# When the Background Matters

## Using Scenarios from Integrated Assessment Models in Prospective Life Cycle Assessment

*Angelica Mendoza Beltran, Brian Cox, Chris Mutel, Detlef P. van Vuuren, David Font Vivanco, Sebastiaan Deetman, Oreane Y. Edelenbosch, Jeroen Guinée, and Arnold Tukker.*

*By Elisa Pastor Vallés*

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# Prospective LCA

Environmental decision support on:

- Systems that do not yet exist.
- Not commercially available.
- Decisions about the future.

E.g. future public policies, emerging technologies, future production and consumption systems.

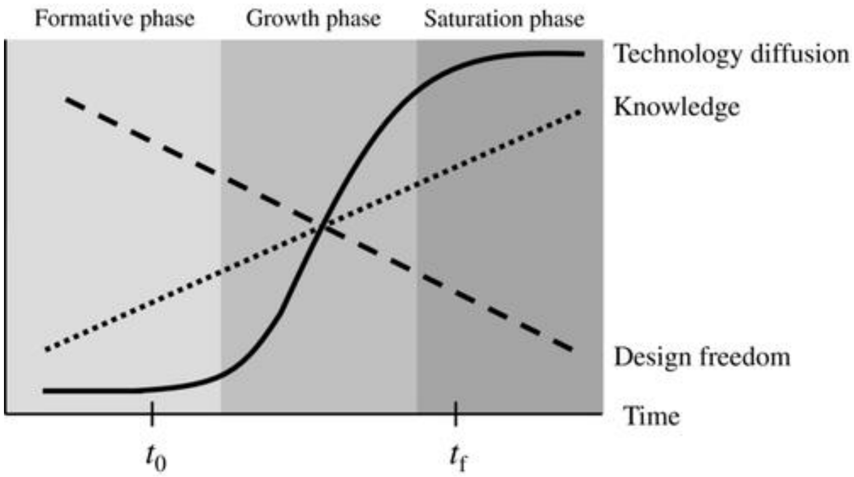
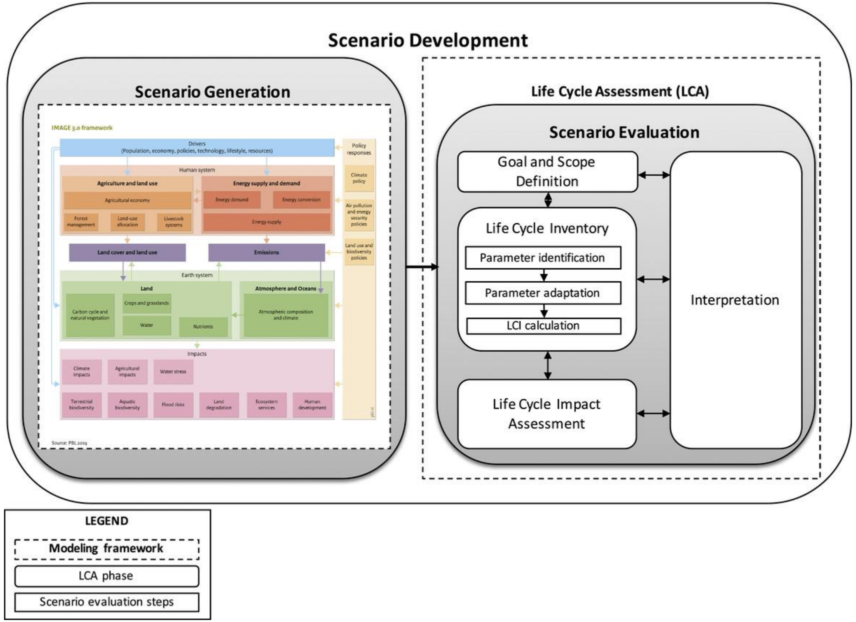



Image source: Arvidsson, R. et al. (2018), Environmental Assessment of Emerging Technologies: Recommendations for Prospective LCA.

# Dealing with uncertainty




"How can Integrated Assessment Models scenarios be systematically linked with LCI parameters to account for future changes in prospective LCAs?"

