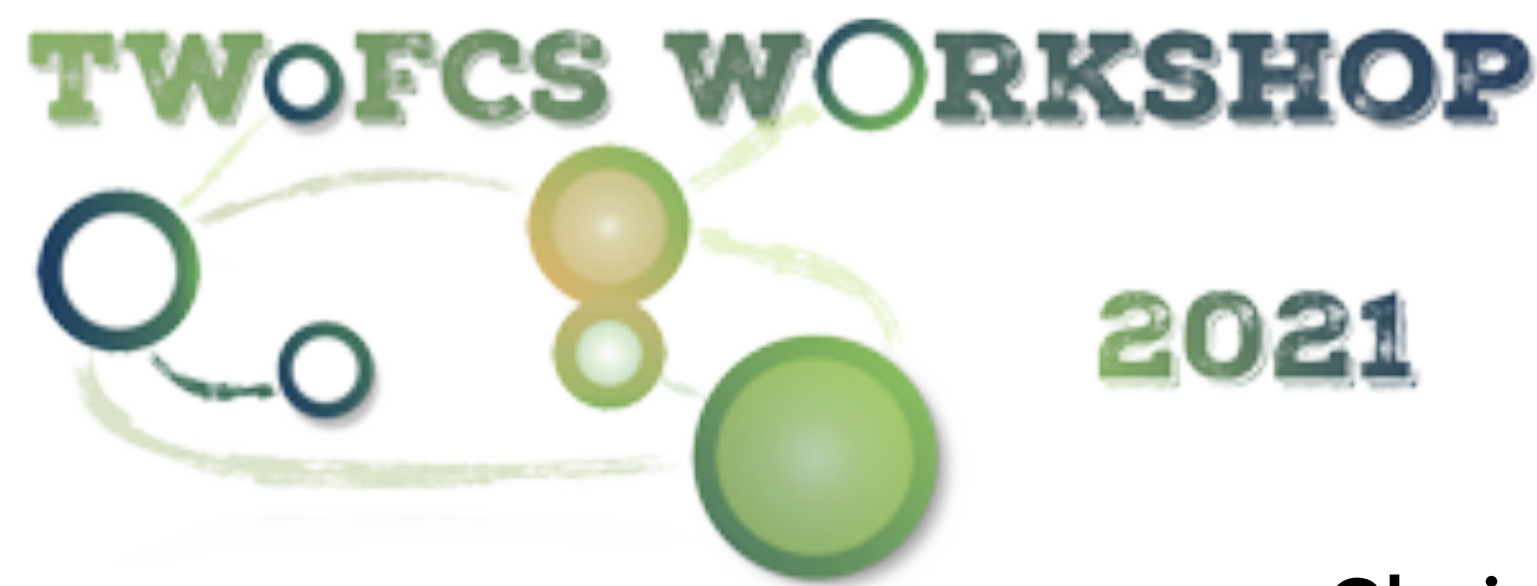




# Fuel Cycle Workshop 2021

**Nuclear fuel cycle interaction with electrical and energy systems**



Chairman : Nicolas Thiolliere, Tuesday 29th June 2021

# History of FCW

## The interdisciplinary session

- **2016** : Two talks related to "pure" economics problematics
  - Global and opening scenario related question
- **2017** : Few talks related to sociology and economics
- **2018** : Strong representation of interdisciplinarity (5 talks and a special session)
  - Economy and interdisciplinary applications session
  - Panel discussion with decision makers (S. Tillement)
- **2019** : Two talks related to economics scenarios
- **2021** : Two interdisciplinary sessions
  - Nuclear fuel cycle interaction with electrical and energy systems
  - Panel discussion with decision makers (S. Tillement : See panel wednesday 30 JUNE 2021, 2 – 4 P.M.)



