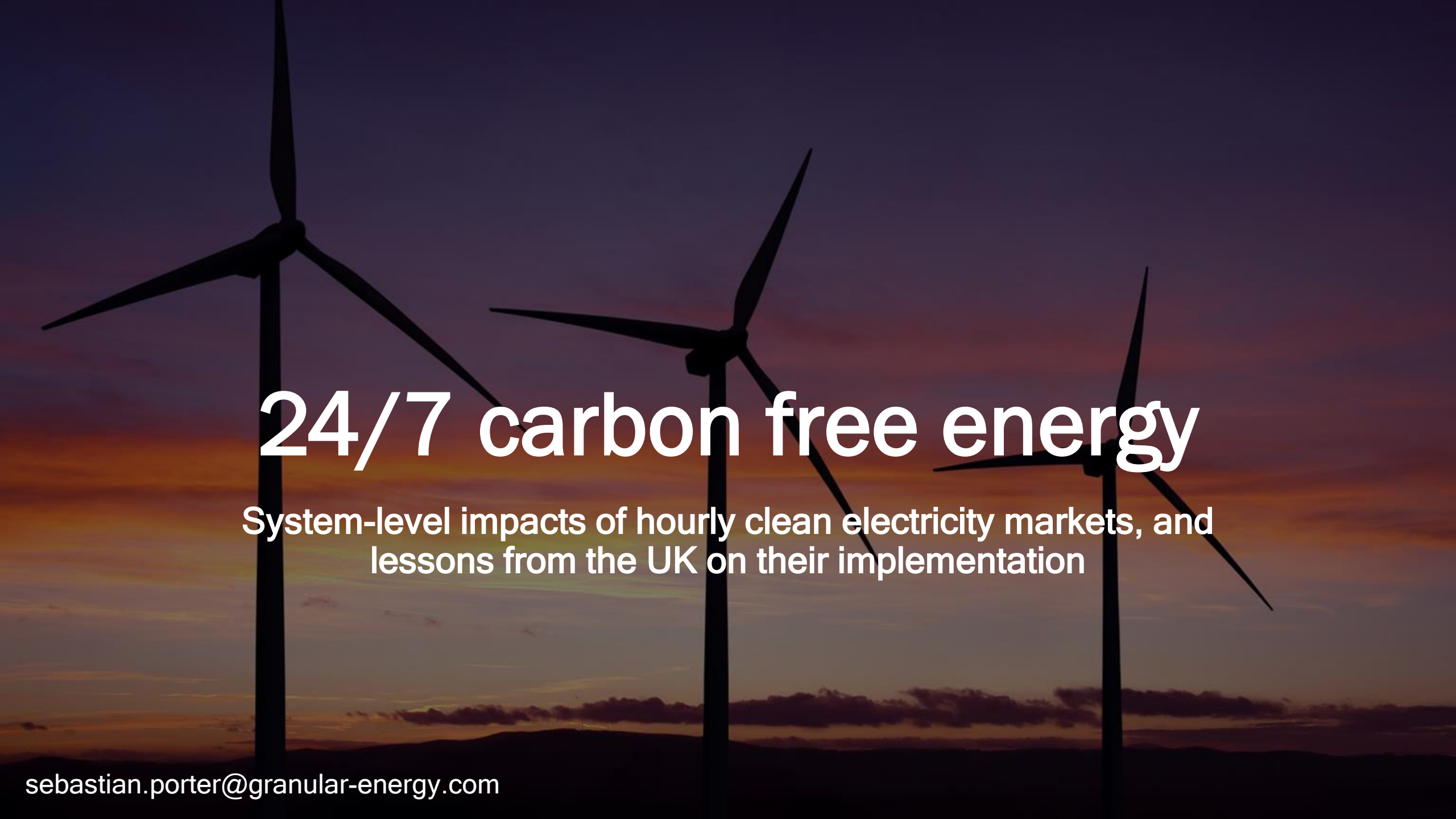


24/7 carbon free energy

System-level impacts of hourly clean electricity markets, and lessons from the UK on their implementation

