The role of financing in Energy Efficiency policies: PRIMES & GEM-E3

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E3Modelling Energy Economy Environment

Rationale

- The decarbonisation of the energy system is a capital intensive process with both ***risks*** and ***opportunities*** for the economies in transition:
  - To the extent that the expenditures required to decarbonise the system are "**new money**" injected into the economy and that they **target domestic production**, the economy will enjoy a benefit from the transition
  - However the transformation of the energy system may require imported equipment and access to **financial resources** that may be **scarce** or available at high interest rates
  - The low carbon energy system may lead to **high energy costs** that impact negatively on the competitiveness of trade exposed sectors
  - The **large scale adoption** of new technologies may lead to cost reductions and offer **competitive advantages**
- Hence the ***net impact*** on GDP is ***uncertain*** as it depends on a multitude of factors including financing availability.

The policy context

- **Energy efficiency (EE):**
  - can reduce CO2 emissions, improve energy security, and lower energy bills for both households and firms,
  - has the potential to boost employment and GDP growth
- **Financing energy efficiency:**
  - The low-carbon transition and energy efficiency would lead to increased upfront investment costs for firms and consumers
  - The financing of this additional upfront capital cost is of crucial importance for the macroeconomic implications of EE expenditures
- Conventional CGE models *do not* represent financial sector
- **Objective:**
  - Explore the macro-economic impacts of the EU low-carbon transition using the GEM-E3 model with improved representation of the financial sector

Finance in GEM-E3

Key features of GEM-E3

- The GEM-E3 model is a global, multi-regional, multi-sectoral, recursive dynamic computable general equilibrium (CGE) model which provides details on the macro-economy and its interaction with the environment and the energy system.
- **Technology progress** is explicitly represented in the model depending on R&D expenditure by private and public sector and taking into account spill-over effects
- Explicit representation of a **detailed financial sector** for each country that includes agent specific debt profiles and market clearing interest rates
- Bottom – up representation of the power generation system (10 power generation technologies)
- Discrete representation of the sectors manufacturing clean energy technologies (Wind, PV, electric cars, batteries)
- Detailed representation of the transport sector and biofuels linked to agriculture

CGE with and w/o financial sector

- **First publication of a CGE with financial sector:**
  - F. Bourguignon, W. H. Branson & J. de Melo (1989) which has been further extended by Fargeix & Sadoulet (1990) and Capros & Karadeloglou (1994).

- **Basic Idea:**
  - Demand for finance: Each agent (in deficit) can receive a loan from domestic capital markets that needs to be repaid in a given time period at a market clearing interest rate
  - Supply of finance: Each agent (in surplus) owns a portfolio of financial products with different returns and risks.

w/o financial sector	*with financial sector*
Debt accumulation does not have an impact on the real economy as in reality via the adjustment of interest rates	Agents financing is subject to their financial position (surplus – deficit)
The financing of an investment project takes place in one period (at the period where the investment products are constructed) and can be financed from the sector, country or abroad	Detailed representation of financial products and detailed accounting of the financial position of each economic agent. Book keeping of stock/flow relationships on debt accounting (domestic and external Private and Public debt)
In a given year/period alternative investment projects compete for the same capital resources (crowding out effect)	Endogenous computation of interest rates for alternative uses of financial resources (deposits, bonds etc.) Use of the endogenous interest rates for rationing financing decisions Allow for the existence of versatile financing schemes that expand through sectors, countries and time. The option to create payback schedules that span over many periods moderates considerably the crowding out effect

Overview of the implementation

- **Agents** represented in the model: Households, Firms, Public Sector, External Sector and a World Bank
- **Financial Assets**: i) Public Bonds, ii) Corporate bonds, iii) Household loans, iv) Deposits, vi) Corporate shares
- **Money supply** can either be fixed with endogenously determined interest rates (money multiplier theory) or be adjustable (endogenous theory money) at given interest rate (i.e. bank reserves adjust as needed to accommodate loan demand at prevailing interest rates).
- Market for financial assets can be domestic, international or mix.
- Financial behavior based on optimal portfolio theory (expected return, risk, duration etc)
- Two interest rates:
    1. *Current interest rate* that clears the market on this year financial products
    2. *Average interest rate of debt* which is composed of the weighted average of previous years interest rates