**STARTS AT 2. p.m.**

*International Panel Discussion: Strategizing for the nuclear of the future*

**Moderator:** S. Tillement, IMT Atlantique

**Panelists:** Key industrial actors from France, Russia, the USA and the UK



**Jeffrey R. Cooper**  
Director of Engineering,  
American Centrifuge  
Operating, LLC (ACO)



**Alexey Lokhov**  
Deputy Director,  
Rosatom Western  
Europe, Russia

**Daniel Mathers**  
Senior advisor  
to NIRO, UK



**J. Van Der Werf**  
Senior VP on Advanced  
Nuclear Energy Systems  
At the EDF Design &  
Technology Branch, France





# FCW 2021 session

## The interdisciplinary session



## Afternoon session- 3:00pm – 5:30pm

**Topical Session: Nuclear fuel cycle interaction with electrical and energy systems**

*Chair: Nicolas THIOLLIERE (IMT Atlantique, France)*

**3:00pm – 3:15pm: INTRODUCTION**

**3:15pm – 3:45pm**

Electric transition in a fictitious emerging country - Impact of external constraints.

*Sibylle MARTIN-LAUZER (CEA, France)*

**3:45pm – 4:15pm**

First approach to the estimation of Levelized cost of Electricity in ANICCA code

*Ivan MERINO (Universidad Catolica Del Maule, Chili)*

**4:15pm – 4:30pm: BREAK**

**4:30pm – 5:00pm**

Impact of Fuel Supply Chain Disruptions on Energy Resilience: A case for Nuclear Energy

