

Session “Power to People”

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NATEM – North American TIMES Energy Model

- Canada, USA, Mexico
- Dynamic least-cost optimization model
- Optimal energy policies to achieve long-term reduction GHG goals (including Net-Zero) for a jurisdiction

NAGEM - North American General Equilibrium Model

- Canada
- Dynamic multi-region hybrid macroeconomic model
- Impact of energy policies (including Net-Zero) on economies (GDP, production, capital, labor etc.)

ProsumArise

ESMIA Consultants Models

Environmental & Health Impact

- Framework for quantification of energy policies impact on air pollution

Tariffs Impact

- Framework for analysis of energy policies impact on tariffs for different consumers categories
- Electricity and natural gas
- Death spiral probability and initiation timing

- Adaptive multi-agent optimization framework
- Optimal investment and energy management decisions (e.g., power dispatch) of energy player
- Energy policy effect on advent of prosumers

Canadian
Energy
Outlook
2018

Canadian
Energy
Outlook
2021

Assessing the 2021

Federal Liberal Climate Plan

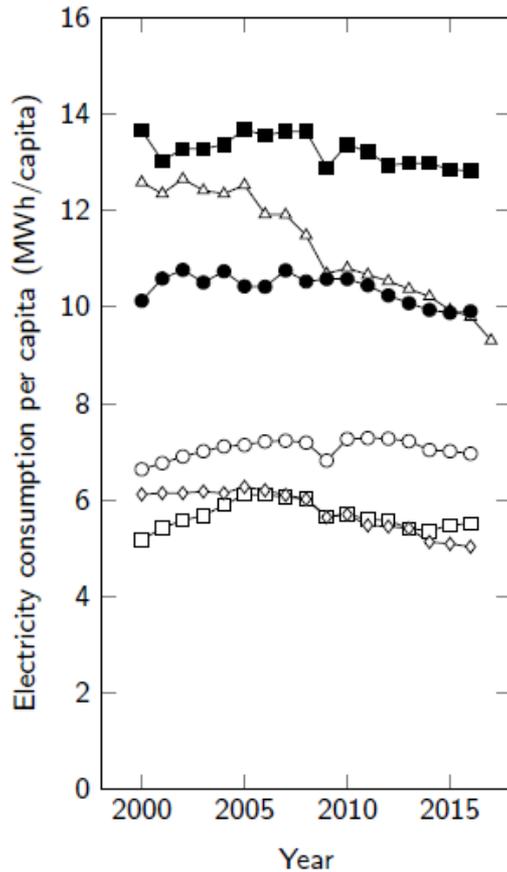
Manitoba's Clean
Energy Strategy

cleanBC
our nature. our power. our future.

