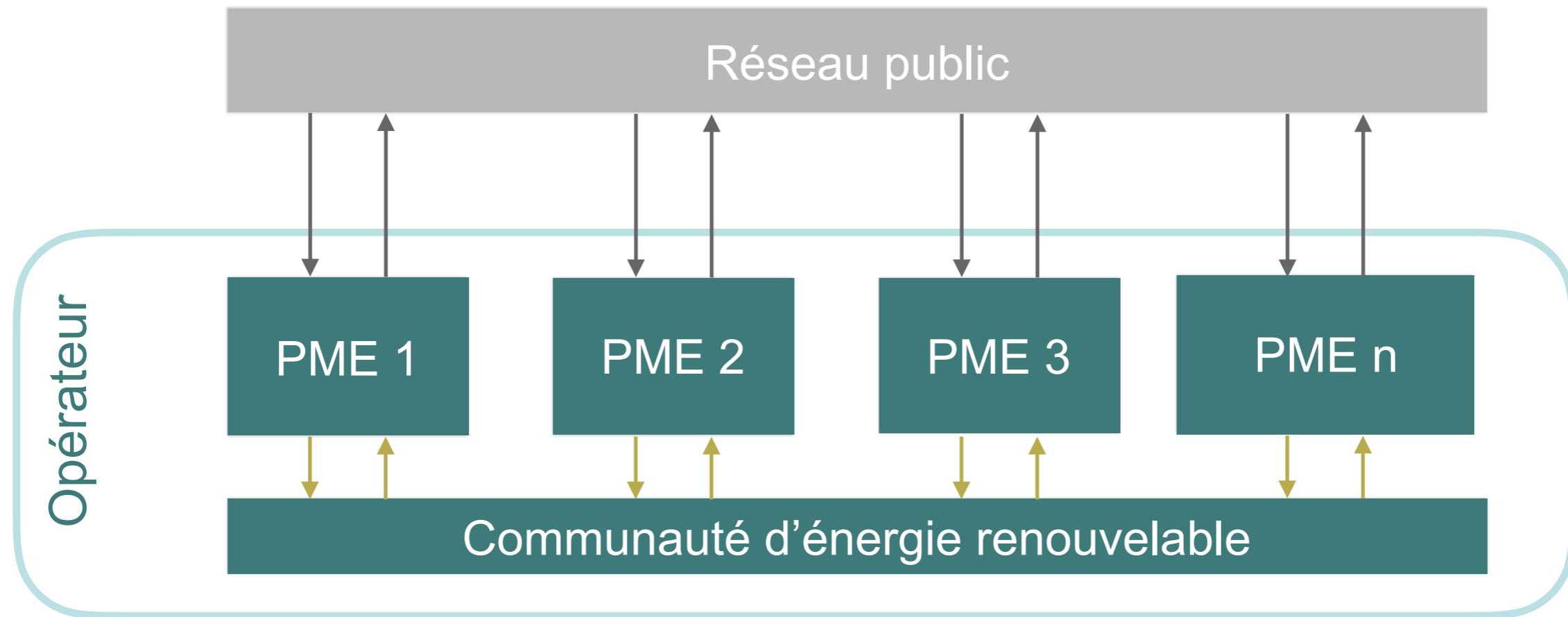


Les Communautés d'Énergie Renouvelable

Introduire un circuit-court dans le marché de l'énergie

Une Communauté d'Énergie Renouvelable, qu'est ce que c'est ? Cas des PME



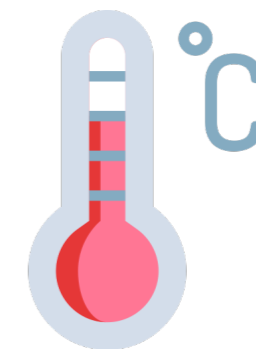
L'opérateur minimise le coût de l'énergie consommée, maximise les revenus provenant de la vente d'énergie et de services, gère les relations entre les membres de la communauté (conventions, facturation, etc.)