*Guillaume L'HER (Colorado School of Mines, USA)*

**5:00pm – 5:30pm: DISCUSSION**

## 2021 Specificities

- 3 "technical" profiles
- Importance of technical-and-economic studies

# FCW and the economy

## The economics calculation

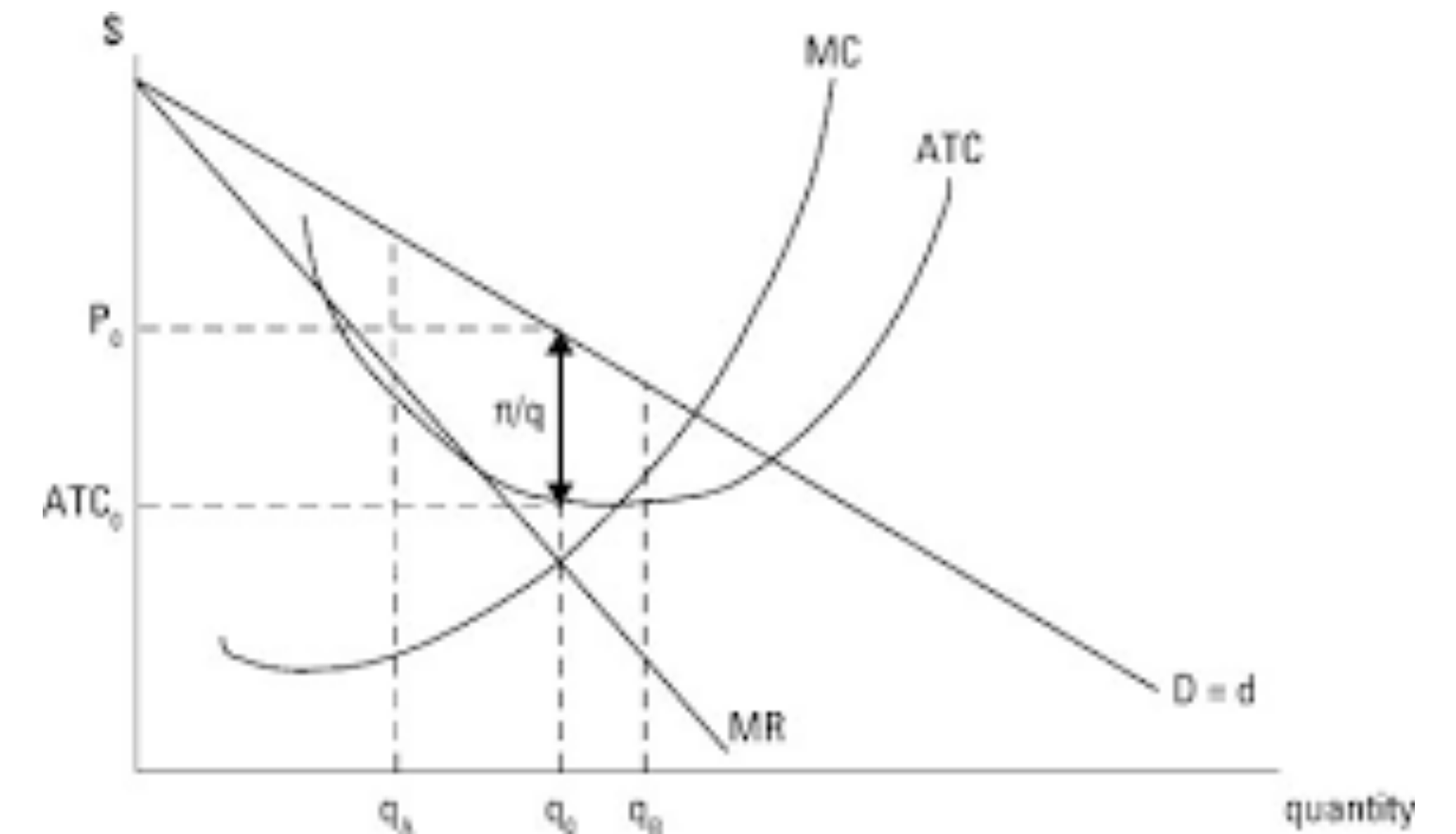


- **What is economics calculation?**
  - The E.C. is a formalized approach that helps an economic agent (States, Firms, Consumers, etc.) to take a decision based on an economical rational argument
  - E.C. is specifically used by firms and States, especially in the framework of the energy sector and energy transition problematics

# FCW and the economy

## The economics calculation

- Firm calculation (Private)
  - Decision support tool for investment strategy
  - Based on the economics profit optimization
  - Also use risk analysis to improve strategy



# FCW and the economy

## The economics calculation



- **Social calculation (Public)**
  - Quantify social utility of public spending
  - Take into account non-profit effects and convert them into same standard
  - Beyond cash-flows: security, pollutions, natural goods protection, climate change, etc.



# FCW and the economy

## The economics calculation and the energy

- The energy sector traditionally use the E.C.
  - Huge investments
  - Long term involvement at the scale of the country
  - Desynchronization between expenses and revenues
  - Strong constraints of Electricity market
- New context of greenhouse gas reduction targets
  - The energy transition involves strong anticipations for very long term strategies
  - The role of the E.C. will / should probably increase