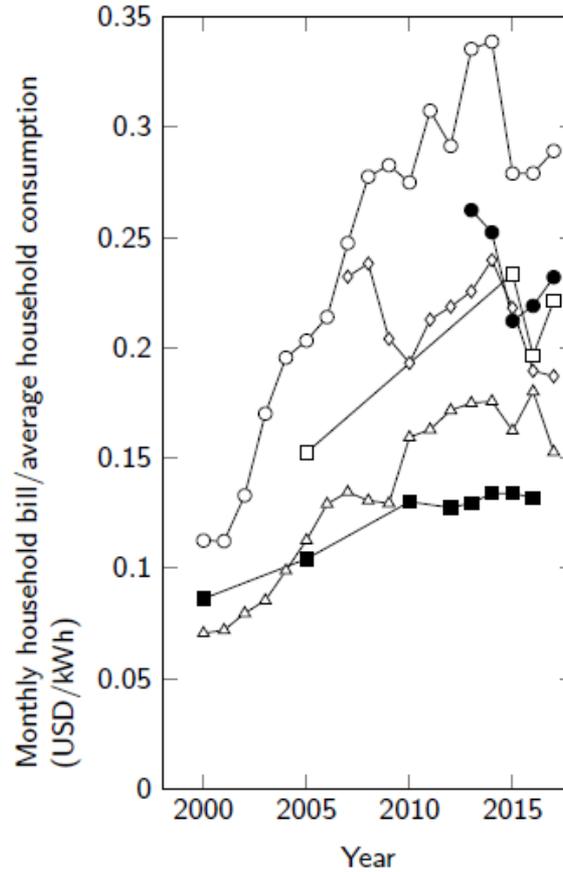
Power to People: Residential Prosumers

- **Spectacular increase of prosumers recorded in the past years:**
 - Millions in Germany, dozens of thousands in France, several thousands in Canada
 - On-grid and emerging off-grid (physically disconnected) prosumers
- **Drivers:**
 - Policy incentives: Feed-in-tariff, Net Metering
 - Advancements in connected technologies
 - Availability of decentralized generators (e.g., PV panel) and residential storage at constantly decreasing costs
 - Pressure of tariff policies: levies, high grid rates, growing fixed charges
 - Non-economic aspects: increasing environmental awareness, strong personal motivation

Electricity Consumption vs Bill



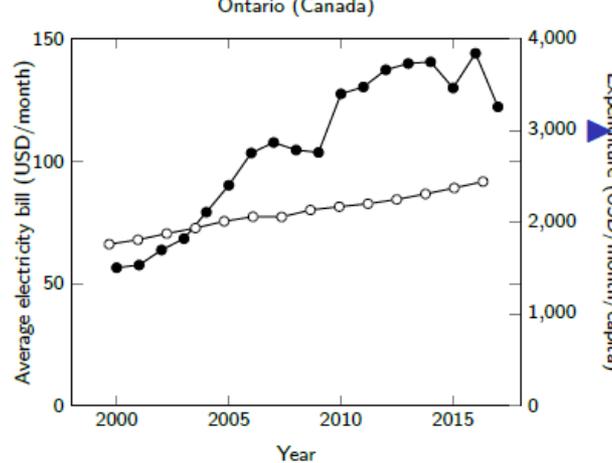
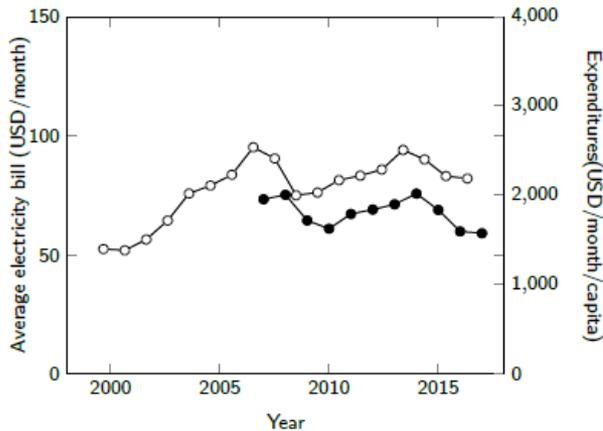
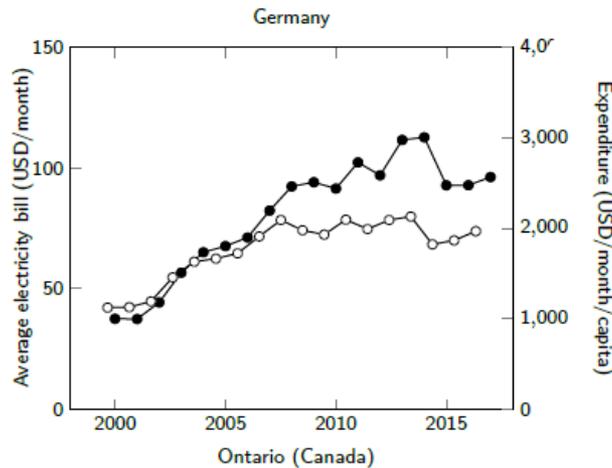
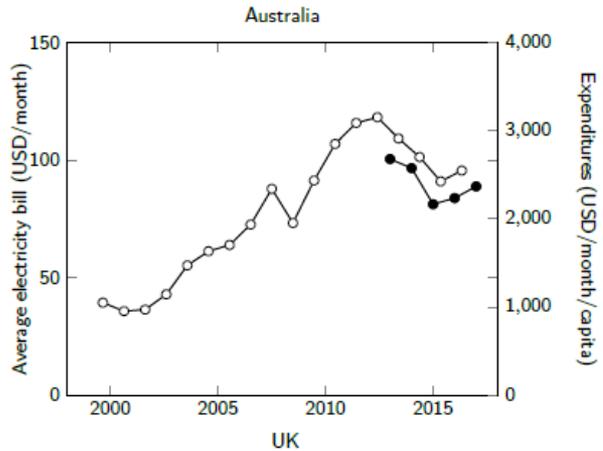
—△— Ontario (Canada)
—■— US
—●— Australia



