# The multi-level economic impacts of deep decarbonization strategies for the energy system

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Chaire Modélisation Prospective
au service du Développement Durable

1. Research objective
2. Modeling approach
   - Energy pathways with LEAP model
   - The IMACLIM economy-wide model
   - Linking the LEAP and IMACLIM models
3. Scenarios
   - Three energy pathways based on common socio-economic drivers
4. Multi-level economic impacts
   - Low-carbon power generation insights
   - Macroeconomic insights
   - Sectoral insights
5. Conclusion

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## Designing deep decarbonization strategies

- Tailored to the national context
- Build on feasible technical solutions and feasible pathway that detail the sequence of transformation

⇒ Focusing on reducing energy-related emissions mainly but other on other emissions

## With quantitative outcomes

- Characterizing deep transformation of both energy and supply
- Assessing economy-wide implications, not only in energy industries, but also in other sectors
- Identifying the 'losers' and the 'winners' to anticipate compensations

⇒ Developing an integrated approach based on loading full energy system pathway into a multi-sector economy-wide model

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# An integrated energy planning and climate change mitigation assessment modeling tool

- Represents detailed energy system at country-scale to formulate energy plans consistent with the national context
- Develops full backcasting scenarios that ensure consistency between strategic proposals and energy choices
- Used to quantify full decarbonized energy pathways with feasible technical options for Argentina[1,2]

## Key information and pace for a given strategy

- Consolidated energy balances
- Capital expenditures, O&M costs for power generation
- Investment expenditures

[1] Nicolás Di Sbroiavacca et al. "Emissions reduction scenarios in the Argentinean Energy Sector". In: *Energy Economics* 56 (2014), pp. 552–563. ISSN: 01409883. DOI: 10.1016/j.eneco.2015.03.021. URL: http://dx.doi.org/10.1016/j.eneco.2015.03.021.

[2] Francisco Lallana et al. "Exploring deep decarbonization pathways for Argentina". In: *Energy Strategy Reviews* Under Revi (2020).

## A multi-sector CGE model available in several national versions

- Hosted in an open-access platform for the sake of transparency[3]
- Simulates full pictures of the future economy under E3[4] constraints
- Assesses the macroeconomic costs and multi-sectoral impacts of oriented policies

### Main features of the current version

- Possible underemployment of production factors (unemployment)
- Demand-driven capital supply linked to the investment
- Description of the consumers' and producers' trade-offs to facilitate a calibration on bottom-up expertise
- Capture of the inter-sectoral links of investment demand (which activities are driving the invesment demand)

[3] Gaëlle Le Treut et al. *IMACLIM-Country platform : a country-scale computable general equilibrium model*. 2019. DOI: 10.5281/ZENODO.3403961. URL: https://zenodo.org/record/3403961.

[4] energy-emission-economy

# Calibrated at year 2012 with 19 sectors[5]

## Hybrid sectors (6)

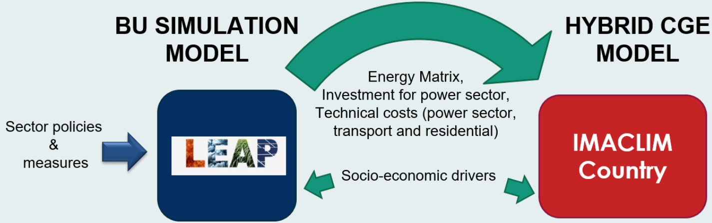
- Crude oil
- Gas
- Fossil fuel
- Biofuels
- Electricity
- Renewables

## Other sectors (13)

- Agriculture
- Cattle
- Cement
- Iron and steel
- Rest of heavy industries
- Food and beverages
- Rest of manufacturing industries
- Transport road freight
- Transport road passengers
- Rest of transport
- Commerces and services
- Construction
- Composite (rest of sectors)

[5] Gaëlle Le Treut et al. "Hybrid Input-Output tables for Argentina at year 2012". In: 1 (2020). DOI: 10.17632/7ZHVC3KNWW.1. URL: https://data.mendeley.com/datasets/7zhvc3knww/1.