Le projet MeryGrid

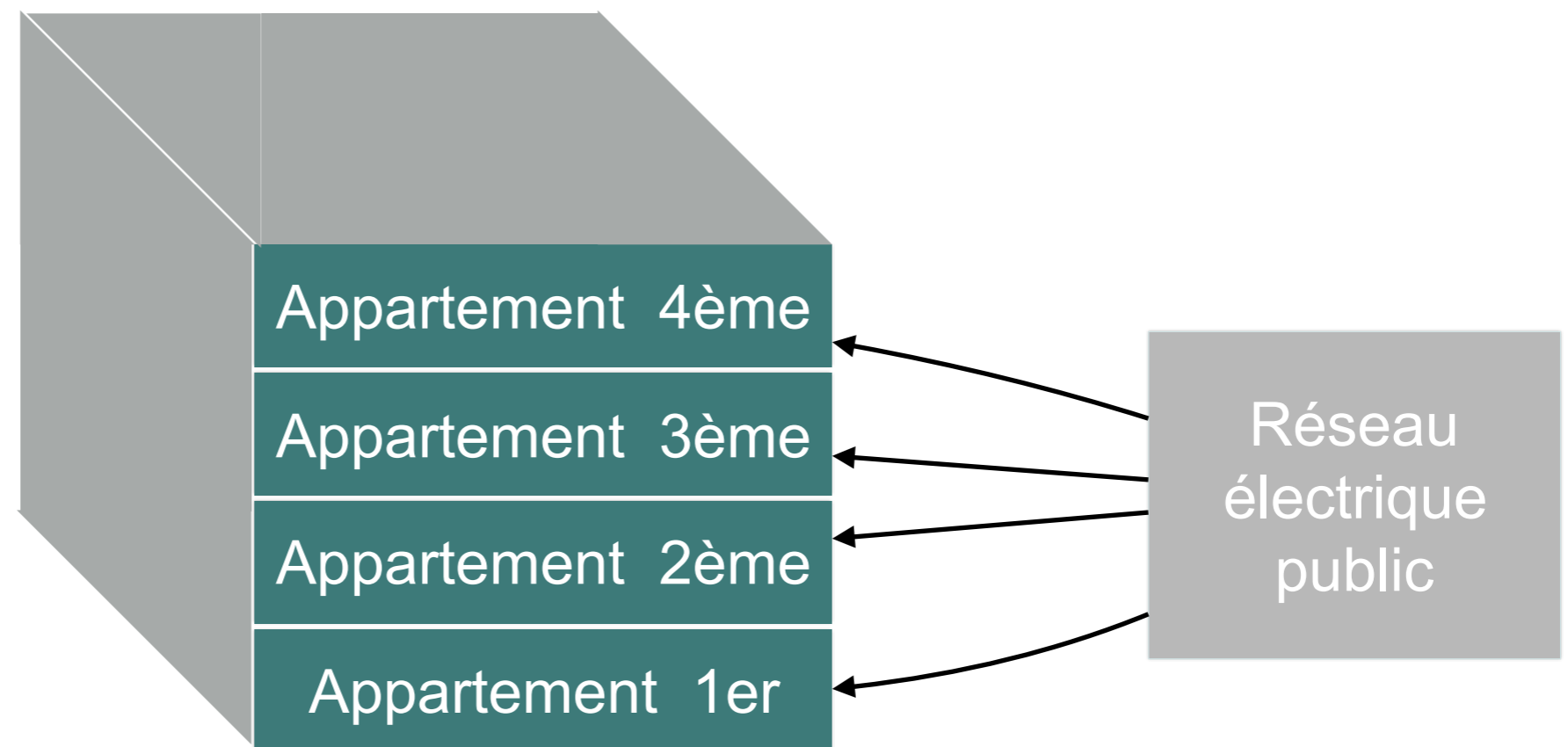


Quels sont les intérêts ?