# FCW and the economy

## Basic concepts of the E.C.

- Discount rate

- Value of time
- Equivalence between cash-flows
- Usually  $r \in [0, 10]$

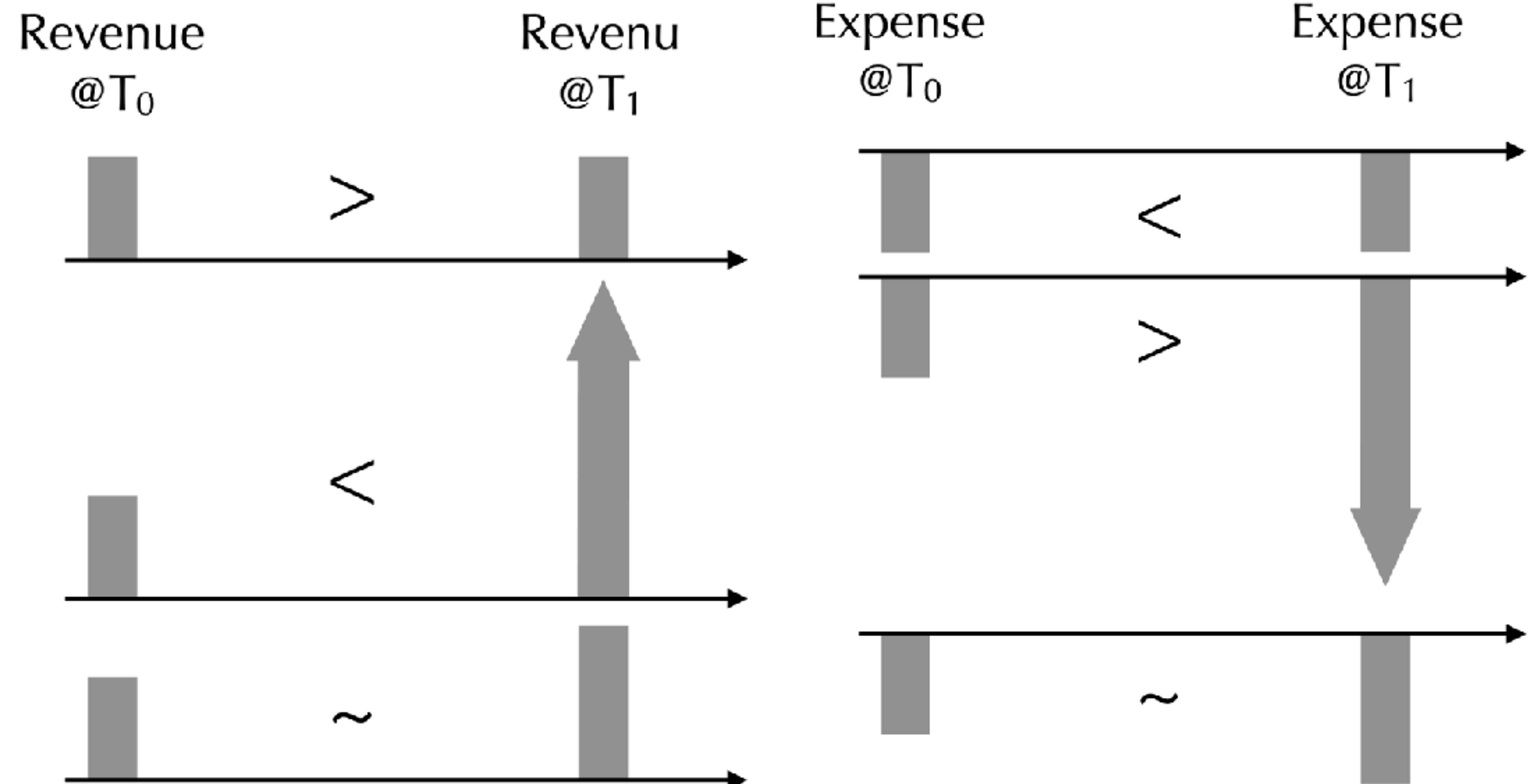
$$\rightarrow r_t = \delta + yg - 0.5y(y+1)\sigma^2$$

