

Dynamic Integrated Environmental and Economic Modelling

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Outline

Part 1: The value of a dynamic model

- What does a static CGE capture?
- Why are dynamics important?
 - Technology and policies.

Part 2: The GreenREFORM-EU Model for Viet Nam

- Integrated Environmental and Economic Model Framework.
- The Danish GreenREFORM → GreenREFORM-EU → Viet Nam adoption.
- Open source, free, and with embedded AI.

01

Why Dynamic Modelling?

The static CGE

- **Static CGE** captures how industries, households, and markets are connected.
- Based on **snapshot of the** economy, it will answer questions like:
 - Impact of carbon prices with current structure?
 - Which sectors are most affected?
 - How are different households impacted?



No timing

Implicitly assumes *permanent* structure.



No technology change

Fixed coefficients; no learning curves.



No transition

No anticipation of policies/forward guidance

A dynamic model

A dynamic model is important for several reasons:

- **The transition phase** should not be ignored.
The green transition often involves several decades of planning.
- **Adjustment costs** can be substantial.
Industries retool, workers retrain, capital is reallocated.
- **Well-designed policy** is not static.
Abrupt policy is costlier than gradual, phased policy (Vogt-Schilb et al., 2018; Rozenberg et al., 2020)

When dynamics matter: Adjustment costs

Vogt-Schilb et al. (2018) is a good example of why a dynamic model is valuable.

They suggest that front-loading abatement efforts may be optimal, when adjustment costs are significant and abatement capital are long-lived.

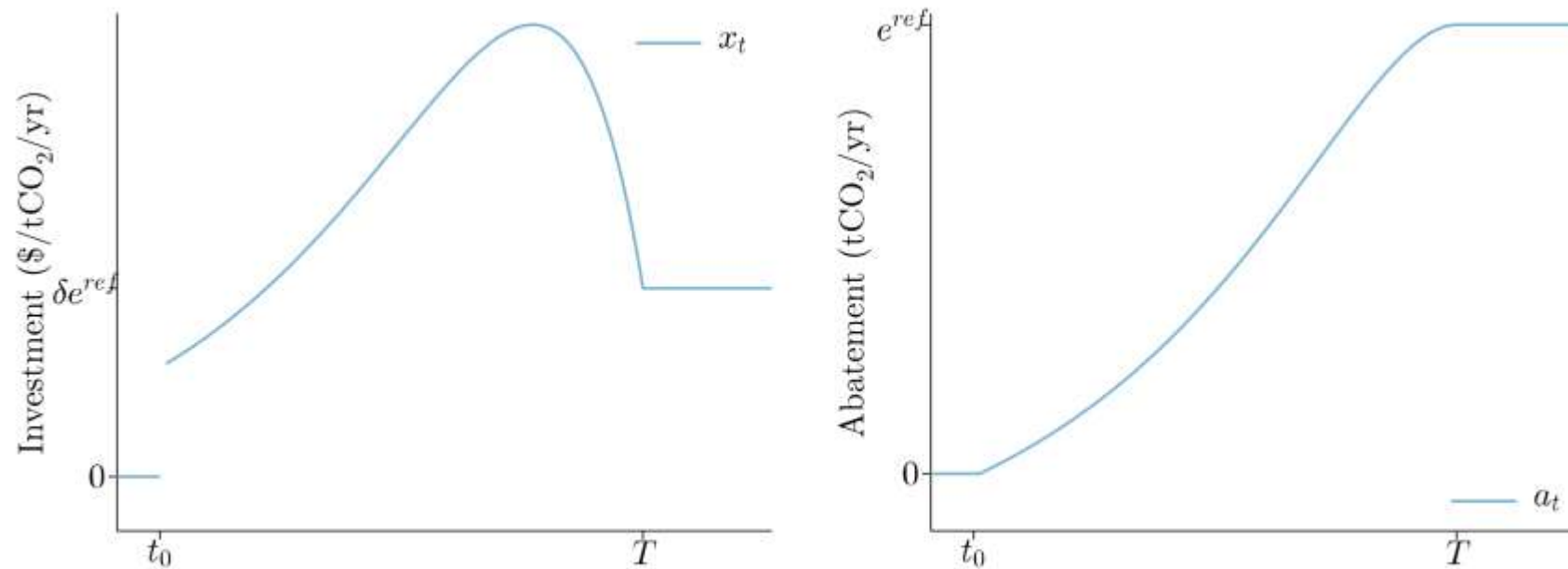


Fig. 2. Optimal timing of abatement investment and resulting abatement pathway. Left: Abatement investment is bell-shaped. Right: Abatement continuously grows over time.