→ Coupling of LCI energy scenarios and IAM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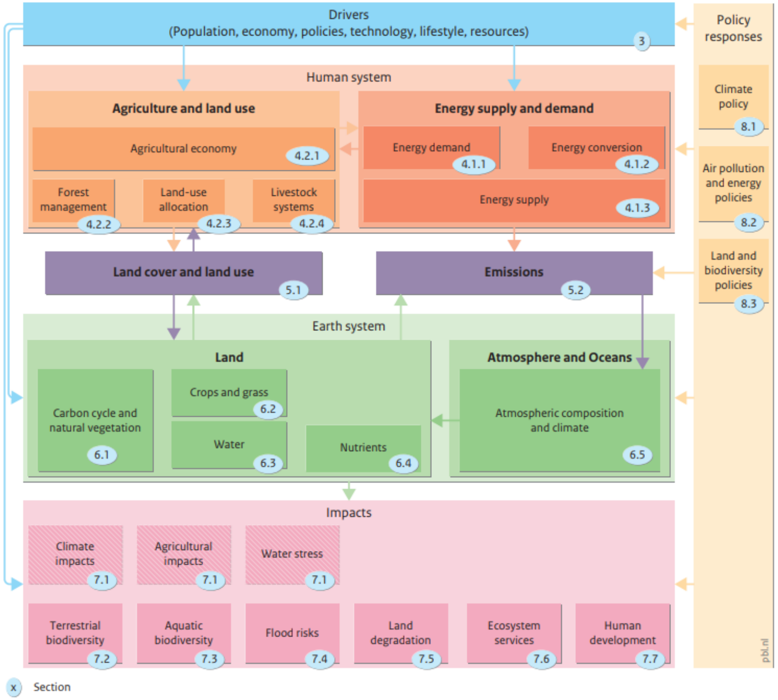
# Scenario generation




Using IAM IMAGE 3.0 to generate scenarios.

- Includes economic and physical models of the global agricultural and energy systems.

Energy model of IMAGE (TIMER).

- Market shares of energy and future energy intensity.
- Cost of the different technologies.
- It also models emission mitigation through a carbon tax that induces investments in more efficient and non-fossil technologies.

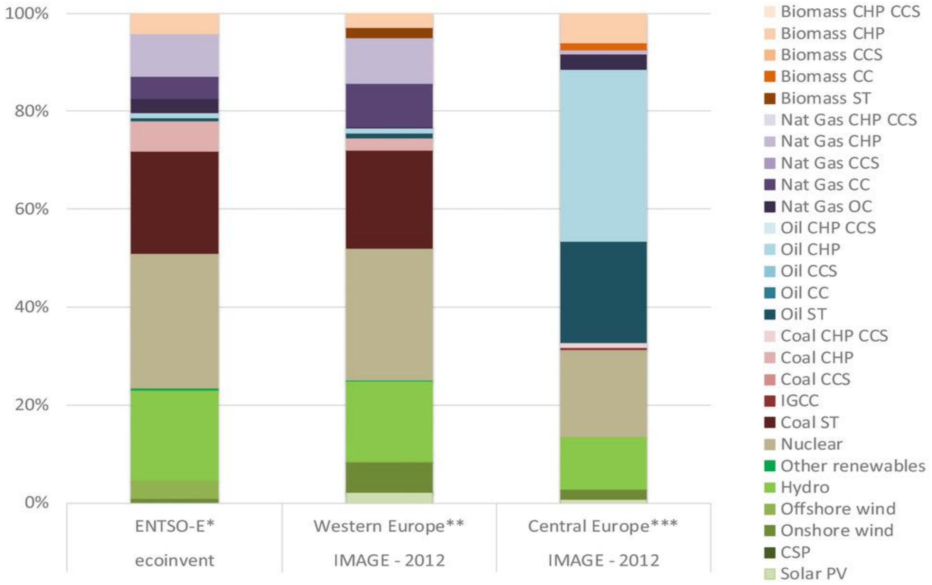
Image source: PBL (2014). Integrated Assessment of Global Environmental Change with IMAGE 3.0. Model description and policy applications.

# Scenario evaluation

Wurst is a python-based software that allows the systematic import, filtering and modification of LCI databases.

- <u>Import</u>: monofunctional processes (cut-off) were adapted using the IMAGE scenario data to generate modified (future) monofunctional processes.
- <u>Identification</u>: parameters to be modified are identified. Both technology related parameters and market parameters, considering regional differences.
- <u>Changes</u>: the final output consists of future ecoinvent databases that are year and scenario dependent.