sebastian.porter@granular-energy.com

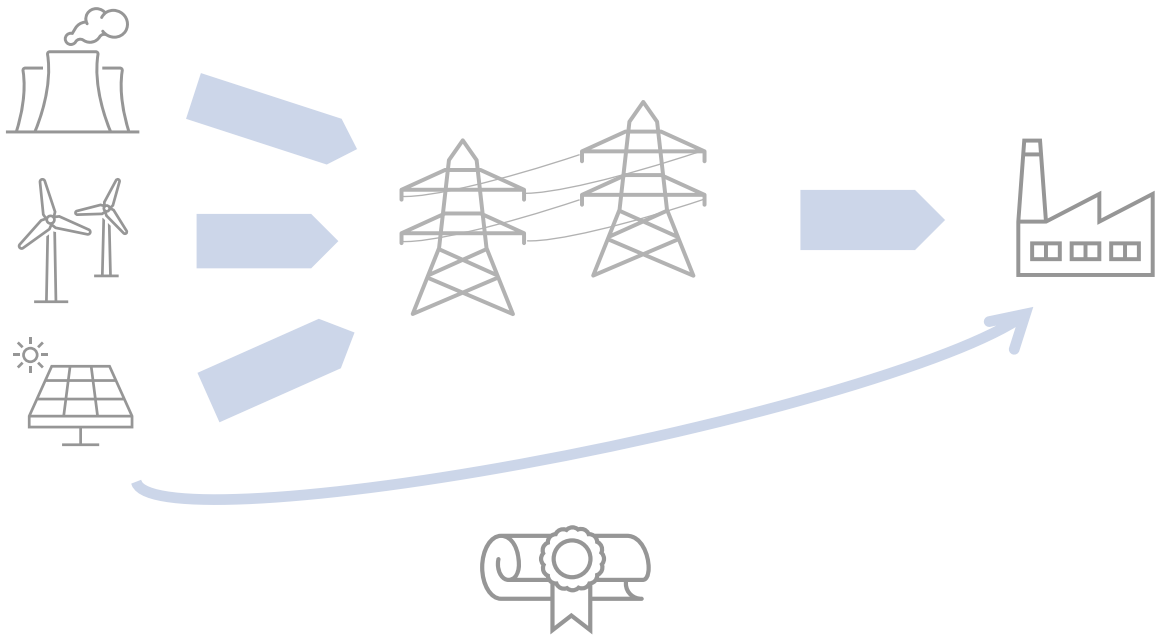
Agenda

- Introduction
- System-level impacts of 24/7 CFE: a literature review
- Lessons on practical implementation of hourly RE markets from the UK
- Conclusions

Introduction

What is clean electricity?

Since all power stations use the same electricity grid...



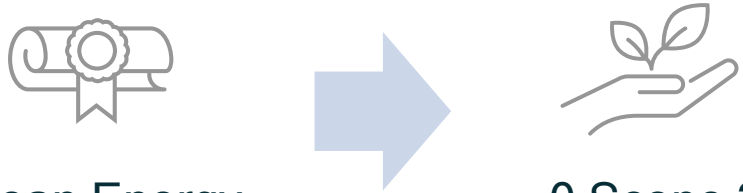
Certificates

are used to track renewable energy

The **Greenhouse Gas Protocol** sets the rules on carbon accounting...

GREENHOUSE GAS PROTOCOL

... and stipulates purchasing clean energy certificates to reduce scope 2 emissions[1]



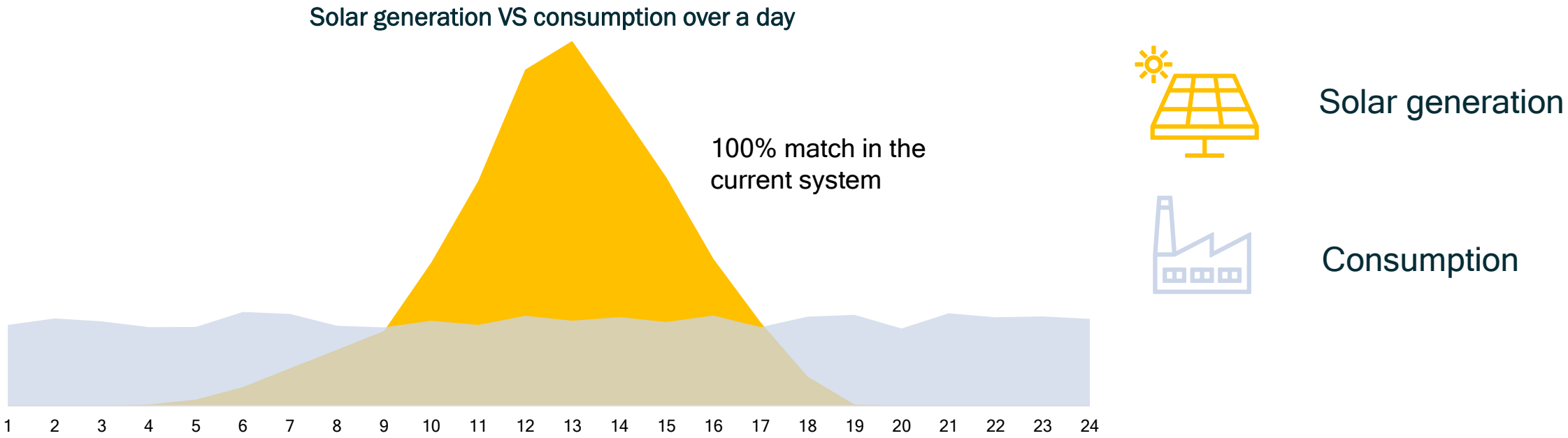
This is known as...

