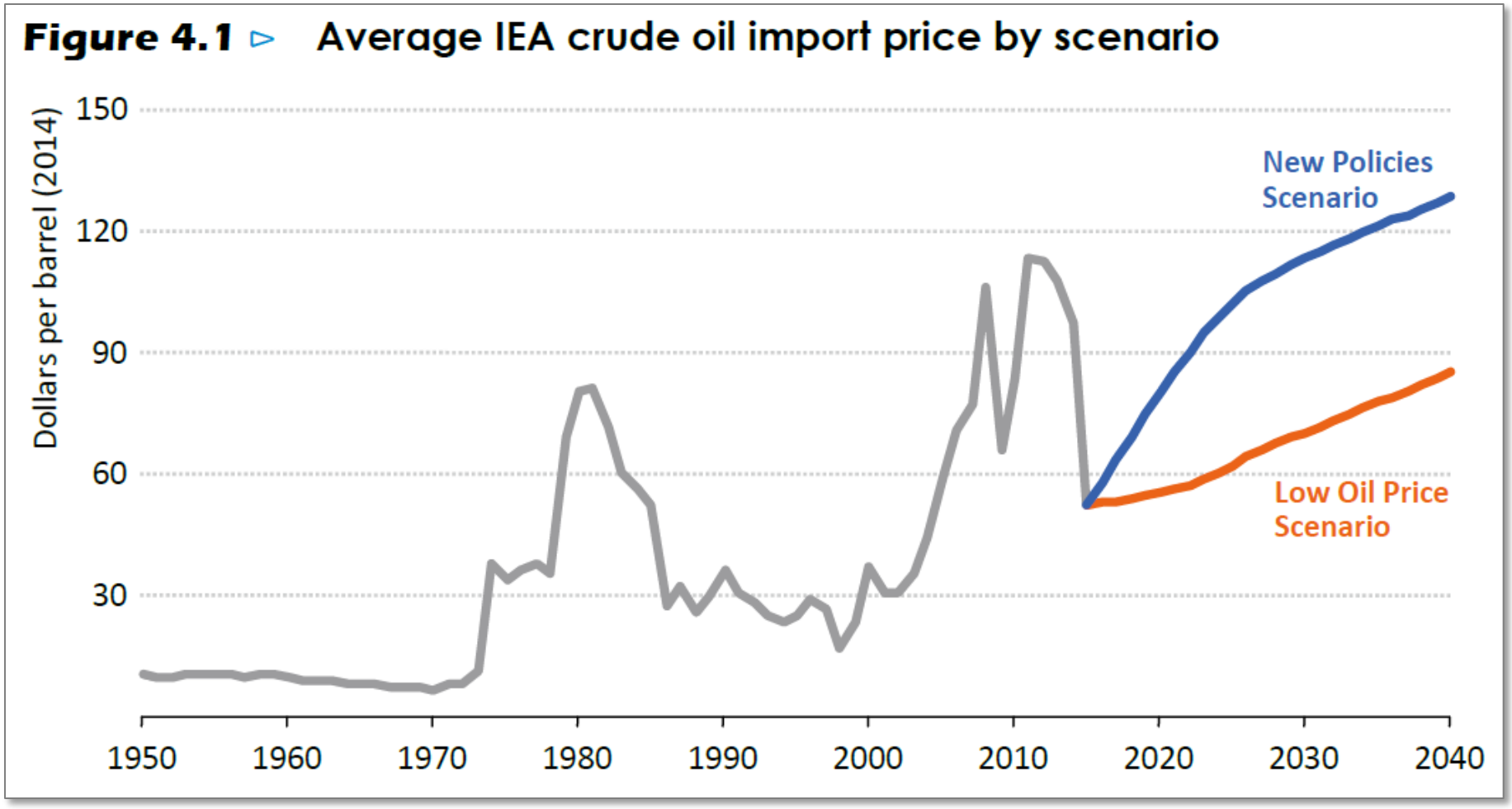
- Subsidies retained here => Subsidy-reform policies could have major energy/carbon impacts in certain countries.

# Questions? Comments?

Contact: David McCollum (mccollum@iiasa.ac.at)

# Back-up slides

# The energy and emissions impacts we calculate are 1-2 orders of magnitude greater than what the IEA reports in its *World Energy Outlook 2015*.