Wealth effect

Pure préférence for the present

precautionary effect

$$F(t_1) = \frac{F(t_2)}{(1+r)^{(t_2-t_1)}}$$



# FCW and the economy

## Basic concepts of the E.C.

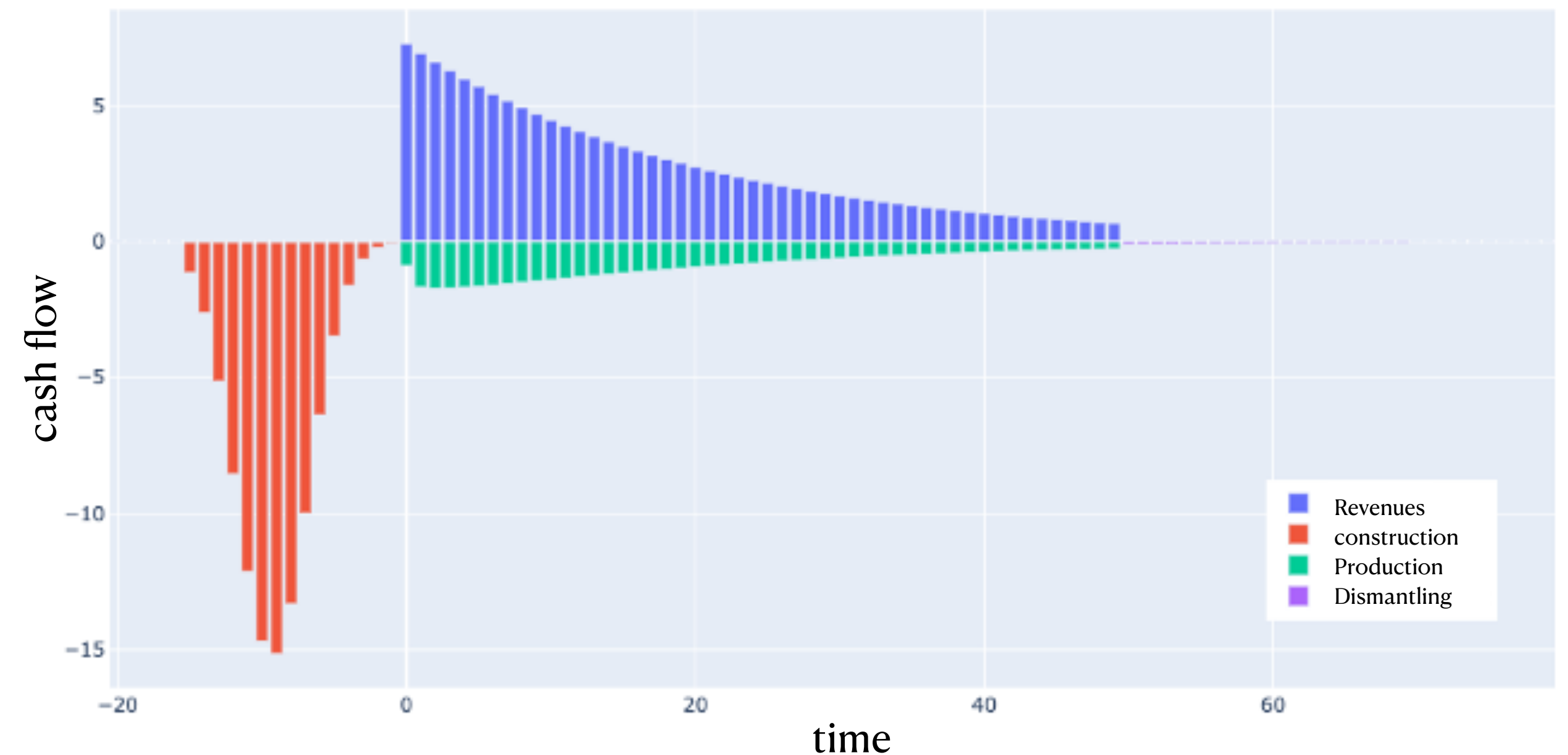
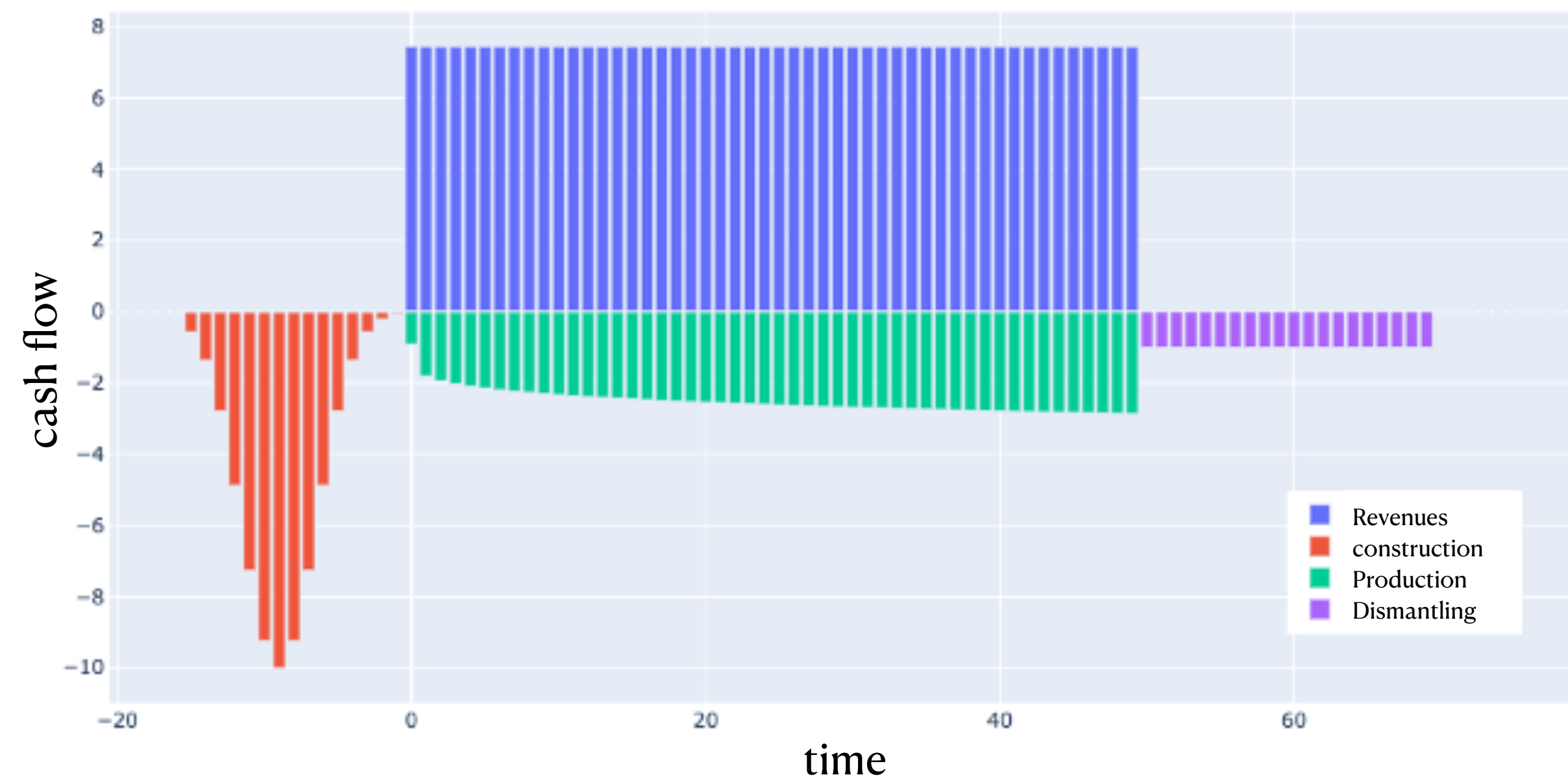
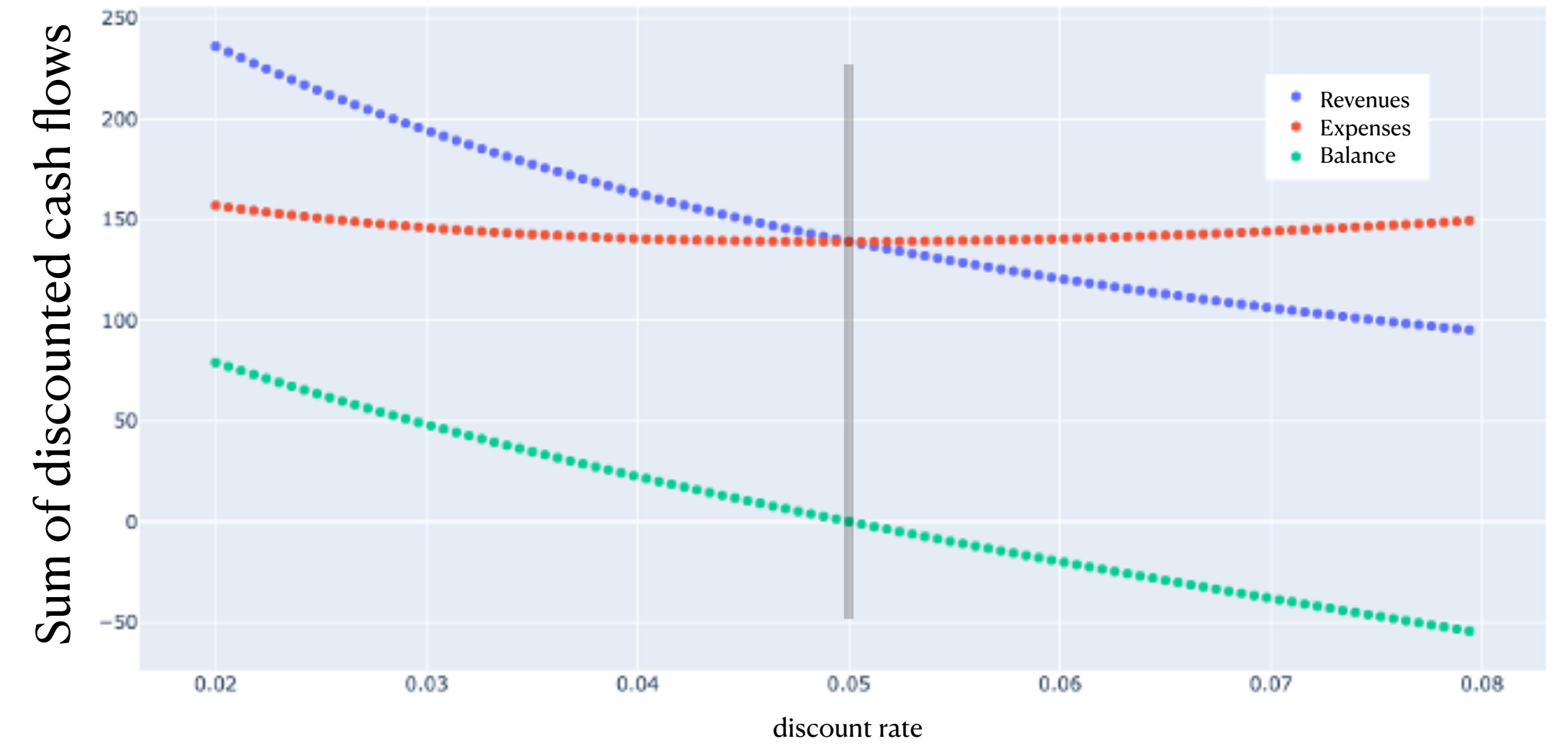