Market-based Carbon Accounting

[1] Greenhouse Gas Protocol, "Scope 2 Guidance," World Resources Institute, Washington DC, 2015.

The current energy certificate system has a serious problem.

The current system records location but not time of production, and matches consumption and generation using these certificates over an **annual** period



Consumption at night can be matched with generation from solar at noon

This does not reflect the physical reality of the grid and can overestimate emissions savings by up to 50%[1]

[1] Matthew Brander, Michael Gillenwater, Francisco Ascui, Creative accounting: A critical perspective on the market-based method for reporting purchased electricity (scope 2) emissions, Energy Policy, Volume 112, 2018, Pages 29-33

Moving to “hourly” certificates may solve this problem

Using certificates that enforces matching between generation and consumption on an hourly or sub-hourly time period could yield significant benefits

Rebuilding trust with consumers

by solving the main issue of timing mismatch between generation and consumption

Additional revenues for storage & flexibility

by capturing the spread between low and high price hours

More accurate carbon accounting

as electricity’s carbon intensity actually varies significantly on an hourly basis

System-level impacts of hourly RE markets

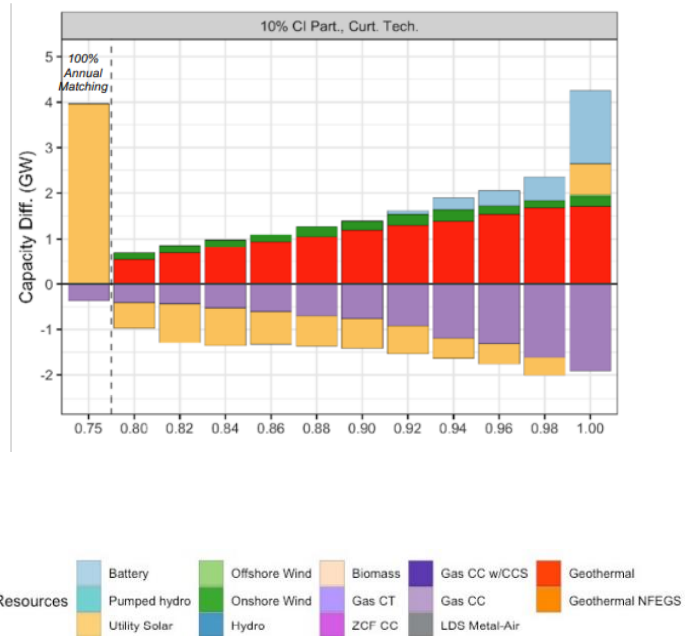
A literature review

Key papers

- "Advancing Decarbonisation Through Clean Electricity Procurement", IEA, November 2022
- "System-level Impacts of 24/7 Carbon-free electricity procurement in Europe", TU Berlin, October 2022
- "Electricity System and Market Impacts of Time-based Attribute Trading and 24/7 Carbon-free Electricity Procurement", Princeton Zero Lab, September 2022
- "System-level Impacts of 24/7 Carbon-free Electricity Procurement", Princeton Zero Lab, November 2021

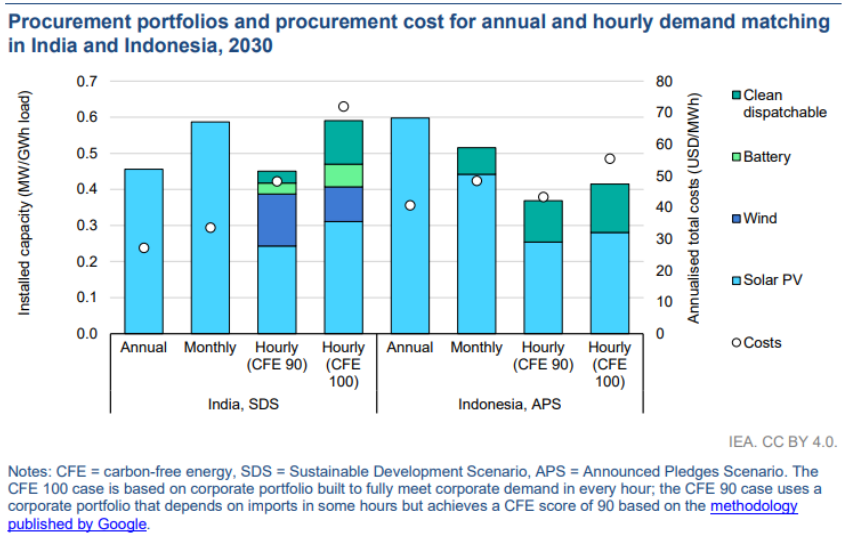
Key Finding 1: Hourly RE procurement can deliver smarter investment in RE capacity