## One-way linking strategy



# Informing the full energy system of LEAP into IMACLIM at each time step

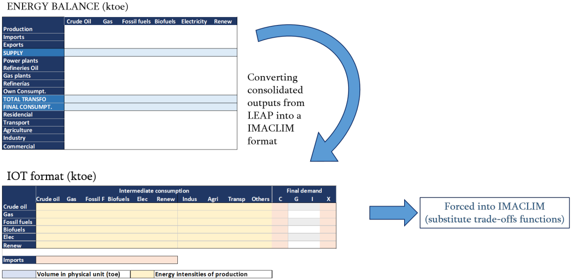



Figure: Automatized conversion module from Energy Balance to Input-Output Table

## Assessment based on energy in volumes

1. Energy intensities of productions (ktoe per unit of production)
2. Households consumption in volume (ktoe)
3. Energy trade in volume for imports and exports (ktoe)

# Including detailed LEAP information on the power sector into IMACLIM at each time step

## Technical costs

1. Time sequence of installed capacities per technology
2. Technology specific capital expenditure (CAPEX)
3. Technology specific operational expenditure (OPEX)

⇒ Assimilated to power sector capital and labor cost

## Investment expenditures

Specific time profile per technology on:

1. Installed capacities, and investment costs
2. Sectoral breakdown in terms of investment goods and services

⇒ Assimilated to the vector of the power sector in the investment matrix

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## Three energy pathways based on common socio-economic drivers

| | | NDC | DD1 | DD2 |
|---|---|---|---|---|
| **General** | | Committed measures | Decarbonization of the energy system | |
| **Demand-side** | | Modest efficiency gains and electrification of uses | High efficiency gains, strong fuel switching and electrification of uses | |
| **Supply-side** | Renewable electricity | Medium development of wind and solar | High development of wind and solar | |
| | Oth. electricity | | Natural gas coupled with CCS | Nuclear and hydro power (to a lesser extent) |
| | Oth. energy | Continuity on natural gas and oil | | |

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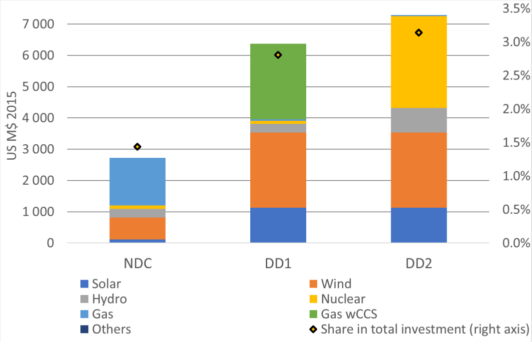



Figure: Mean annual investment in power generation and its mean share out of total investment (2015-2050)

## Key points

- Power generation investment costs all higher in DD scenarios
- +1.5-2%*points* of its share in total investment in DD scenarios

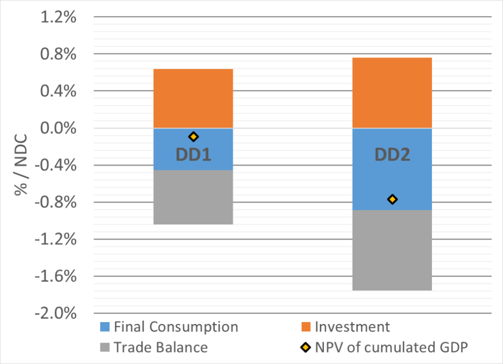
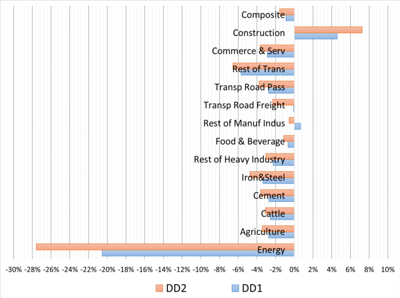


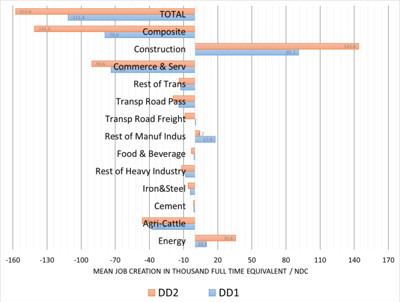

Figure: Net present value of cumulated GDP losses in DD scenarios, and mean annual incremental difference of GDP components as shares of GDP compared to NDC

## Key points

- Limited GDP implications
- Higher share of investment in GDP
- Limited aggregate welfare implications and competitiveness losses




(a) Mean annual production / NDC (%)




(b) Employment (kFTE) / NDC

## Key points

- Lower total output but net jobs creations in the energy sector
- Higher activity on upstream sectors (low-carbon equipments)
- Net negative balance for employment but small out of total

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## Assumptions and limits to be stressed

1. Perfect adaptation of the labor force (no friction related to skill shifts and industrial restructuring)
2. Optimal general financing conditions with no crowding-out
3. No specific industrial strategies for the low-carbon equipment supply

## General conclusions

- Sizable structural change in the economy and investment efforts
- Strong shifts of sectoral value-added
- Net job creations in upstream industries
- Risk of competitiveness losses depending on industrial strategies

⇒ DD pathways are feasible but requires consistent planning (organization of the job transition, financial policy packages, etc.) and joint enabling conditions

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Thank you for your attention !

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