—□— Spain
—○— Germany
—◇— UK

- Decreasing electricity consumption
- Increasing electricity bill

Household Expenditures vs Electricity Bill

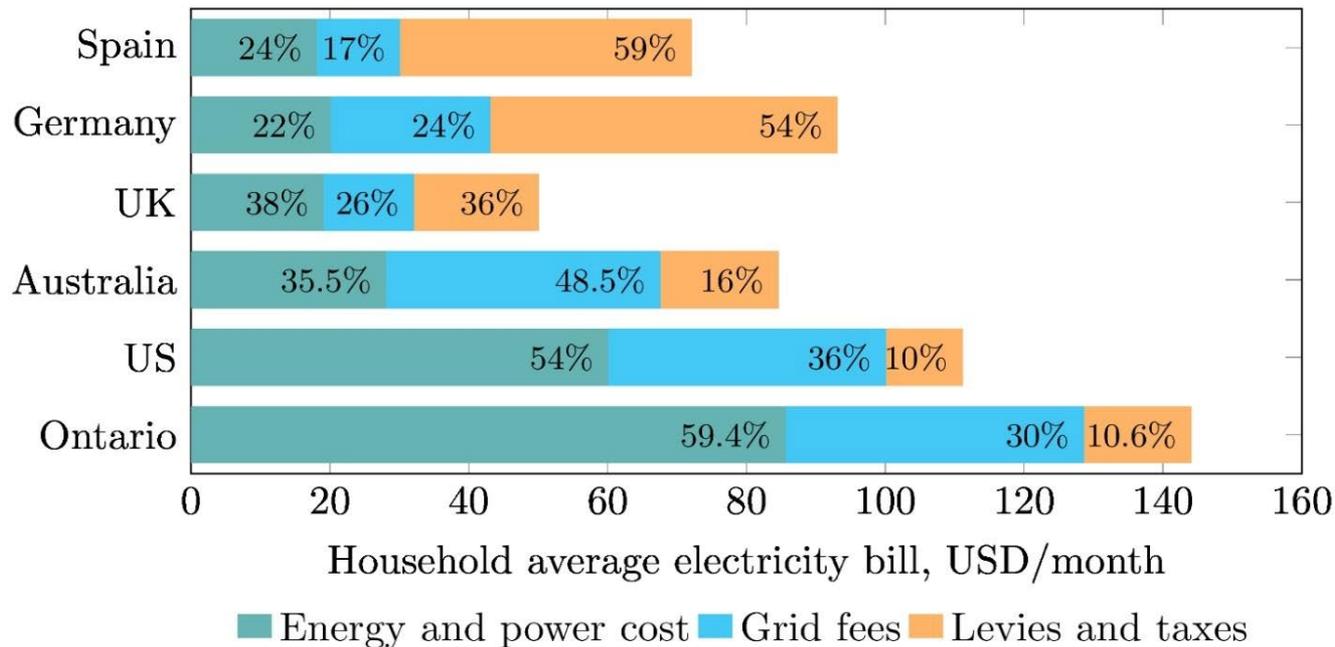


- Electricity bills may grow faster than total household expenditures

● Average electricity bill (USD)
○ Expenditure (USD/month/capita)