California:
additional 2 GW geothermal capacity



Source: Princeton Zero Lab

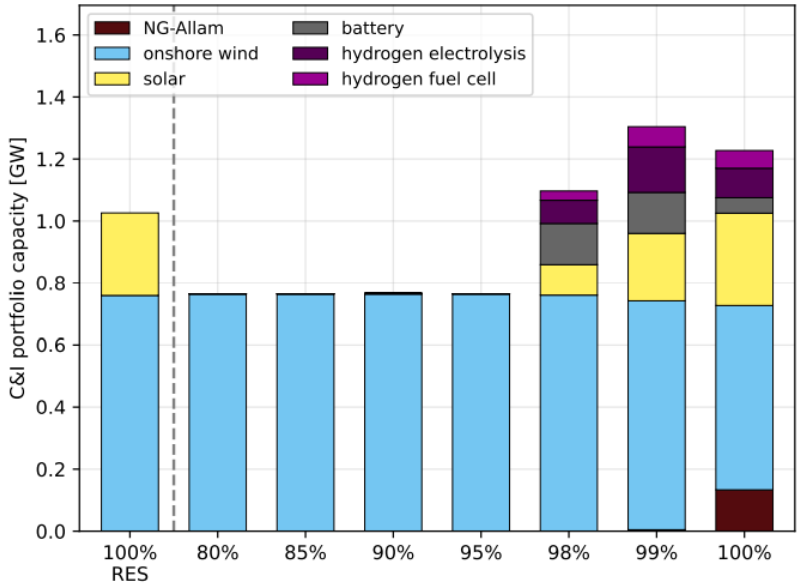
India and Indonesia:
Diversification from solar to wind and clean dispatchable resources



Notes: CFE = carbon-free energy, SDS = Sustainable Development Scenario, APS = Announced Pledges Scenario. The CFE 100 case is based on corporate portfolio built to fully meet corporate demand in every hour; the CFE 90 case uses a corporate portfolio that depends on imports in some hours but achieves a CFE score of 90 based on the methodology published by Google.

Source: IEA

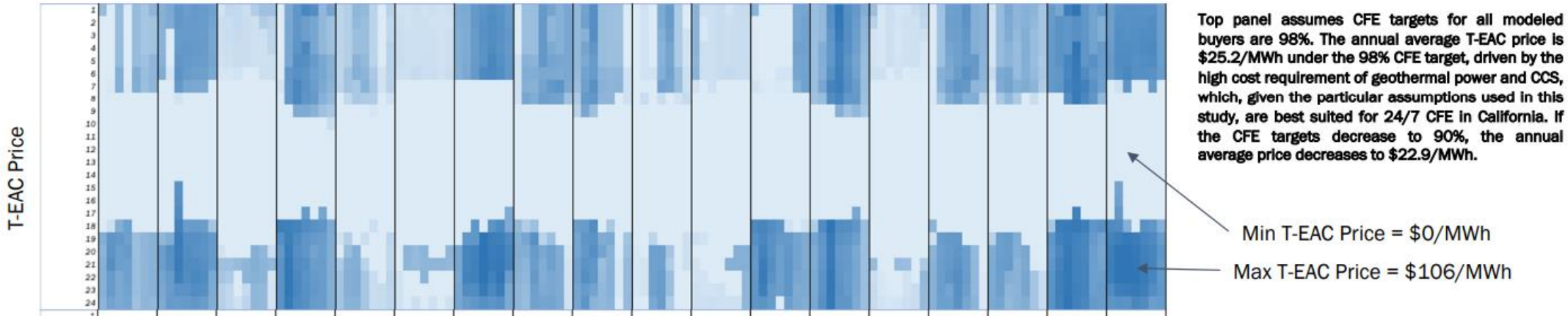
Denmark:
additional 0.35 GW wind and clean dispatchable resources



Source: TU Berlin

Key Finding 2: Hourly RE markets can promote the integration of storage on the grid