→ Life Cycle Inventory Calculation




According to ISO 3166-1 2 letter country code:
*ENTSO-E countries are: AT, BE, CH, DE, FI, FR, GB, GR, IE, IS, IT, LU, LV, NL, NO, RS, SE, BA, BG, CZ, EE, HR, HU, LT, MK, PL, RO, SI, SK
**Western Europe countries are: AD, AT, BE, CH, DE, DK, ES, FI, FR, FO, GB, GI, GR, IE, IS, IT, LI, LU, MC, MT, NL, NO, PT, SE, SM, VA
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# Case study - LCA

Comparison of electric vehicles (EVs) and internal combustion engines (ICEVs)

- Calculation of the LCI and characterized LCA results using the modeled future ecoinvent databases with Brightway2.
- For simplification, the foreground description corresponds to processes as defined in ecoinvent, that remain unchanged in the future, which is a modelling choice rather than a limitation of the approach.
- The functional unit is 1 kilometer driven by each vehicle in Europe.
- Use of ReCiPe 2008 with a hierarchist perspective.
- The IMAGE scenarios used are the Shared Socioeconomic Pathways SSP1, SSP2 and SSP3 as a starting point for exploring climate policy scenarios, which correspond to the radiative forcing levels of the Representative Concentration Pathways (RCPs).

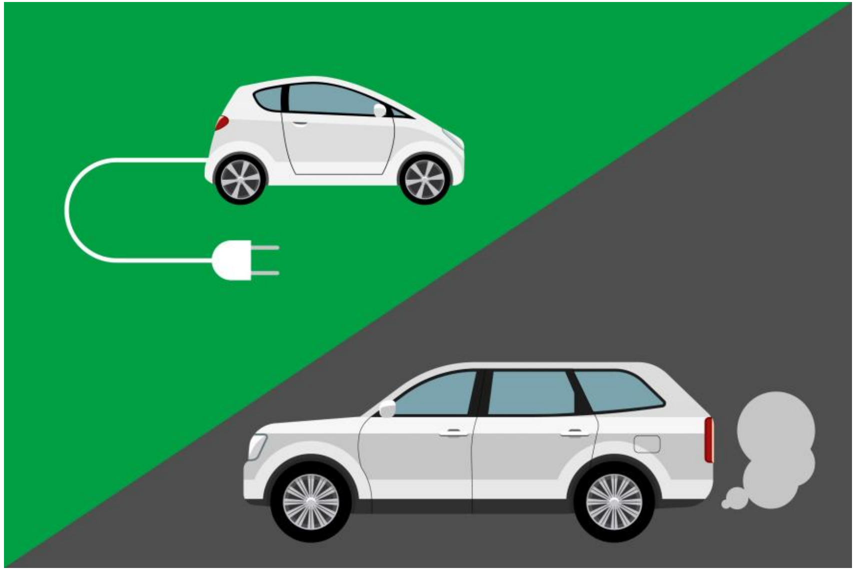
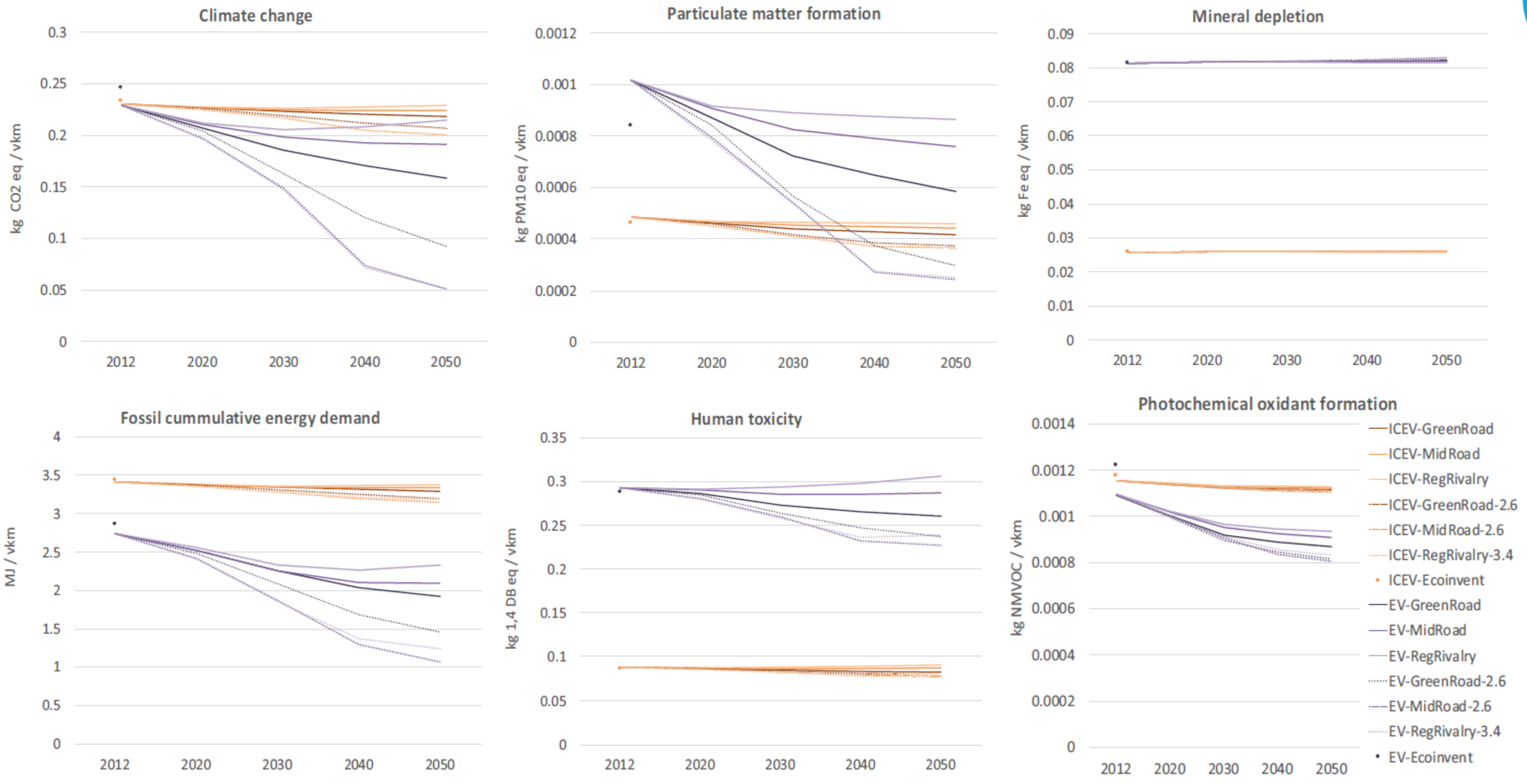