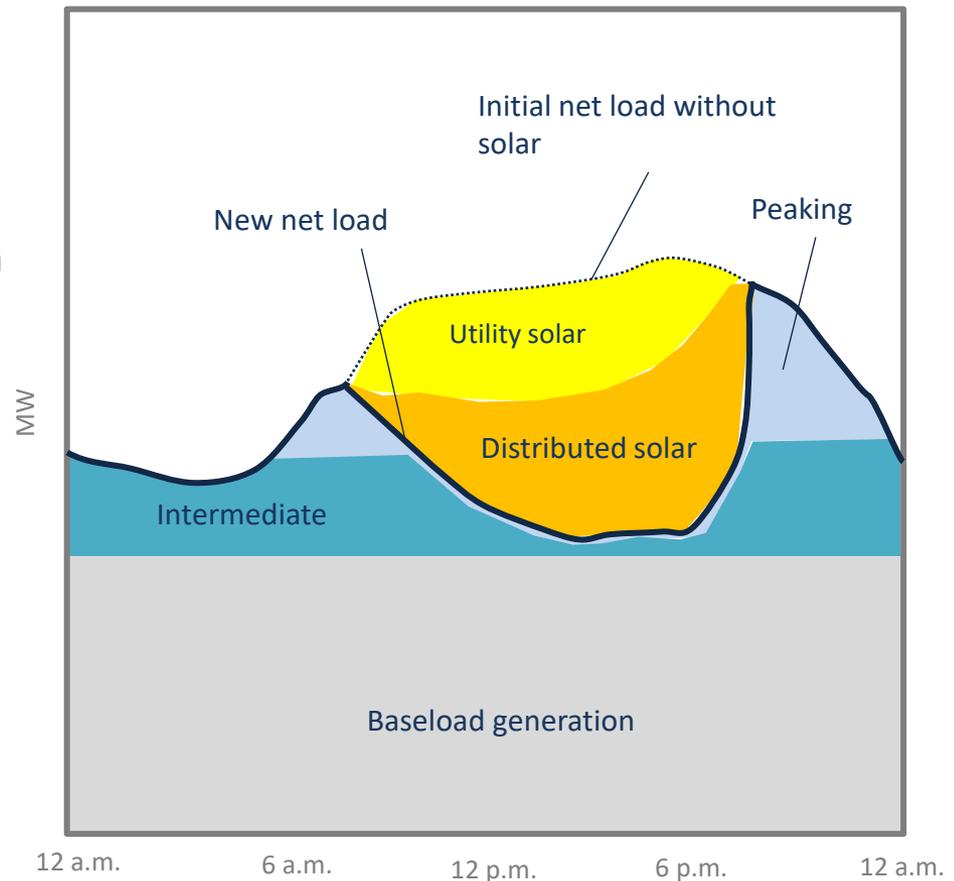
Costs driving bill increase

- Levies for low carbon policies (e.g., Feed-in-tariff)
- Costs to maintain and built other generators
- Grid costs for maintenance and upgrade



Disruptive Effects from On-grid Prosumers

- **“Duck curve” effect:**
 - Large penetration of distributed PV generators
 - Policy, such as Net Metering, promoting self-consumption
 - Not enough support technologies, such as storage
- **In numbers:**
 - California maximum 3-hour net load ramp: increased from 12,000 MW in 2016 to 16,000 MW in 2019 [CAISO 2022]
 - Other jurisdictions experiencing same effect: Australia, China, Europe etc.
- **Implications:**
 - Investment in solutions to flatten the “duck curve”, grid upgrade to support important ramps
 - Investment in peak generators (most likely fossil fuel)