Borrowing and Lending Behaviours

Behaviours are formulated by institutional sector and depend on interest rates which clear the financial markets and on anticipation factors

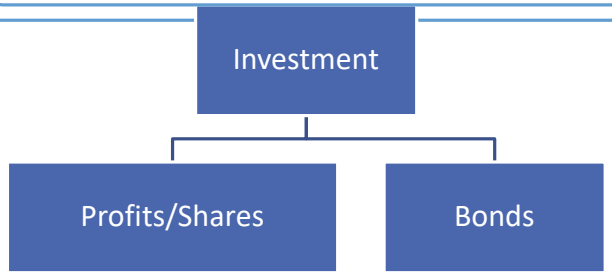
Public

1. The public sector spends depending on budget balancing targets and borrowing from different origins depends on interest rates
2. Public budget is balanced through: i) income tax, ii) Bonds.

World Bank

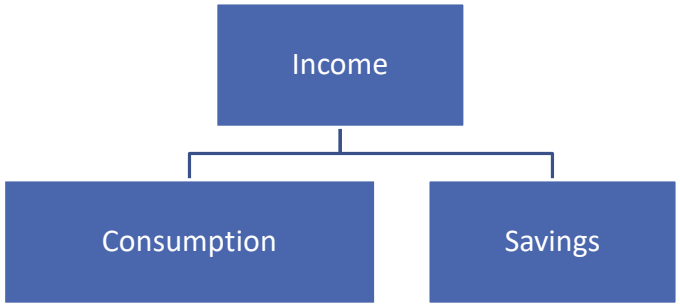
1. Receive deposits from all countries and pay back an interest so as to ensure zero profits
2. Bank portfolio is based on : 1) expected return, 2) risk (that depends on the financial position of the agent at previous periods)

Firms



- Firms borrowing (bonds) = Financing requirements – Profits not distributed

Households



- Households are the main source of financing (through savings) for all agents with deficits
- Households receive loans only for consumption