Clean Energy Certificate Price Variation in California

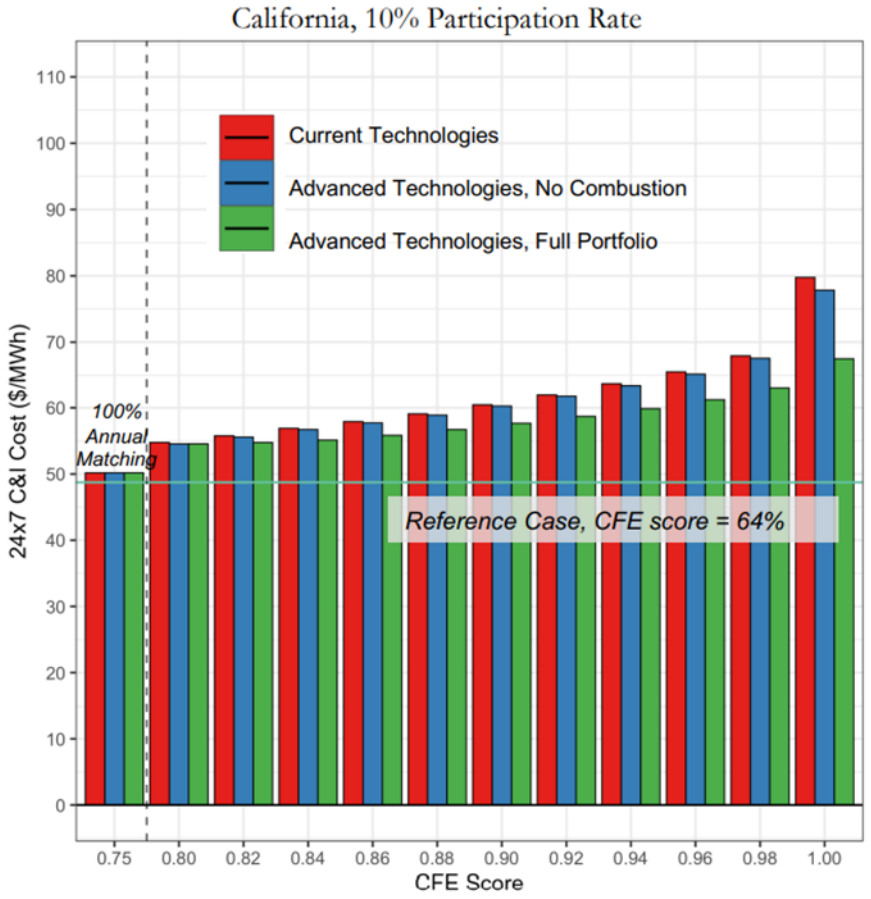


Source: Princeton Zero Lab

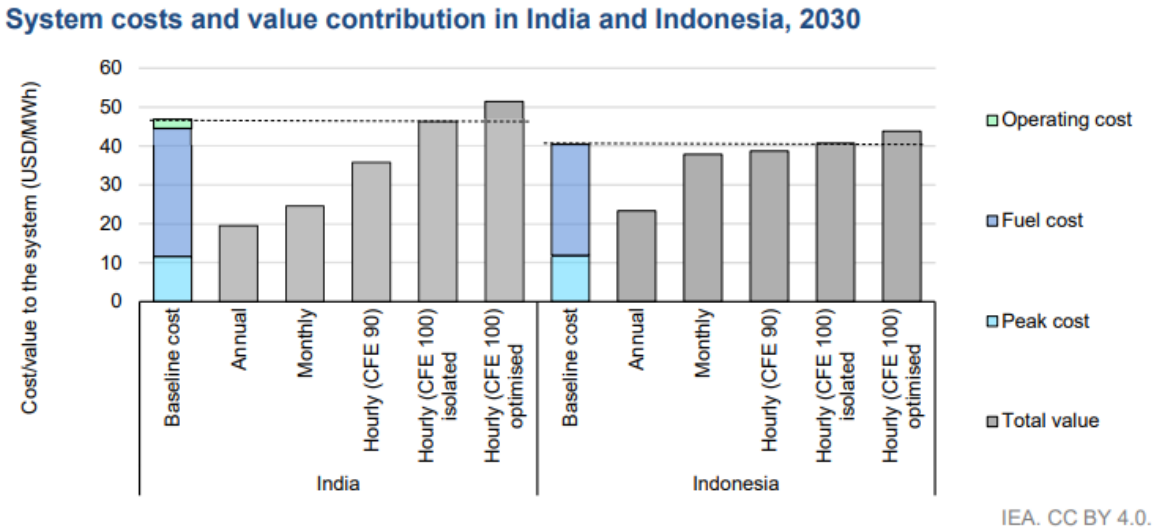
Modelling of California's energy system shows that hourly clean energy certificate (T-EAC) prices can vary by as much as $106/MWh in a single day.
This allows storage assets to capture the spread in price, giving them an additional revenue stream.

Key Finding 3: 100% hourly RE is more expensive but delivers higher system value.