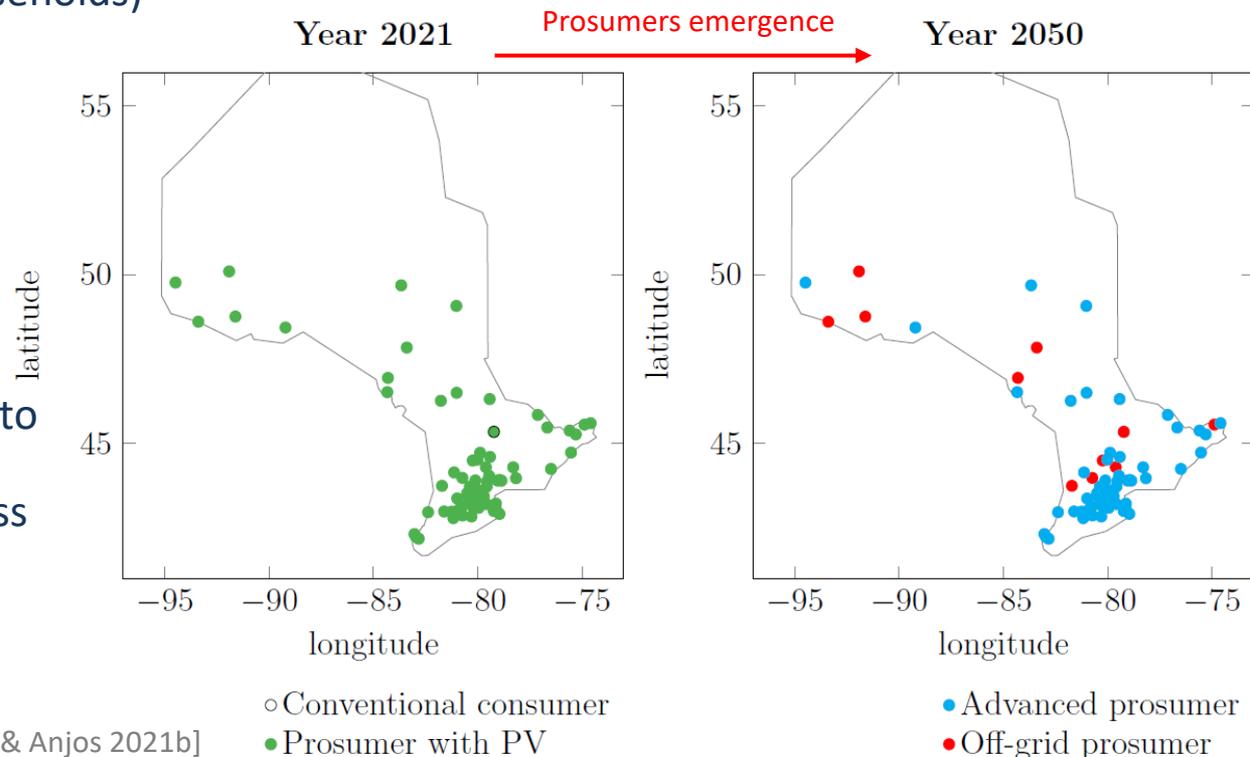
Disruptive Effects from Off-grid Prosumers

- **Potential for off-grid prosumers emergence:**

- Mandatory condition to live off-grid is a seasonal storage of >2.5 MWh & 15kW PV
- Example of simulation for Ontario (if rates continue to increase as they were before 2021) with **ProsumArise** (model combining strategic decisions and power dispatch optimization for households)