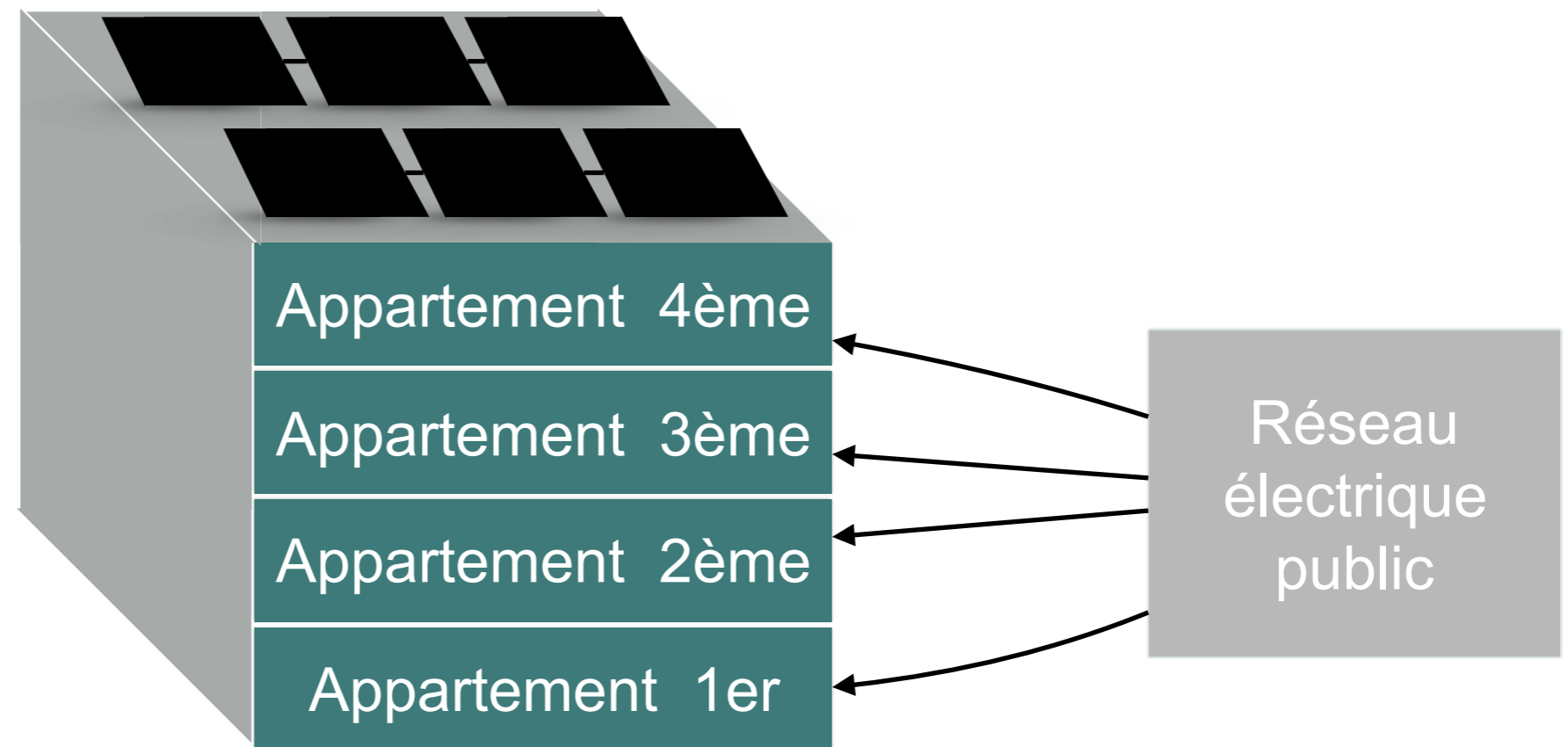
- Maximiser utilisation du réseau local
 - ✦ économiser sur le tarif réseau
- Découple "l'investissement" de "l'utilisation"
 - ✦ donne accès à l'énergie renouvelable aux personnes qui n'ont pas nécessairement les moyens d'investir (différent du tiers-investisseur)
- Maximiser la pénétration des "énergies renouvelables"
 - ✦ diminuer les émissions de CO₂
- Maximiser l'efficacité des autres sources d'énergie
 - ✦ diminuer les pertes d'énergie (co-génération, ...)



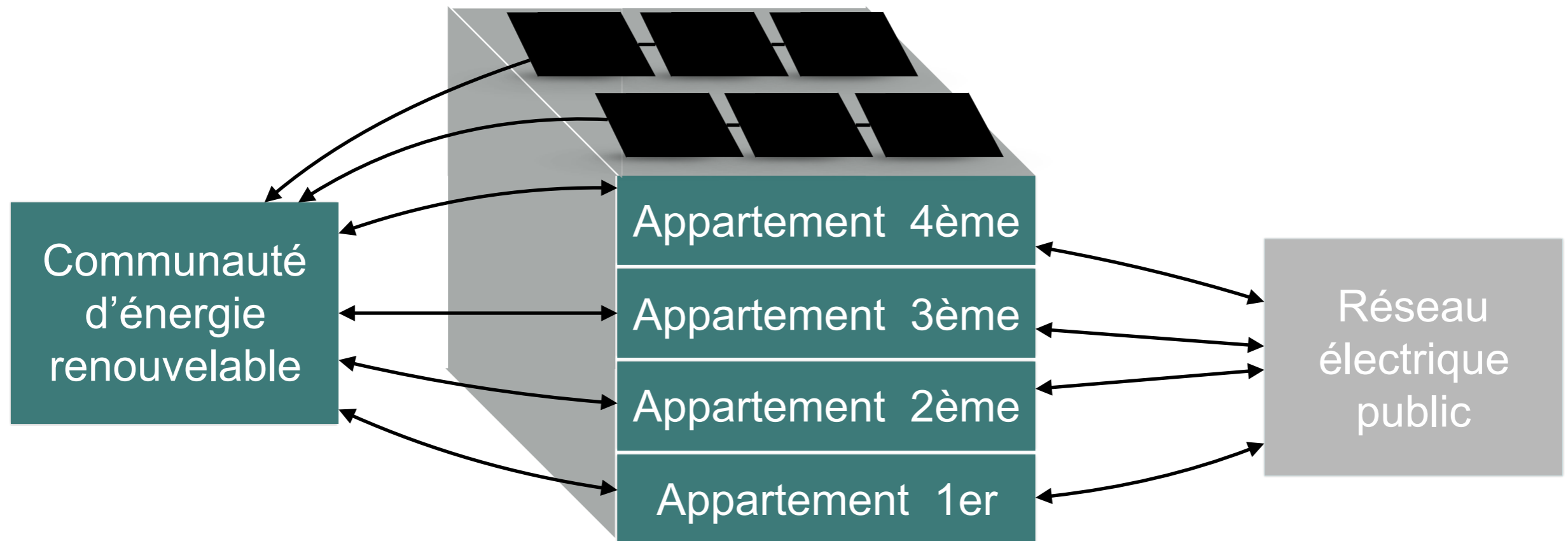
C'est exactement la même situation pour une copropriété ...