When dynamics matter: Policy

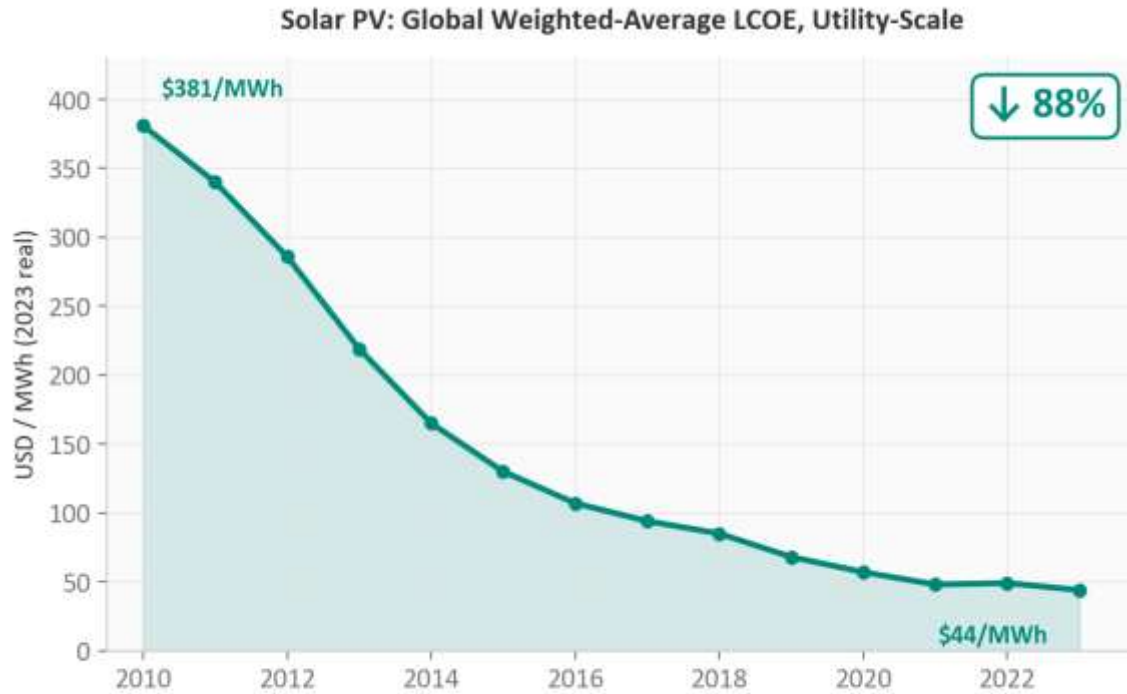
As Peter mentioned, empirical evidence from EU-ETS largely shows that green transition can be achieved at low costs using carbon pricing.

An essential feature of the EU-ETS is that the trajectory is known. This follows the principle that well-designed policy is credible and forward-looking.

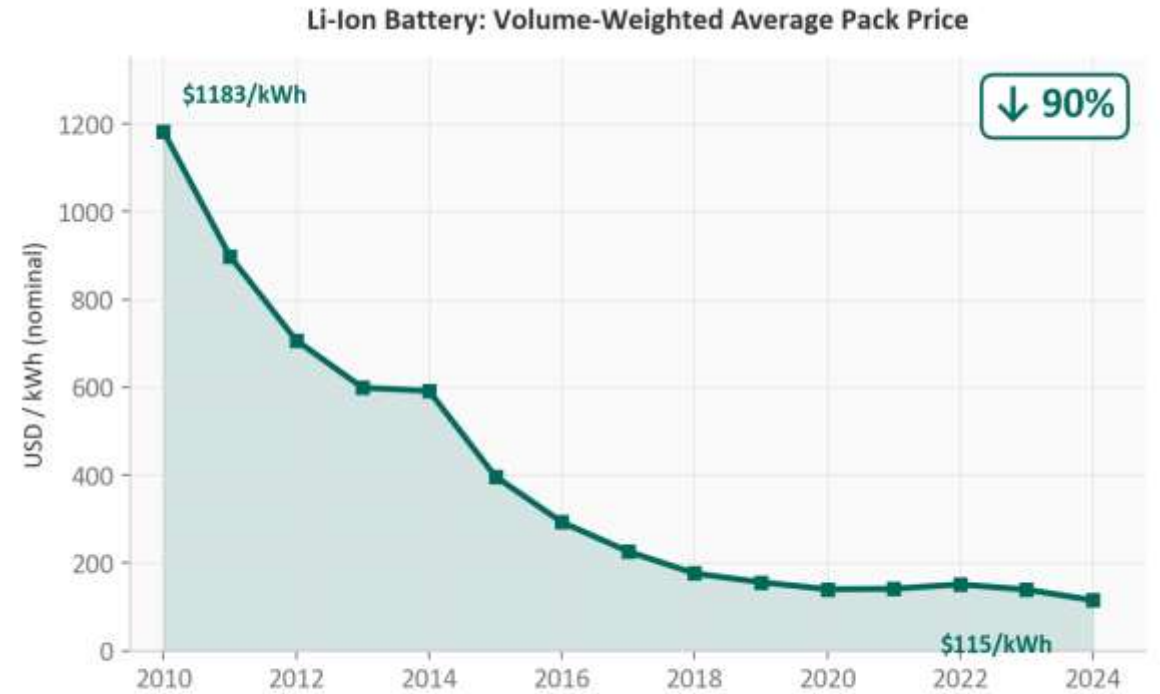
- Ensures that firms can plan for the long run; crucial for investments in long-lived abatement capital.
- Reduces uncertainty.
- Particularly important for emergence and coordination of new markets (e.g. carbon capture technologies).