### • Net Present Value

- Sum of net discounted cash-flows at the reference time

### • Internal profitability rate

- Rate that provides  $N.P.V. = 0$



# FCW and the economy

## Basic concepts of the E.C.

### • Levelized Cost Of Electricity

- Assumptions : Discount rate and electricity price are stable on the project lifetime
- LCOE is the price of electricity that provides the equality between "the present value of the sum of discounted revenues and the present value of the sum of discounted costs" (NEA)

$$\rightarrow \text{LCOE} = \frac{\sum_t [I(t) + OM(t) + F(t) + C(t) + D(t)] \frac{1}{(1+r)^t}}{\sum_t [E(t)] \frac{1}{(1+r)^t}}$$

### • Important points

- The energy, as a physical value, is not discounted...
- Revenues from electricity sold at a constant price are discounted
- There is no market effect in LCOE... On of the limitations.

(=> Ivan Merino)



# FCW and the economy

## The physicist, the economist and the model

### • The physicist

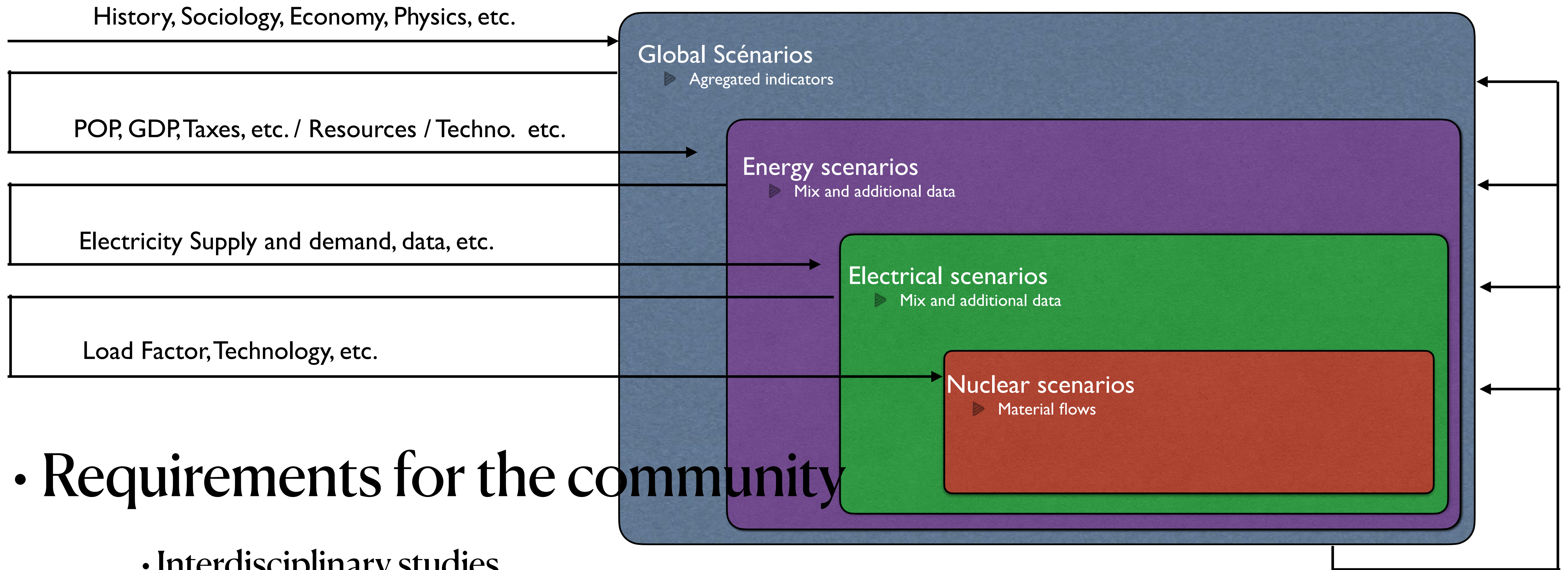
- The model should reproduce the reality
- We should be able to quantify deviation between the model and the reality
- But... How to deal with a deep uncertain future? Assumptions on the evolution of electricity production, technologies, etc. have huge impact on results
- Resilience? Robustness ? (=> Guillaume L'Her)