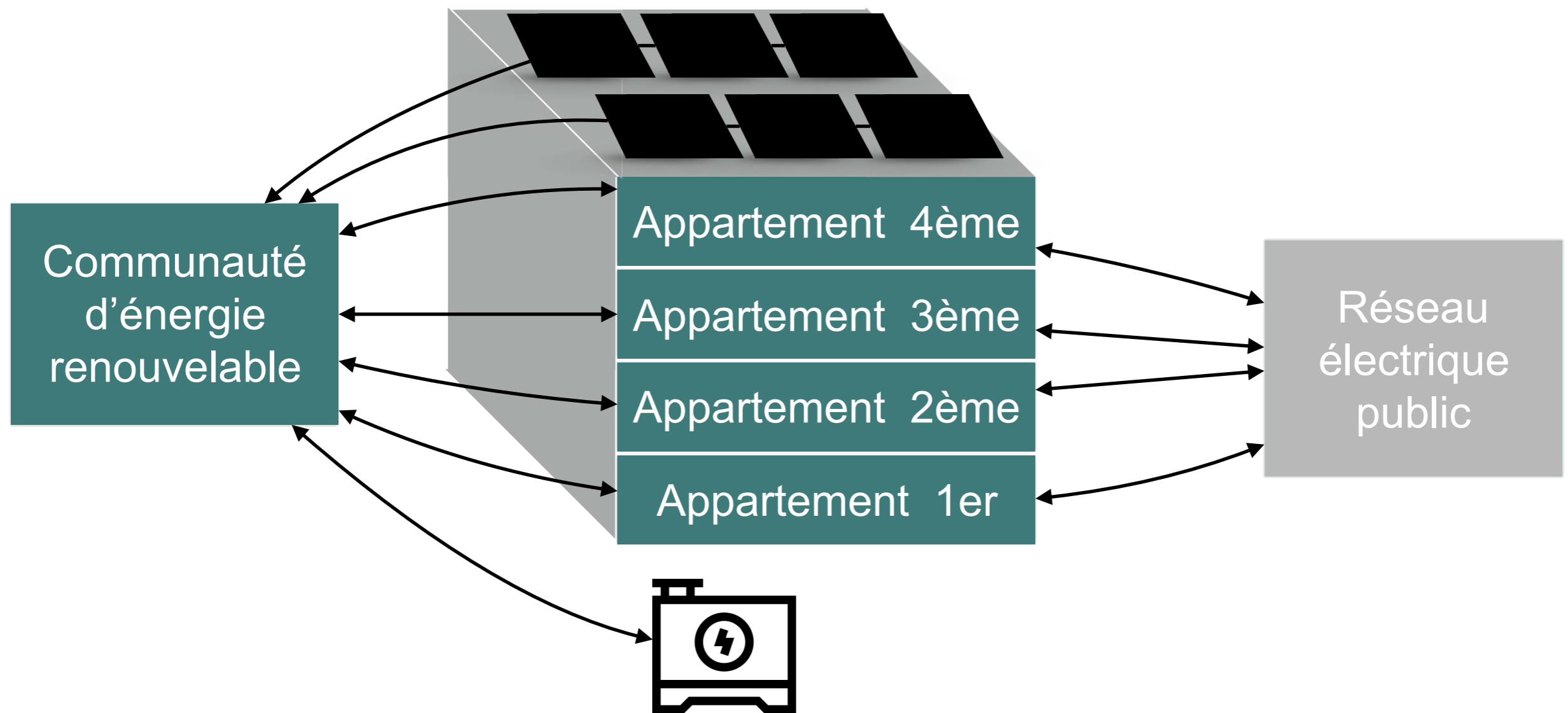
Pour le moment : uniquement pour les communs !