Cost for 24/7 participating C&I consumers – California



Source: Princeton Zero Lab



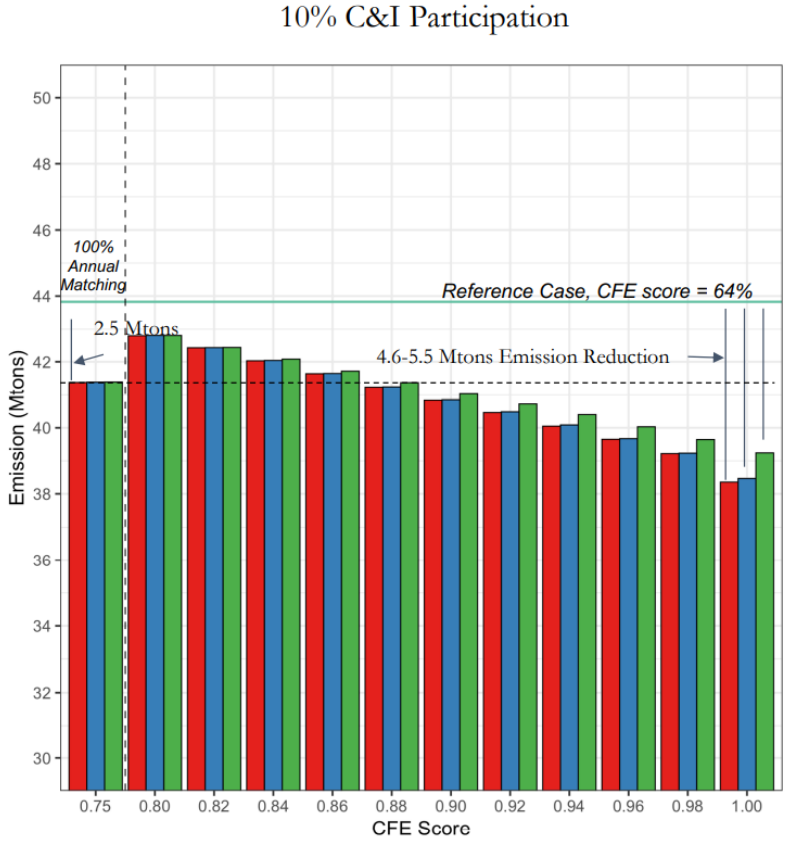
Notes: CFE = carbon-free energy, SDS = Sustainable Development Scenario, APS = Announced Pledges Scenario. The CFE 100 case is based on corporate portfolio built to fully meet corporate demand in every hour; the CFE 90 case uses a corporate portfolio that depends on imports in some hours but achieves a CFE score of 90 based on the methodology published by Google. Isolated dispatch refers to a case in which the corporate portfolio is operated only to match the corporate load profile. Optimised dispatch seeks to align optimisation of the corporate portfolio with that of the entire power system.

Source: IEA

Key finding 4: hourly RE markets deliver better grid decarbonisation outcomes

California:

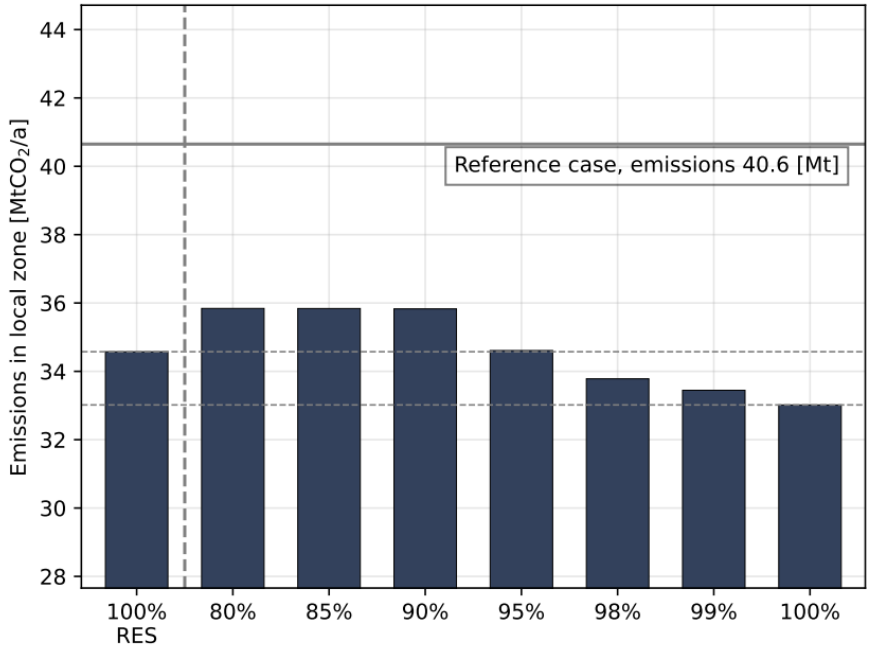
2.5M tons CO_2 reduced vs annual RE markets per year (+ 84%-120%)



Source: Princeton Zero Lab

Germany:

2M tons CO_2 reduced vs annual RE markets per year (+30%)



Source: TU Berlin

Practical Implementation of hourly RE markets

Lessons from the UK

The GB Demonstrator Project– The importance of involving many electricity market stakeholders.