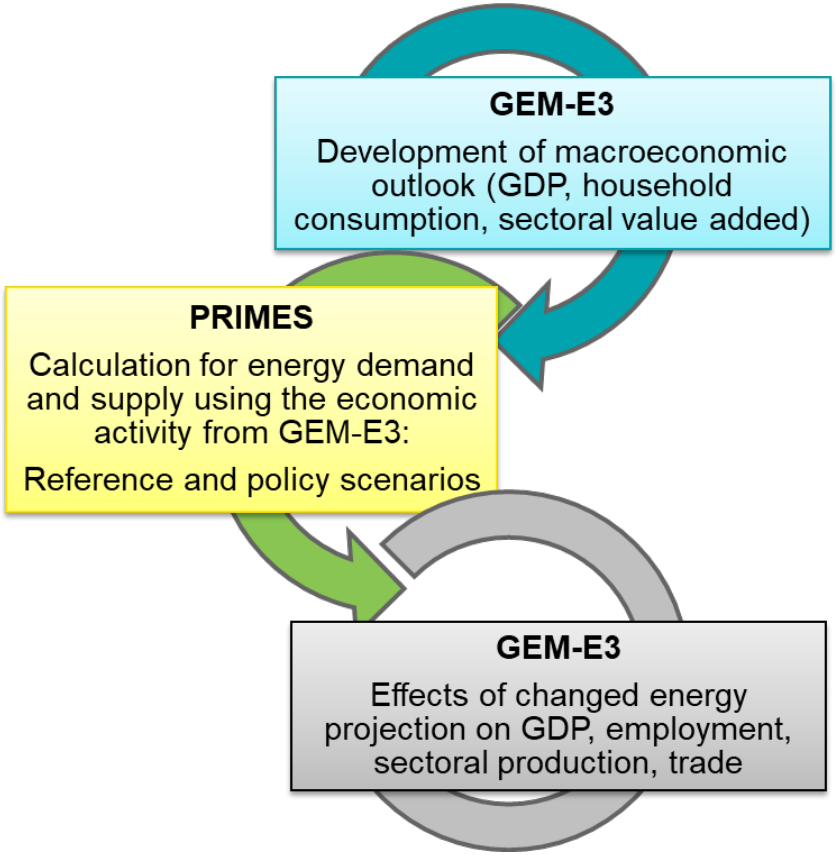
Financing EE expenditures in GEM-E3

- Households and firms increase their **upfront spending** to *renovate houses*, to purchase more *efficient equipment* and *electric cars*
- Energy efficiency investment require construction, materials (ferrous and non-ferrous metals, chemical products, non-metallic minerals), equipment and market services.
- Conversely, their costs for fuel and electricity purchasing will decline permanently
- From a macroeconomic perspective, the increase of upfront costs puts pressure on agents' budgets, depending on availability of external financing.
- Financing the upfront costs may exert a crowding out effect, to the detriment of productive investment, at a degree which depends on external financing and the availability of borrowing
- Expenditures in energy efficiency do not increase the stock of productive capital in the economy
- Households' do not derive utility from energy efficiency; instead their utility is affected indirectly through the income effect from the reduced energy costs

Scenario Setup

Methodology

- **PRIMES**: Detailed market equilibrium energy model for EU28 MS by 2050
  - Represents agents' behavior and structural long-term transitions
- **GEM-E3**: Global multi-sectoral CGE model
  - Endogenous economic and trade projections with detailed energy sectors
- **<u>Analysis Undertaken</u>**:
  - Representation of financial mechanisms
  - Analysis of financial impacts of energy efficiency policies



Implementing the energy efficiency policy scenarios in GEM-E3

- **Reference scenario**
  - Based on the continuation of current trends, while no new climate policies are implemented
- **Counterfactual scenario:**
  - 40% reduction in EU GHG emissions in 2030 (from 1990)
  - 80% reduction in EU GHG emissions in 2050 (from 1990)
  - 10% energy savings in 2030 & 30% in 2050 (from Reference scenario)
  - Non-EU regions adopt their reference policies
- **GEME3-PRIMES**
  - Energy-related scenario inputs are taken from the PRIMES scenario results (fuel mix, energy demand, energy efficiency investments)
- **Financing schemes**
  - *"Self-financing"*: no additional borrowing is possible and thus economic agents bear income limitations when funding investments in energy efficiency and RES;
  - *"Loan-based financing"*: firms and households can borrow in capital markets

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- The self-financing variant corresponds to immediate financial closure and implies that the model will show full crowding out effect

- In the loan-based variant, agents are able to distribute capital costs over several years to alleviate crowding out effects. The modelling foresees annual pay back of interests and principal of the loans.