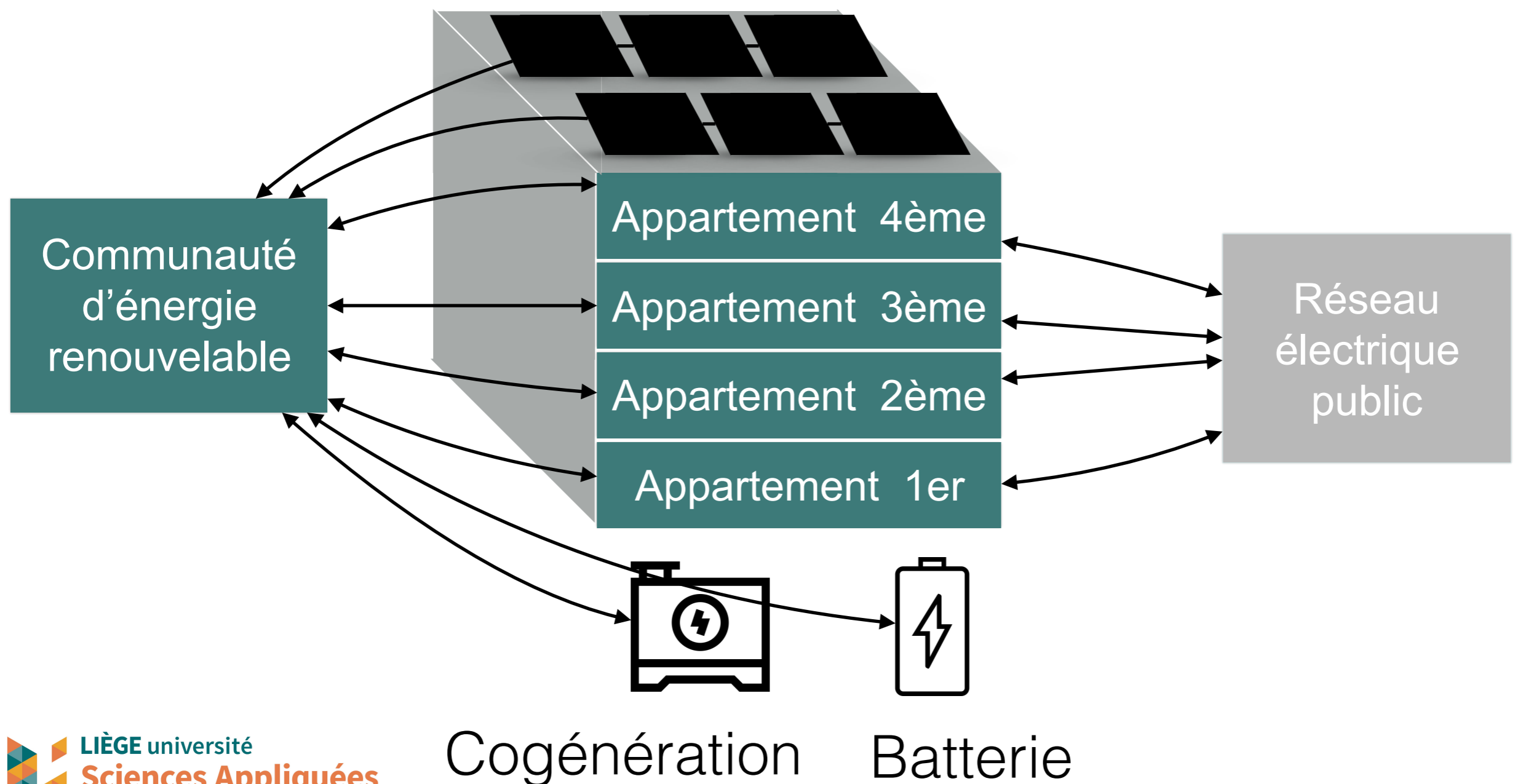
Partager l'électricité produite



C'est exactement la même situation pour une copropriété



C'est exactement la même situation pour une copropriété

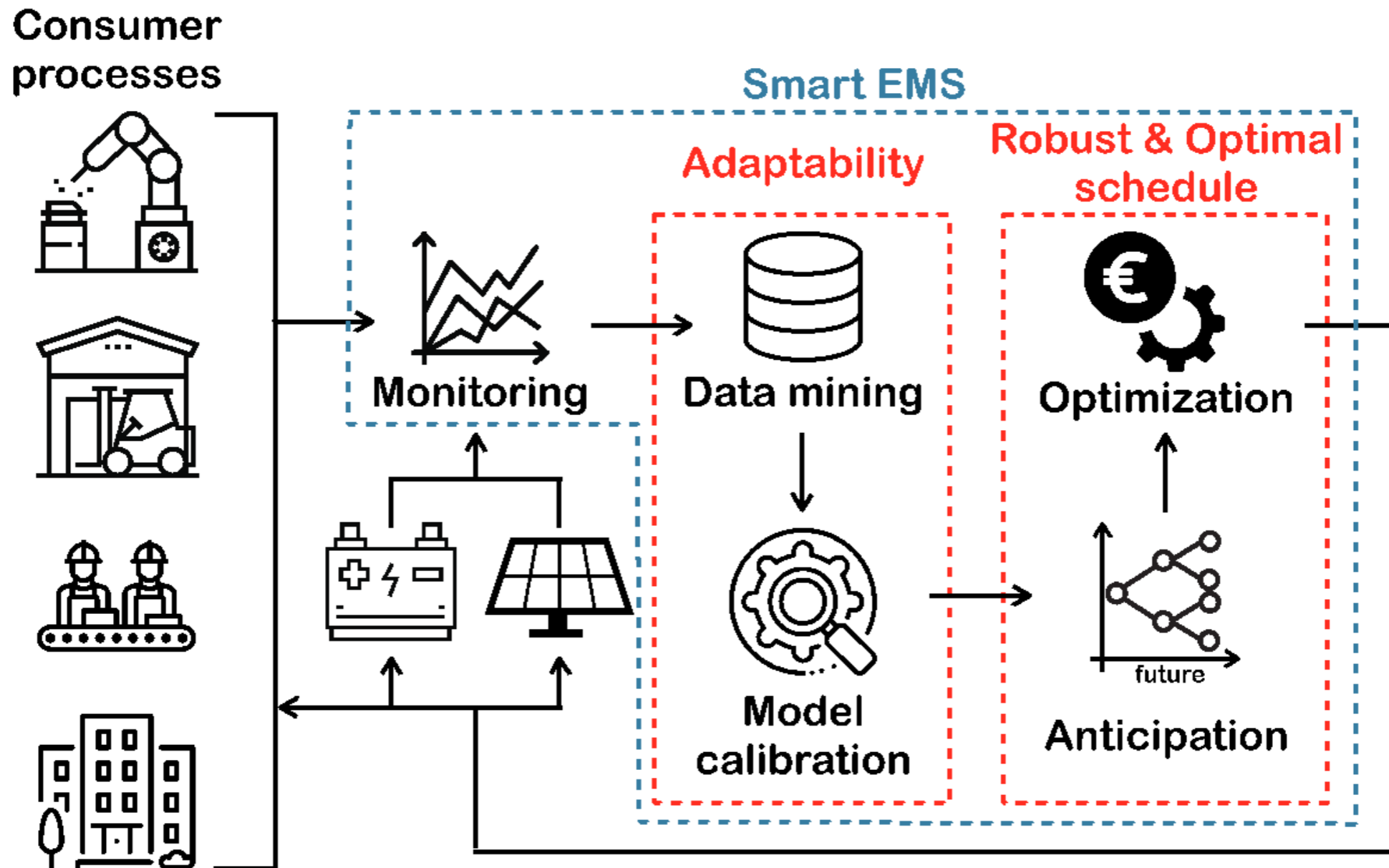


Que faut-il mettre en place ?

- Nécessite un effort pour synchroniser production et consommation
 - ✦ flexibilité de la consommation, production, stockage
- ✦ Nécessite un cadre légal, et une manière concrète de fonctionner dans ce cadre légal



Comment ? Grâce à un système de gestion de l'énergie (EMS) pour surveiller et optimiser les décisions d'achat / vente / échange / stockage / ...



Comment ? Avec un bon “modèle de marché”

- Chaque membre garde toujours l'opportunité de consommer l'énergie du réseau
- Des règles pour garantir l'équité des décisions de gestion
- Référence : le projet MeryGrid



Un compromis entre



Cadre Wallon

- Rôle de l'opérateur
 - ♦ Société
 - ♦ Pas un GRD
- Ne fixe pas encore de tarif pour l'utilisation communauté
- Quelques extraits du décret ...

Définitions

- « *2^oter* » communauté d'énergie renouvelable » : personne morale constituée d'un ensemble de participants en vue de partager, via le réseau public de distribution ou de transport local, de l'électricité exclusivement produite à partir de sources d'énergie renouvelables ou de cogénération de qualité, par des unités de production et, le cas échéant, de stockage, détenues par ladite personne morale, au sein du périmètre local où elle exerce ses activités ;
- *2^oquater* « électricité autoconsommée collectivement » : électricité produite par la communauté d'énergie renouvelable et consommée par ses participants au cours de la même période quart-horaire ; »

Représentation