GRANULAR

- Start up providing SaaS services to manage and trade certificates
- Role:
  - Pilot lead, overseeing the whole certification scheme
  - Provides certificate management platform to participant
  - Jointly develop the exchange with Nord Pool

NORD POOL

- Nord Pool, Europe's leading power market, delivers efficient, simple and secure trading across Europe
- Role:
  - Exchange platform and auction development
  - Operate the exchange
  - REGO account trustee

ELEXON

- Elexon manages the BSC, and the power imbalance mechanism.
- Role:
  - Support to design the certification framework
  - Expertise on GB metering and settlements
  - Exploring further roles in an enduring solution (e.g. metering, imbalance)

UNICORN

- European IT software company providing products and solutions in Energy and Utilities for TSOs, European initiatives, Exchanges, Energy Certificates, Power Trading, Flexibility, Electromobility and more.
- Role: provides the hourly certificate registry

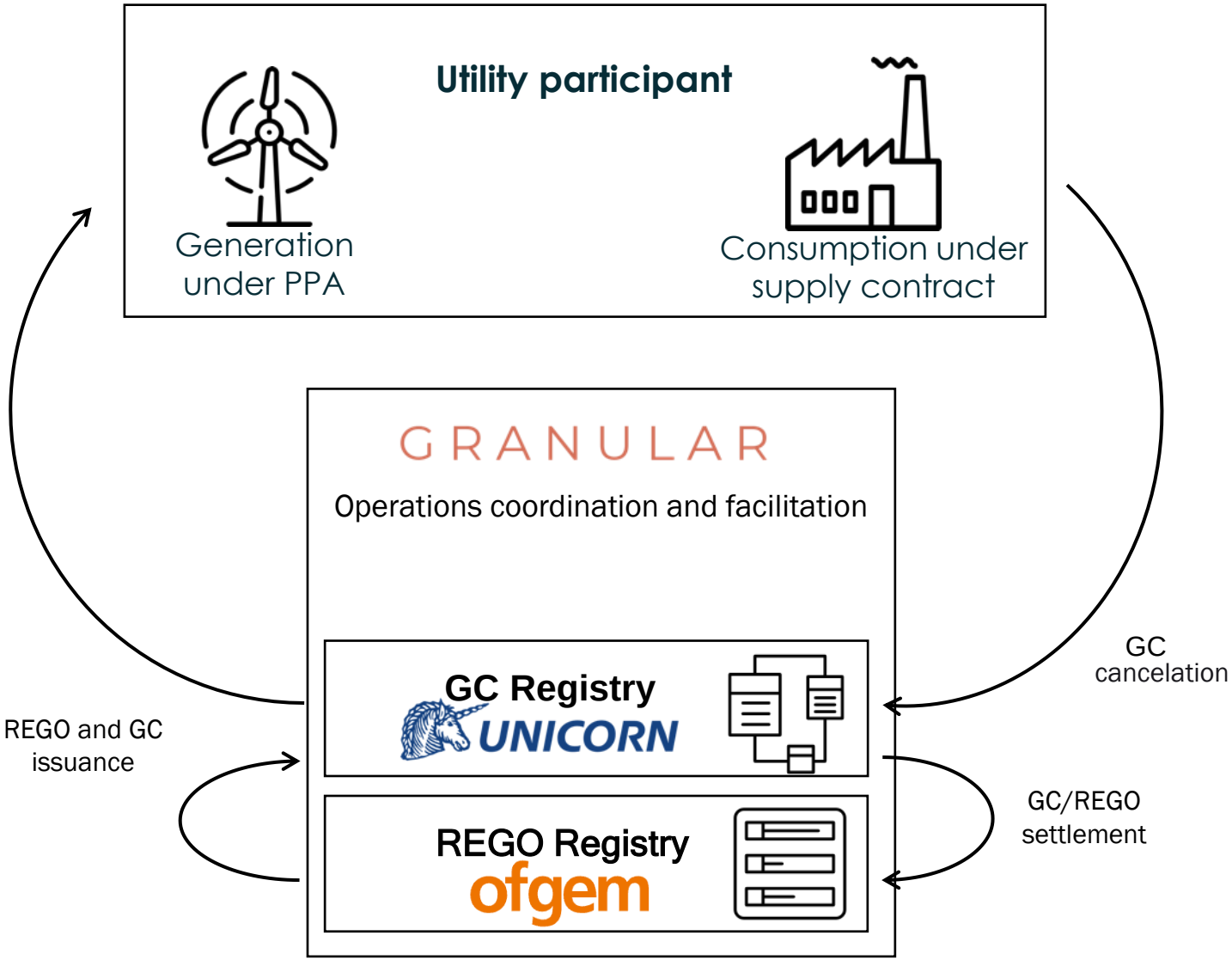
CATAPULT Energy Systems

- independent, not-for-profit innovation centre
- Role:
  - Expertise to design the certification framework
  - Support drafting the pilot reports
  - Support disseminating findings of the PoC