When dynamics matter: Technology

Green technologies follow steep learning curves — a dynamic model captures this



Source: IRENA, Renewable Power Generation Costs in 2023 (2024)



Source: BloombergNEF, Lithium-ion Battery Price Survey (2024)

02

The GreenREFORM-EU Model

From Denmark to Europe to Viet Nam

The GreenREFORM framework

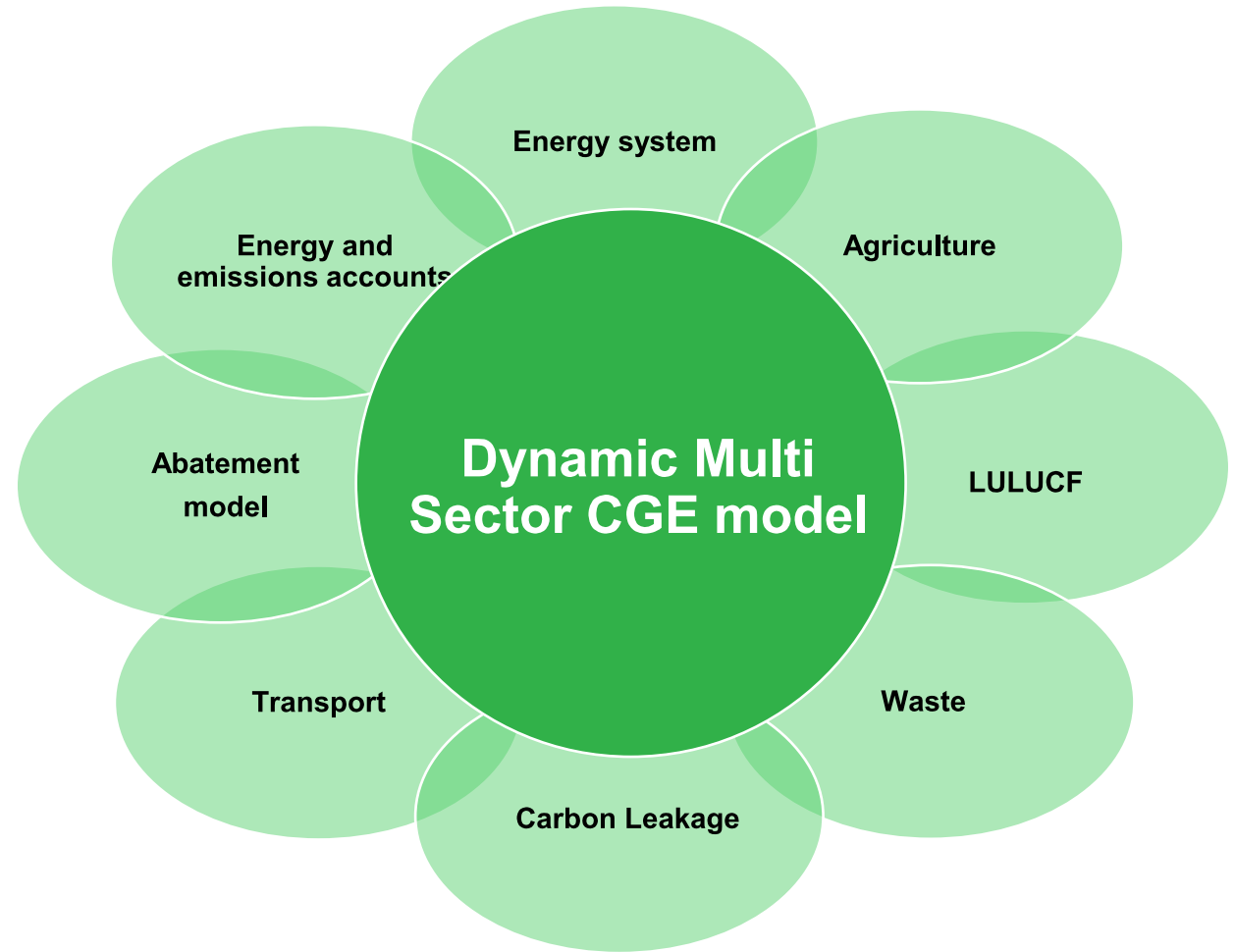


- **Stage 1 – GreenREFORM:**
Developing a Danish dynamic, integrated environmental and economic model.
- **Stage 2 – GreenREFORM-EU:**
Danish model framework simplified and adopted by five EU countries (Belgium, Italy, Austria, Finland, Poland).
- **Stage 3: GreenREFORM-Global(?)**

Stage 1: GreenREFORM

An integrated environmental and macroeconomic model.

- Large macroeconomic core model: Dynamic, forward looking, highly disaggregated.
- Specialized models for key aspects for climate and environment.



Stage 1: GreenREFORM

- Origin in research project from University of Copenhagen in 2017 in tight collaboration with DREAM modelling group.
- Gradual expansion from 2019-today:
 - Model matures from research at UCPH to official use via DREAM.
 - Currently maintained and used by DREAM.
 - Data supplied by range of institutions (Statistics Denmark, Danish Energy Agency, Ministry of Finance, Danish Technical University etc).
 - Applied across departments, ministries, think tanks etc..

Stage 2: GreenREFORM-EU

GreenREFORM-EU is developed to be an *off-the-shelf*, lightweight version of GreenREFORM:

- Contains the core macroeconomic model from GreenREFORM,
- the emission abatement module,
- and the general flexible/modular structure developed for GreenREFORM.

Adopted by five EU countries: Belgium, Italy, Austria, Finland, Poland.

Proof of concept for exporting model framework and adjusting to local circumstances.

Stage 3:

Proof of concept development for five European countries raise general interest in the model: Third stage now has 16+ European countries that will adopt the GreenREFORM-EU framework.

Due to the scale of the project and advances in technology (AI + open source optimization software), we now plan to build entirely new model framework:

- Build entirely using open source using Julia and Python (no proprietary software).