- « Au sein d'un réseau privé ou d'un réseau fermé professionnel, les clients avais connectés à ce réseau peuvent mandater le gestionnaire de réseau concerné à exercer, en leur nom et pour leur compte, leur éligibilité.
- De même, les participants à une communauté d'énergie renouvelable peuvent mandater ladite communauté à exercer, en leur nom et pour leur compte, leur éligibilité pour la partie d'électricité non autoconsommée collectivement.

Objectifs, participation libre, « localité »

- « Art. 42^{quater}. § 1^{er} **La communauté d'énergie renouvelable a pour but de produire, consommer, stocker et vendre de l'électricité renouvelable en vue de procurer des bénéfices environnementaux, sociaux et économiques** tant à ses participants qu'au niveau du périmètre local et ce notamment **en optimisant la synchronisation des flux d'électricité.**
- La participation à une communauté d'énergie renouvelable est **libre** et volontaire moyennant le respect des conditions fixées par ou en vertu du présent décret.
- Le Gouvernement détermine, après avis de la CWaPE et concertation avec les gestionnaires de réseaux, **le périmètre local**. Ce périmètre local peut être différencié en tenant compte notamment des **contraintes techniques du réseau** et de la qualité des participants.

Statut de la communauté

- § 2. Toute communauté d'énergie renouvelable détermine dans ses statuts les règles relatives à la représentation de ses participants. **La communauté est l'interlocuteur unique du gestionnaire de réseau concerné et de la CWaPE et assume la responsabilité de la gestion de ses activités.**
- Les statuts de la communauté d'énergie renouvelable contiennent au minimum les éléments suivants :
- 1° les dispositions relatives au contrôle effectif de la communauté d'énergie renouvelable par ses participants ;
- 2° les dispositions relatives à l'indépendance et l'autonomie de la communauté d'énergie renouvelable.