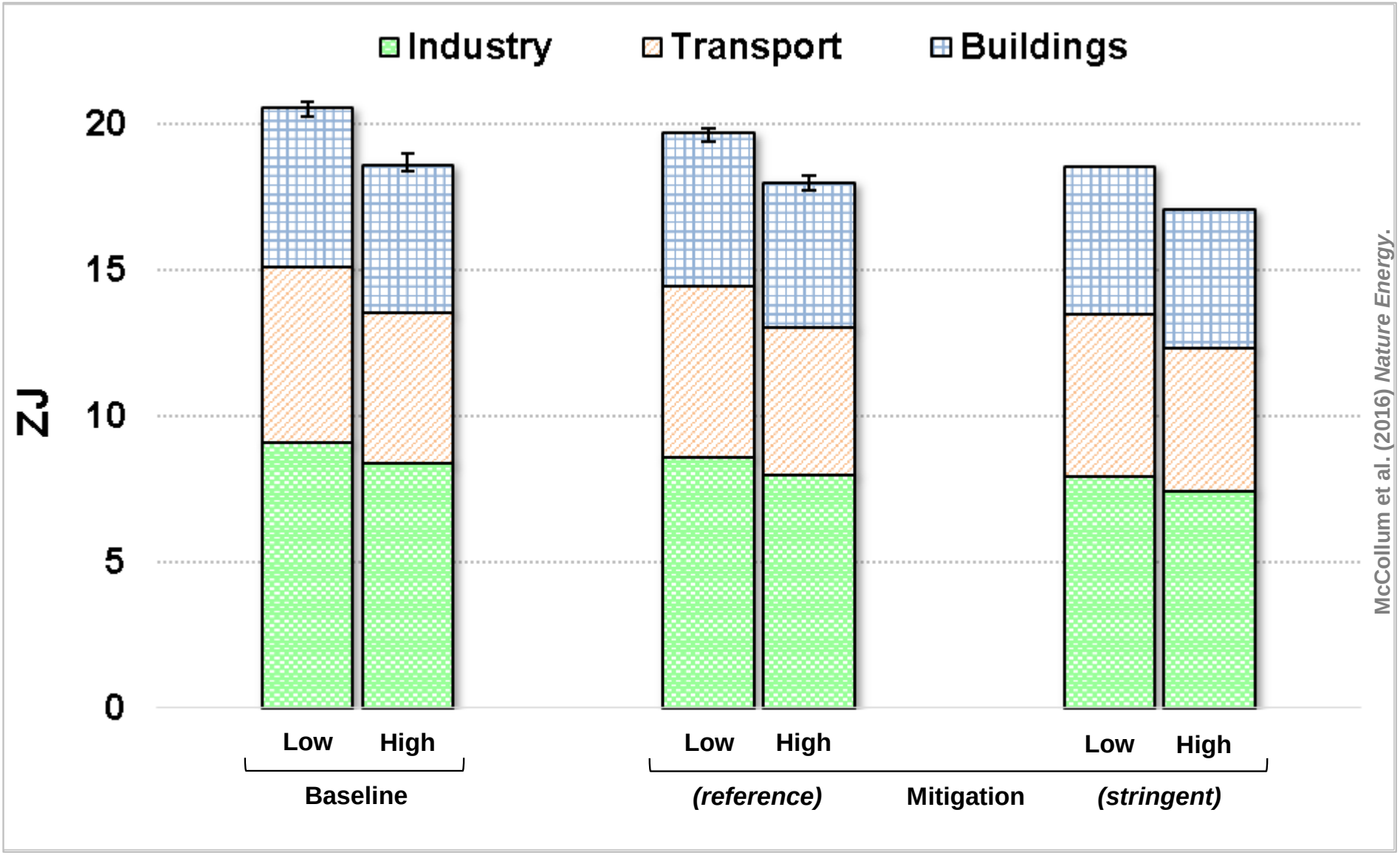



Source: International Energy Agency, *World Energy Outlook 2015*

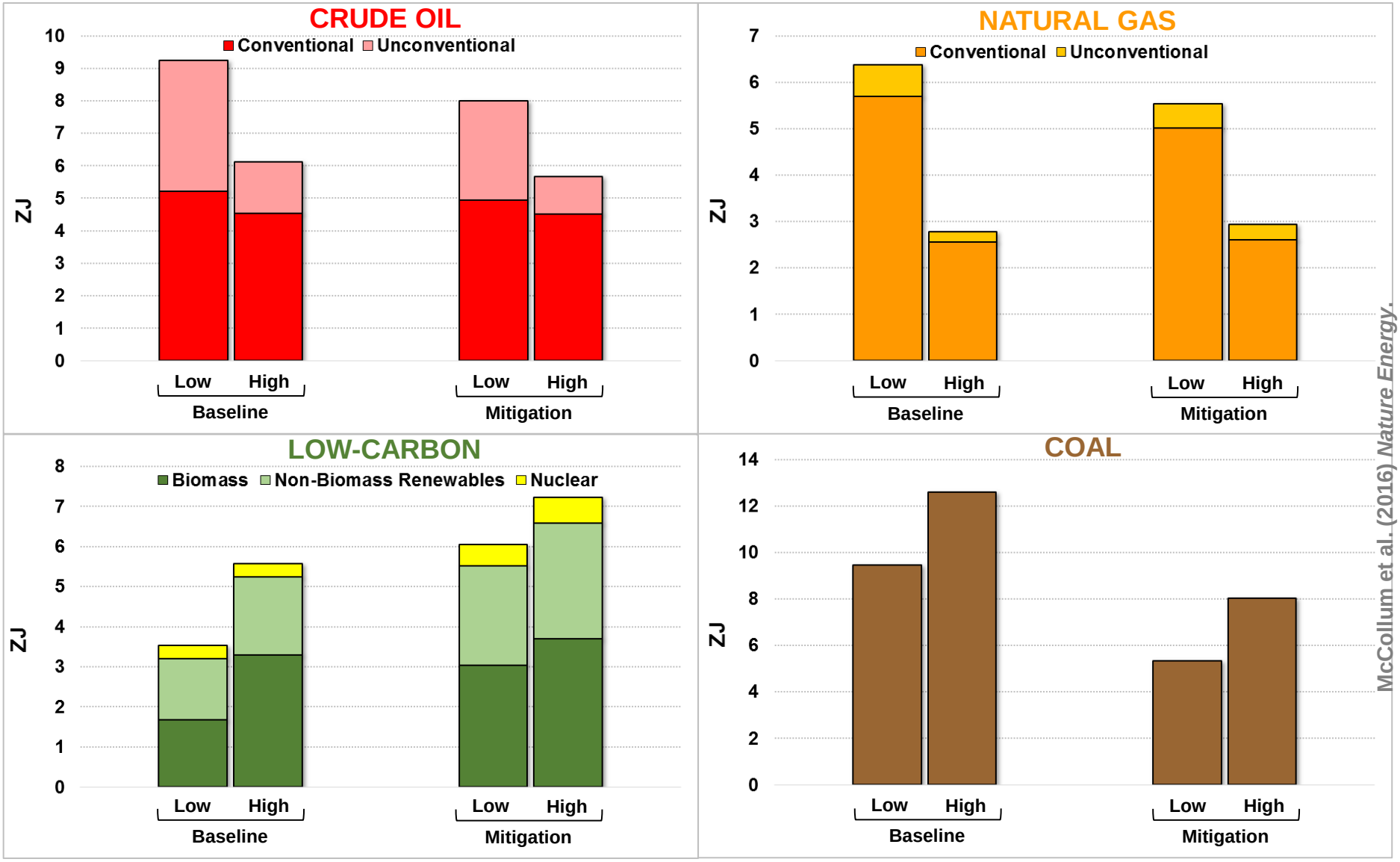
# Energy demand by type (cum., 2010-50), low vs. high oil prices


McCollum et al. (2016) *Nature Energy*.

# Final energy demand by end-use sector (cum., 2010-50), low vs. high oil prices



# Results for a more stringent climate policy scenario (<2.3 C)



# Results for a more stringent climate policy scenario (<2.3 C)


McCollum et al. (2016) *Nature Energy*.

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