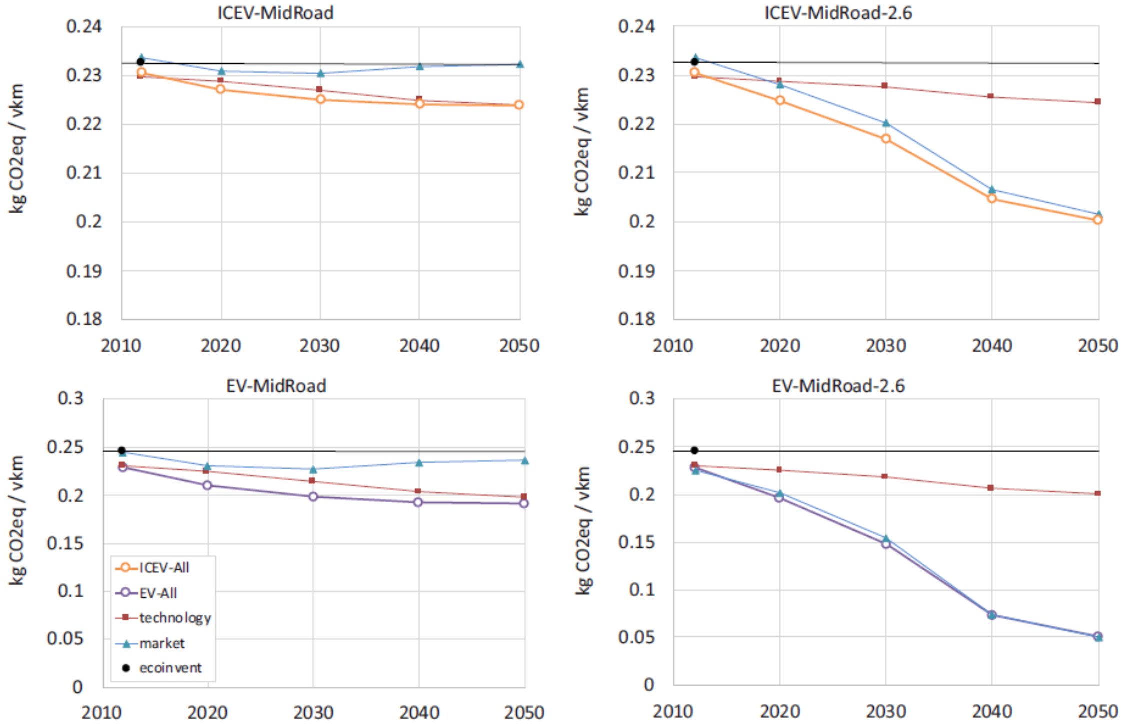
Image source: https://carro.sg/blog/internal-combustion-engine-vehicle-vs-electric/