Smart meters

- Chaque participant à une communauté d'énergie renouvelable est **équipé d'un compteur télé-relevé** enregistrant les courbes de charge permettant de connaître et de vérifier qu'au cours d'une même **période quart-horaire** :
- 1° la quantité d'électricité autoconsommée collectivement n'est supérieure ni à la production totale d'électricité, en ce compris l'électricité issue d'un moyen de stockage, ni à la consommation totale d'électricité, en ce compris l'électricité utilisée pour charger un moyen de stockage ;
- 2° la quantité d'électricité affectée à chaque participant conformément aux règles d'échange définies dans la convention visée au paragraphe 3 n'est pas supérieure à sa consommation effective.

Plus de net-metering

- Le régime de la compensation entre les quantités d'électricité prélevées et injectées sur le réseau de distribution octroyée sur base annuelle aux installations de production d'électricité verte d'une puissance nette développable inférieure ou égale à 10kW **est incompatible** avec la participation à une communauté d'énergie renouvelable. L'utilisateur du réseau qui souhaite participer à une communauté d'énergie renouvelable suspend expressément, auprès du gestionnaire de réseau concerné, l'application du régime de compensation pendant la durée de sa participation à ladite communauté.

Tarification spécifique

- Les quantités d'électricité autoconsommées collectivement font l'objet d'une **tarification spécifique pour l'utilisation du réseau, ainsi que pour la contribution aux taxes, surcharges et autres tarifs régulés** relatifs aux tarifs de distribution et de transport conformément au décret du 19 janvier 2017 relatif à la méthodologie tarifaire applicable aux gestionnaires de réseau de distribution de gaz et d'électricité. ».

Autorisation délivrée par la Cwape

- Les communautés d'énergie renouvelable sont soumises à l'octroi d'une autorisation délivrée par la CWaPE moyennant le respect des conditions fixées par ou en vertu du décret.
- Après avis de la CWaPE et en concertation avec les gestionnaires de réseaux, le Gouvernement fixe, **le cas échéant de façon différenciée en fonction du périmètre local concerné et de la qualité des participants, les conditions générales, droits et obligations** de la communauté d'énergie renouvelable notamment en termes de seuils d'autoconsommation. § 2. La demande d'autorisation est adressée au gestionnaire du réseau sur lequel la communauté d'énergie renouvelable souhaite exercer ses activités. Elle est accompagnée notamment des documents suivants :
 - 1° un rapport descriptif de la situation administrative et électrique de chacun des futurs participants ;
 - 2° les **profils historiques ou simulés de production d'électricité à partir de sources renouvelables ou de cogénération** de qualité et de consommation locale justifiant la communauté d'énergie renouvelable ;
 - 3° les **mesures prévues en vue de pouvoir notamment synchroniser les consommations et les productions d'électricité** au sein de la communauté d'énergie renouvelable afin d'optimiser les flux d'électricité.

Gestion des donnée par le GRD

- « Art. 42septies. § 1^{er}. Les gestionnaires de réseaux mettent en œuvre, selon les tarifs régulés, les dispositifs techniques, administratifs et contractuels nécessaires, notamment en ce qui concerne le comptage d'électricité, pour favoriser le développement dans des conditions transparentes et non-discriminatoires des communautés d'énergie renouvelable.

Conditions : seuil d'autoconsommation, (réduction de pointe?)

- En cas d'avis favorable, celui-ci contient notamment des propositions de conditions spécifiques ainsi que de seuils d'autoconsommation collective dont le respect permet l'application du tarif spécifique visé à l'article *42quater*, § 5.

Références scientifiques

Cornélusse, B., Savelli, I., Paoletti, S., Giannitrapani, A., & Vicino, A. (2019). **A Community Microgrid Architecture with an Internal Local Market.** *arXiv preprint arXiv:1810.09803.*

Cornélusse, B., Ernst, D., & Lachi, S. (2018). **Optimal operation and fair profit allocation in community microgrids.** CIRED workshop on energy communities.

Duchesne, L., Savelli, I., Cornélusse, B. (2019). **Sensitivity Analysis of a Local Market Model for Community Microgrids.** To appear in proceedings of IEEE power tech 2019.

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A community microgrid architecture with an internal local market

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ARTICLE INFO

ABSTRACT

Keywords: Community microgrid, Energy market, Marginal pricing, Blockchain programming

This work fits in the context of community microgrids, where members of a community can exchange energy and services among themselves, without going through the usual channels of the public electricity grid. We introduce and analyze a framework to operate a community microgrid, and to share the resulting revenues and costs among its members. A market-oriented pricing of energy exchanges within the community is obtained by implementing an internal local market based on the marginal pricing scheme. The market aims at maximizing the social welfare of the community, thanks to the more efficient allocation of resources, the reduction of the peak power to be paid, and the increased amount of reserve, achieved at an aggregate level. A community microgrid operator, acting as a benevolent planner, redistributes revenues and costs among the members, in such a way that the solution achieved by each member within the community is not worse than the solution it would achieve by acting individually. In this way, each member is incentivized to participate in the community on a voluntary basis. The overall framework is formalized in the form of a bilevel model, where the lower level problem clears the market, while the upper level problem plays the role of the community microgrid operator. Numerical results obtained on a real test case implemented in Belgium show around 54% cost savings on a yearly scale for the community, as compared to the case when its members act individually.