- We can embed AI context alongside the model code to ensure that any user can understand and start using the model instantly with very limited training.

The aspiration is to simply make an advanced economic model that is not only free and open source, but also much easier to use than any other model.

Stage 3: Application for Viet Nam

GreenREFORM-EU model framework is mainly developed by the DREAM group.

We apply the framework to the case of Viet Nam and adjust the model to local conditions and to answer relevant policy questions to the local context e.g.

- How to ensure a just green transition given available technologies and how households and industries currently rely on fossil energy.
- How to ensure a resilient green energy transition that does not leave industries vulnerable to trade shocks or fragile supply chains.
- How to ensure that the transition does not hinder other development objectives such as poverty reduction and inequality.

What the Model Will Do for Viet Nam

Trace the transition path from today's energy mix to net-zero 2050

Under different policy scenarios and technology assumptions

Evaluate carbon pricing mechanisms

Phased ETS, carbon taxes, combinations with subsidies and standards

Quantify distributional impacts over time

Who gains, who loses, when — and how compensation schemes can help

Incorporate falling technology costs

Renewables, battery storage, green hydrogen — dynamic cost trajectories

Building This Together: Next Steps

Calibration to Vietnamese data

Building on the 2019 ESAM, with updates as new data becomes available

Iterative adaptation of modules

Viet Nam–specific energy mix, industrial structure, household types

Capacity building & training

Open-source + AI design makes adoption feasible

Planned outputs

Scenario analyses to support green policy development in Viet Nam

Summary

A static CGE is a useful starting point

Captures the structure of the economy — but cannot trace the transition

The green transition is inherently dynamic

Adjustment costs, technology learning, credible policy — all unfold over time

The GreenREFORM-EU framework adds what's missing

Forward-looking agents, technology dynamics, feedback loops, year-by-year tracking

Open-source, AI-supported, and being adapted for Viet Nam

Designed to help evaluate the policies that matter