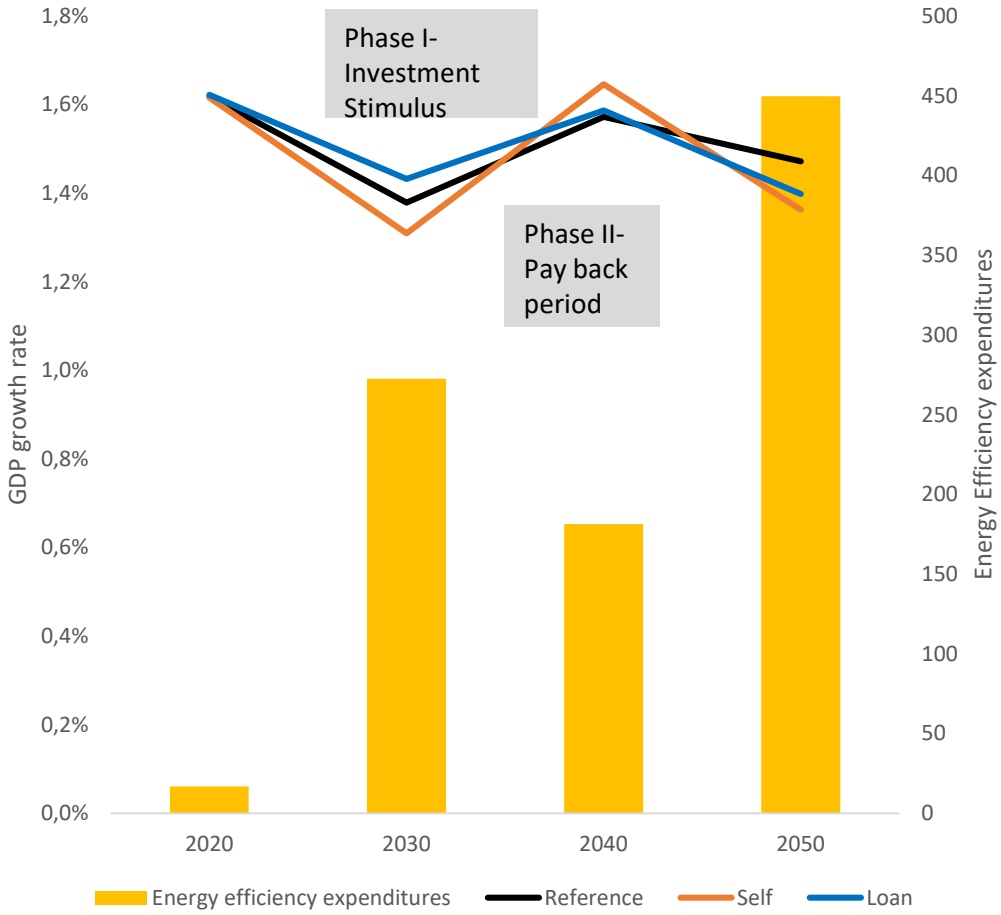
Assumptions for financing and loans

- **Key point:** to define *a financial sustainability rule* for loans
  - For this purpose we have assumed that the indebtedness to revenues ratio should not exceed a certain threshold by 2050
  - The threshold is calculated using the Reference scenario
- The **loans** received by firms and households:
  - cover 90% of total expenditure in 2020 and 2030 and 70% of total expenditure in 2035-2050
  - last for 10 years and repayment starts one period after it is issued
  - involve equal payments over time, covering principal and interests, the latter being calculated at market clearing interest rates of the year of payment.
  - Loans received up to 2035 are fully paid back by 2050, while loans received in 2045-2050 create debt beyond 2050 amounting to 6% of their total income, which is considered sustainable as yearly savings of the private sector surpasses yearly instalments of the loan)

Results

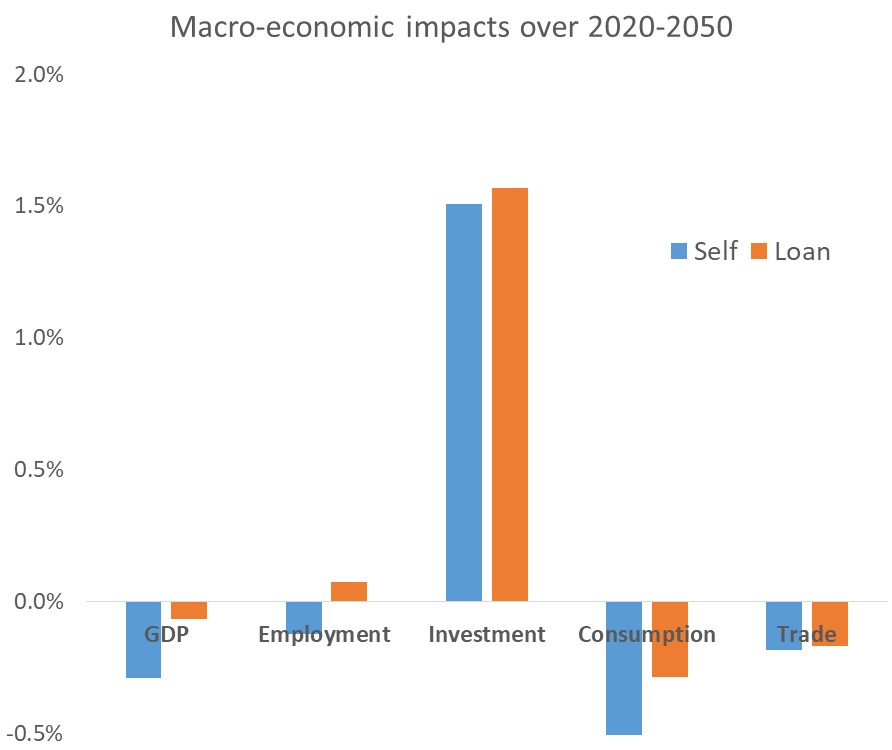
Impacts on GDP

- *High importance* of the financing mechanism (loan-based finance):
  - 2030 shows positive results triggered by high investment expenditure and limited crowding-out
  - GDP losses in 2040 as loans are paid back implying increased costs for the economy
  - Provision of finance eases the transition requirements leading to higher GDP relative to self-finance