Other supporters

- **NGESO**: supportive of the initiative, will participate to stakeholder engagement process and reports
- **PWC (in discussions)**: audit of the certification scheme

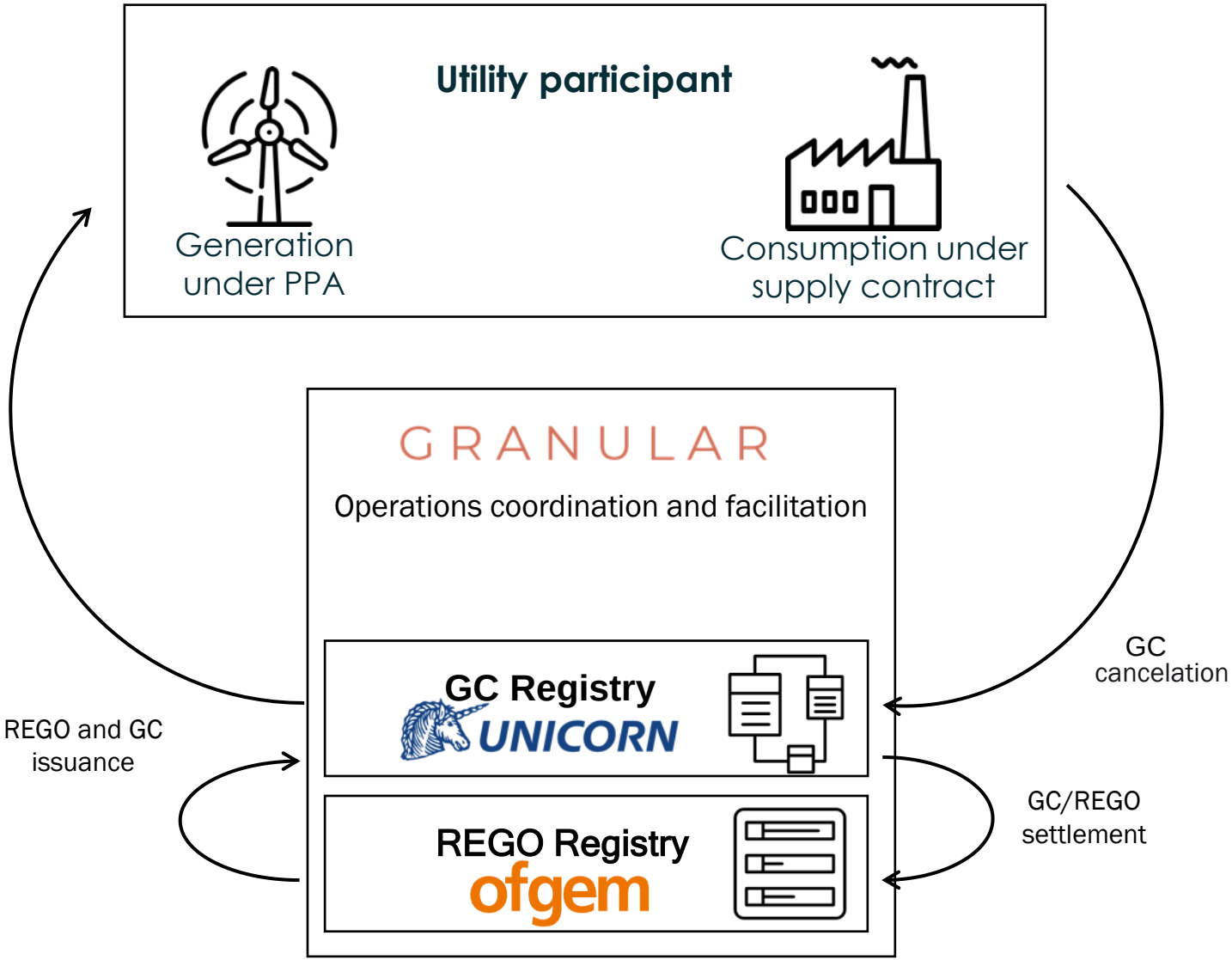
The GB Demonstrator Project– Utilities emerge as key players



- Utilities sit at a key node in power markets
- They have access to both consumption and generation data
- They are already experienced in managing the matching of consumption and production in forward, day-ahead, and intra-day electricity markets

- **Utilities are the key to scaling hourly electricity markets**

The GB demonstrator Project – Importance of accommodating legacy certificate systems



- Legacy certificate systems are present in most advanced electricity markets
- Their core role is to prevent double counting of renewable energy claims
- Introducing a new certificate system could risk double counting

- **Hourly electricity markets must initially be backward-compatible with legacy certificate systems to prevent double counting.**

Conclusions

Conclusions

- Hourly electricity markets are a new and rapidly evolving field
- Likely to play a key role in the energy transition

- More data and academic studies are needed, particularly on policy implications.

- Contact: sebastian.porter@granular-energy.com