### • The economist

- The model is a representation of the reality
- The model carry some positive and normative considerations
- A cost is not a physical data !
- The model is mainly a common framework that allows discussing assumptions, methodologies and results

# FCW and the economy

Up to energy scenarios...



## • Requirements for the community

- Interdisciplinary studies
- Coupling approaches

(=> Sibylle Martin-Lauzer)



## **Electric transition in a fictitious emerging country - Impact of external constraints.**

Martin-Lauzer Sibylle<sup>1</sup>, Cathalau Stéphane<sup>1</sup>

<sup>1</sup>DES/IRESNE/DER, CEA Cadarache (Saint Paul-lez-Durance, France)

- **Energy / Electrical Scenarios study**
  - Transition of a fictitious country
  - Reducing the economy dependence on oil and gas
  - Carbon tax, Energy efficiency, Carbon free electricity...



## **First approach to the estimation of Levelized cost of Electricity in ANICCA code**

Merino Ivan<sup>1</sup>, Valdés Jorge<sup>1</sup>, Hernandez Solis Augusto<sup>2</sup>

<sup>1</sup>Universidad Catolica Del Maule (Chili)

<sup>2</sup>Centre d'Etude de l'Energie Nucléaire (Belgium)

- **Levelized Cost of Electricity calculation**
  - Economic module in ANICCA
  - LCOE breakdown
  - Uncertainty analysis from Monte Carlo method

## **Impact of Fuel Supply Chain Disruptions on Energy Resilience: A case for Nuclear Energy**

L'her Guillaume<sup>1</sup>, Deinert Mark<sup>1</sup>

<sup>1</sup>Colorado School of Mines (United States)

- **Energy network disruption**
  - Natural events
  - Strong dependance in energy supply chain induces a small system resilience
  - Role of the nuclear energy

- Nuclear fuel cycle interaction with electrical and energy systems
- Questions / Comments ?



# • Discussion topics

Theme #1 : How can we / should we strengthen the links between economics and physics scenario studies ?

Currently, it seems that there is a "weak link" :

- Reference costs -> Economics study
- Physics -> COST -> Eco

Is this possible to build a strong link, like a direct coupling

- Internship of Aimeric Eustache @CEA Cadarache (Coupling between LCOE calculator and the COSI code)
- Work of Ivan Merino with ANICCA

=> What are the scientific questions we want to provide answers ?

# • Discussion topics



Theme #2 : Can we do economy studies without any economists in the team ?

=> We don't really have the necessary distance and the deep knowledge of concepts and formalism

=> How can we have "safeguard" for our studies and our conclusions ?

Physicist : What is your experiment with economists ?

Economist : What is your experiment with physicists ?