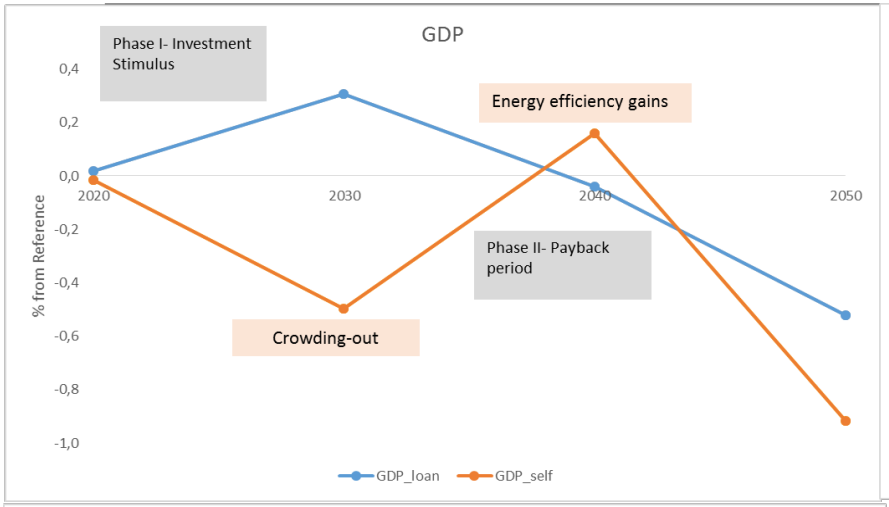


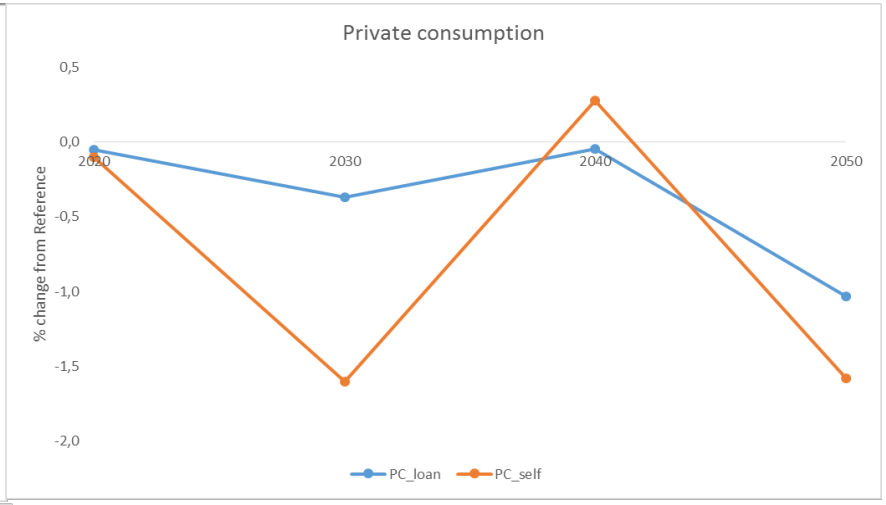
Macro-Economic impacts of Loan and Self variant

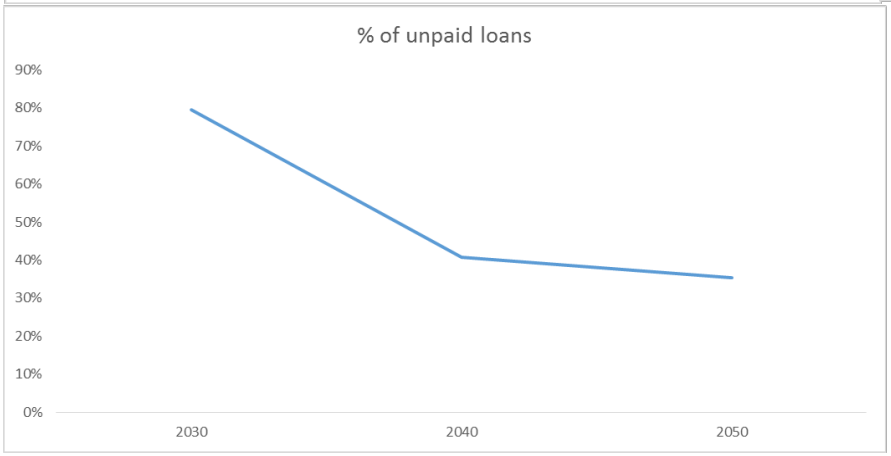
- Tightness in the capital market:
  - implies higher financing costs
  - leads to higher crowding out effects
  - negatively affects GDP as the costs for energy services increase
- Easiness of financing:
  - limits crowding out effects
  - allows activity benefits induced by investment to compensate the effects of increased energy service costs
  - reduces competitiveness losses
  - allows for higher consumption and investment