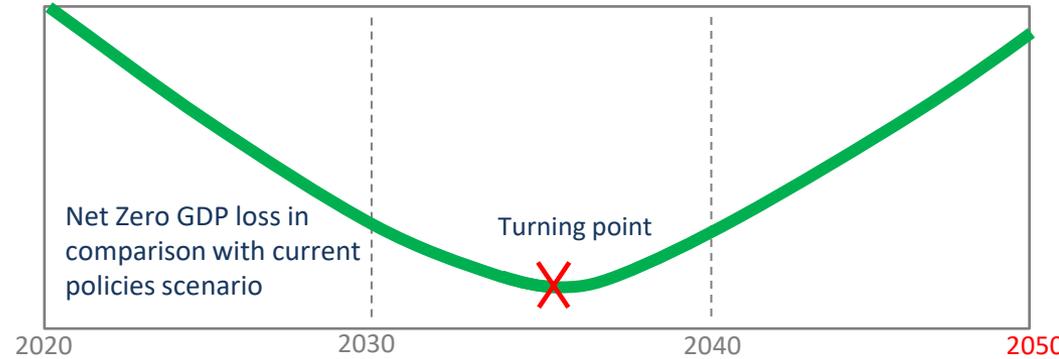
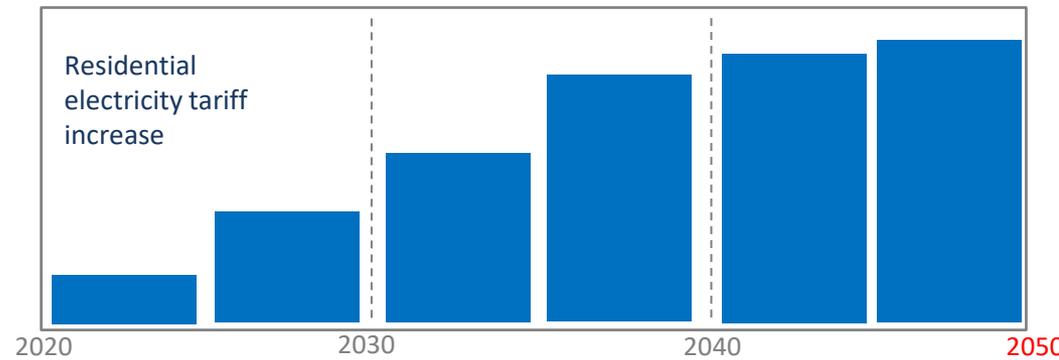
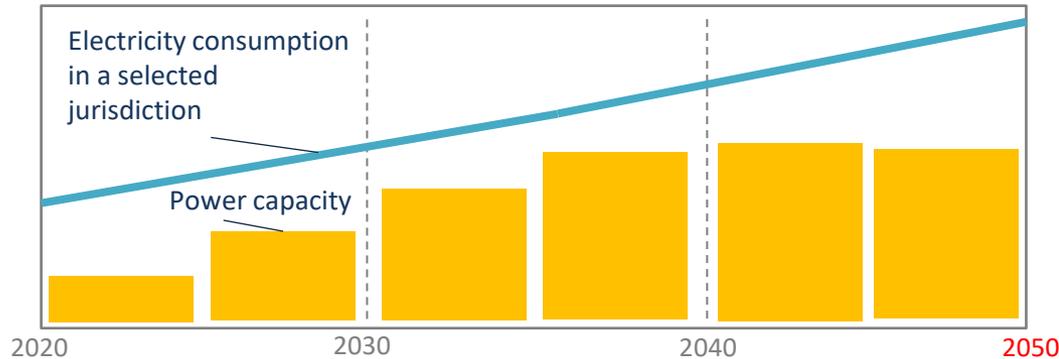
- **Implications:**

- Feasibility of disconnections
- Threshold of off-grid prosumers causing important grid disruption is difficult to estimate due the complex multi-process dynamics (effects of Net Zero policies)



[Kuznetsova & Anjos 2021b]

Prosumers, Utilities and Net-Zero



[Average most-likely tendencies based on ESMIA studies]

Carbon neutrality milestone

- **First half of 2020-2050:**
 - Fast increase of electricity demand
 - Deployment of additional capacities
 - Fast increase of electricity tariffs
 - In general in a jurisdiction: Net-Zero GDP loss
 - investment in transition (not yet enough competitive) measures,
 - capital and labor reallocation,
 - increase of taxes, prices, inflation
 - Consumers active search to mitigate costs
- **Second half of 2020-2050:**
 - Economy recovery
 - Net Zero measures are more mature, efficient and competitive
 - Less rapid tariffs increase

Recommendations

- Promote prosumers (to contribute to Net-Zero goals and decrease electrification pressure on Utilities), but mitigate disruptive effects
 - **Prosumers:** Recognized to be active grid players (regulation promoting Utilities-Prosumers collaboration and not pushing them apart)
 - **Utilities:** Long-term transition strategies planning (beyond 2050) and diversification (substitution activities and products)
 - **Government:** Several Net Zero transition paths with optimized policies implementation in time and magnitude (to avoid shocks and ensure economy adaptation)
 - Transparency and communication on policies, strategic actions and future rates (When the turning point will occur?)

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