# Results



Climate change
kg CO2 eq / vkm
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2020
2030
2040
2050
Particulate matter formation
kg PM10 eq / vkm
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Mineral depletion
kg Fe eq / vkm
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Fossil cummulative energy demand
MJ / vkm
4
3.5
3
2.5
2
1.5
1
0.5
0
Human toxicity
kg 1,4 DB eq / vkm
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Photochemical oxidant formation
kg NMVOC / vkm
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
ICEV-GreenRoad
ICEV-MidRoad
ICEV-RegRivalry
ICEV-GreenRoad-2.6
ICEV-MidRoad-2.6
ICEV-RegRivalry-3.4
ICEV-Ecoinvent
EV-GreenRoad
EV-MidRoad
EV-RegRivalry
EV-GreenRoad-2.6
EV-MidRoad-2.6
EV-RegRivalry-3.4
EV-Ecoinvent

# Results by market/technology





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# Combined results

| | year | Background adaptation | Fossil Cumulative Energy Demand | Climate Change | Human Toxicity | Mineral Depletion | Particulate Matter Formation | Photochemical Oxidant Formation | | Fossil Cumulative Energy Demand | Climate Change | Human Toxicity | Mineral Depletion | Particulate Matter Formation | Photochemical Oxidant Formation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ICEV-MidRoad | 2012 | technology | 0,8% | 1,3% | 1,5% | 0,0% | 3,9% | 2,1% | EV-MidRoad | 5,1% | 6,2% | 2,4% | 0,1% | 11,3% | 10,5% |
| | 2012 | market | -0,1% | -0,4% | -2,9% | 0,0% | -9,0% | -0,2% | | 2,5% | 0,6% | -4,9% | 0,1% | -32,5% | 0,3% |
| | 2012 | All | 0,7% | 0,9% | -1,0% | 0,0% | -4,8% | 2,0% | | 7,1% | 6,9% | -1,8% | 0,1% | -20,7% | 10,7% |
| | 2020 | technology | 1,1% | 1,7% | 1,9% | 0,1% | 5,9% | 2,8% | | 7,3% | 8,6% | 3,2% | 0,1% | 17,5% | 14,5% |
| | 2020 | market | 0,5% | 0,7% | -2,5% | -0,2% | -7,3% | 0,6% | | 6,1% | 6,1% | -4,7% | -0,3% | -26,7% | 4,4% |
| | 2020 | All | 1,6% | 2,4% | -0,2% | -0,2% | -0,9% | 3,1% | | 12,9% | 14,3% | -0,7% | -0,2% | -7,6% | 16,9% |
| | 2030 | technology | 1,7% | 2,4% | 2,6% | 0,1% | 8,4% | 3,7% | | 11,2% | 12,7% | 4,4% | 0,1% | 25,5% | 19,5% |
| | 2030 | market | 0,9% | 0,9% | -2,6% | -0,3% | -7,5% | 0,7% | | 9,2% | 7,4% | -4,8% | -0,5% | -27,8% | 5,1% |
| | 2030 | All | 2,5% | 3,3% | 0,6% | -0,2% | 2,2% | 4,1% | | 19,5% | 19,4% | 0,7% | -0,4% | 2,1% | 22,3% |
| | 2040 | technology | 2,3% | 3,3% | 3,5% | 0,1% | 10,0% | 4,2% | | 15,8% | 17,4% | 6,0% | 0,2% | 30,6% | 22,1% |
| | 2040 | market | 0,7% | 0,4% | -3,8% | -0,3% | -9,1% | 0,5% | | 7,8% | 4,7% | -7,0% | -0,5% | -33,7% | 3,9% |
| | 2040 | All | 2,9% | 3,7% | 0,7% | -0,2% | 3,4% | 4,5% | | 22,7% | 21,8% | 1,0% | -0,4% | 6,2% | 24,5% |
| | 2050 | technology | 2,6% | 3,7% | 4,0% | 0,1% | 10,7% | 4,5% | | 17,9% | 19,6% | 6,7% | 0,2% | 33,0% | 23,8% |
| | 2050 | market | 0,4% | 0,1% | -4,8% | -0,4% | -8,9% | 0,6% | | 6,5% | 3,7% | -8,4% | -0,6% | -33,3% | 4,0% |
| | 2050 | All | 2,9% | 3,7% | 0,1% | -0,3% | 4,5% | 4,8% | | 22,8% | 22,3% | 0,2% | -0,4% | 9,8% | 25,8% |

# Discusion

- The integration of IMAGE scenarios into ecoinvent served to account for a limited yet relevant set of future background changes.
- Uncertainty was acknowledged by means of consistent scenarios representing possible futures.
- Limitations on the impacts of the use phase, best available data representation and focus on the electricity sector.
- This method may accommodate information flows from LCA to IAM, refining the data quality and leading to even more robust assessments.