Macro-Economic impacts of Loan and Self variant

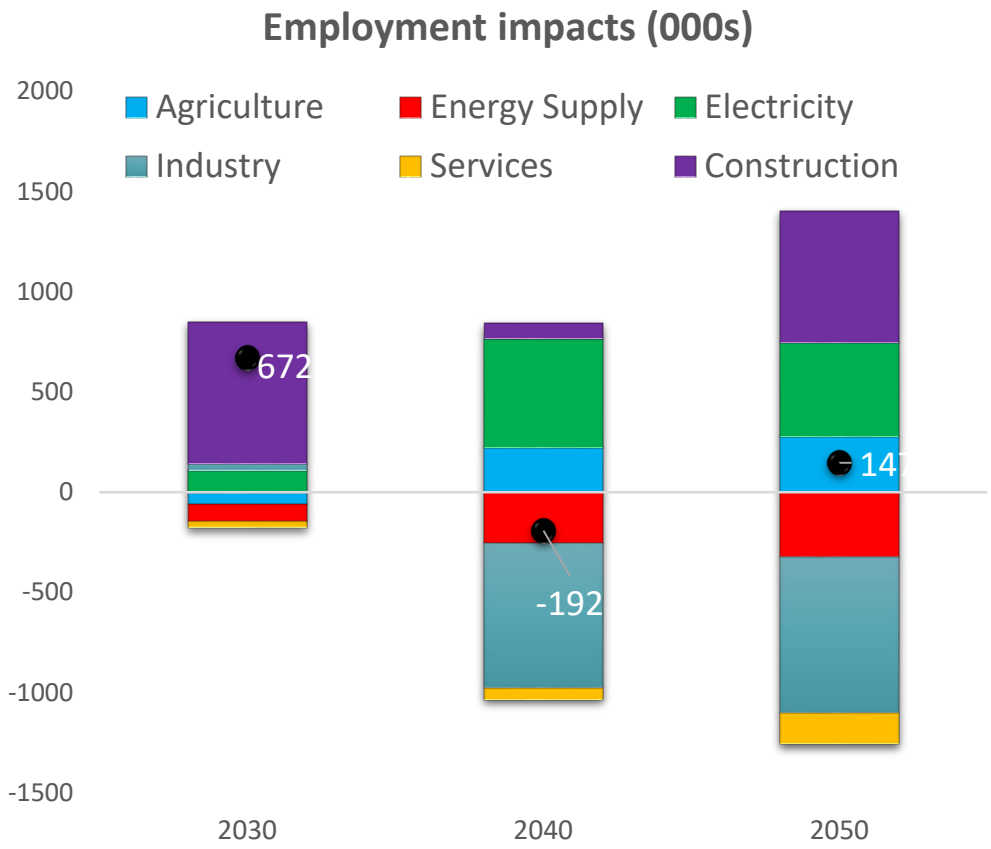






Impacts on Employment ("Loan-based" variant)

- Employment impacts reflect general economic trends
- Overall positive employment impacts in 2030 and in 2050:
  - Job gains in construction due to high investment in efficiency and RES
  - Electricity and agriculture benefit from high electrification and biofuels
  - Clear losses in fossil fuel sectors
- Impacts on industry depend on:
  - supply chain effects and
  - international competitiveness



Conclusions

- The low-carbon energy transition is not a “free lunch” – the lending that supports the wave of capital investment has to be paid for over subsequent decades
- Access of households and firms to low-cost finance is a prerequisite to finance their low-carbon investment
- The incorporation of the financial sector in GEM-E3 improved the realism of the model’s simulation properties
- Different financial assumptions impact macro-economic and employment outcomes of energy efficiency

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Thank you

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