1. Introduction

The increasing penetration of distributed generation (DG) from renewable energy sources and energy storage systems in distribution networks paves the way to new market models that favor a local usage of the generated electricity [1]. In this context, microgrids are gaining increasing popularity as an architecture capable of making a more efficient use of resources at a local level [2], and maximizing the local consumption of electricity generated in a distributed manner [3]. When interconnected to the public grid, microgrids may also provide services, such as peak shaving and power balance.

The contribution of this paper focuses on community microgrids, where members of the community (termed entities in the following) decide to pool their resources (generation, load and/or storage devices) to reduce their costs, increase their revenues, and achieve a more efficient use of their assets. A schematic representation of an entity is shown in Fig. 1. The entities of the community are assumed to be connected to the same local bus, through which they exchange energy among themselves and with the public grid. After introducing a conceptual architecture of the community microgrid, this paper develops the model of an internal local market, based on the marginal pricing scheme, whose aim is to maximize the social welfare of the community.

1.1. Related work

Microgrid energy markets provide small-scale prosumers with a market platform to trade locally generated energy within their community. In some cases, the trading takes place without the need of central intermediaries. Blockchain-based local energy trading is proposed in [4], where prosumers can trade self-produced energy in a peer-to-peer fashion. A case study based on a real community microgrid project in Brooklyn is also reported. In [5], a non-cooperative game arises from the transferable payoff allocation mechanism designed to aggregate renewable power producers in a two-settlement power market.

In most cases, the internal community market is managed by a third party. A coupled microgrid power and reserve capacity planning

CIRED Workshop - Ljubljana, 7-8 June 2018

Paper 0281

Optimal operation and fair profit allocation in community microgrids

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ABSTRACT

This work fits in the context of community microgrids, where entities of a community can exchange energy and services among them without going through the usual channels of the public grid. We propose and analyze solutions methods to operate a community and to share the profit gained by the community between the entities forming the community, especially when the cost and revenues originate from different streams.

INTRODUCTION

This work fits in the context of energy communities, where entities of a community can exchange energy and services among them [1] without going through the usual channels of the public grid. It is practically motivated by the need arising from the pilot project MeryGrid [2], in which several companies and a storage system form a community microgrid. By community microgrid, we mean a special case of energy community that is a geographically limited power system made of several legal entities, each entity being a single-user microgrid with its own generation, consumption, storage, and level of flexibility. In this case, an operator manages the community in order to reach the highest economic efficiency by optimizing the energy flows and the interactions within the community and with the public grid, while satisfying the constraints set by the entities and constraints of the public grid (Figure 1). Leaving aside the (re)sizing and long term contracting questions, the operation of a microgrid can be divided in several phases, from day-ahead bidding to settlement. Although all these decision stages should be designed in a coherent way, this paper considers only the operational planning stage that optimizes decisions one day ahead with periods of 15 minutes given some prices, consumption and generation forecasts. The main focus of this paper is how to share the profit gained by the community between the entities forming the community, especially when the cost and revenues originate from different streams: an entity generates revenues from energy sales, either to the grid or to the community, and from ancillary services to the grid; energy purchases from the grid and from the community as well as peak penalties constitute the costs of an entity. The research questions addressed are, assuming we can solve the operational planning problem of an entity to optimality (i) how should we formulate the operational planning problem of the community and the mechanism that shares the profit gained by the community between the entities and the operator? (ii) How fair is the mechanism and how does it incentivize the entities to join or stay in a community?

A way to price electricity and heat in local communities was proposed in [3], but only focused on the energy commodity. A fair economic settlement scheme for participants in a microgrid is proposed in [4], which considers the sizing problem but is limited to the electricity commodity. In a multi-TSO coordination context, [5] introduces a methodology and reviews some fairness notions that are of interest and are adapted to our problem in this paper. This topic is becoming of foremost importance with the rise of energy communities [6].

Starting from the operational planning problem of a single entity, we formulate the community operational planning problem of the operator. Then we propose and discuss three schemes to allocate the profit gained by this community-level optimization. Fairness is a subjective notion, but some indicators allow us to compare profit sharing mechanisms based on the solutions they lead to on a specific microgrid. Illustrative results are reported for a case inspired by the MeryGrid project [2].

MATHEMATICAL MODEL

Entities are indexed by the letter u and grouped in the set \mathcal{U} . The superscript SU denotes a quantity relative to an entity (a single-user) and the superscript MU denotes a quantity relative to the community (multi-user). The devices of an entity are modeled as follows. The devices consuming electricity fall in three categories: *inflexible demand* must be satisfied, hence can be seen as demand at maximum price; *flexible demand* must be satisfied as well but

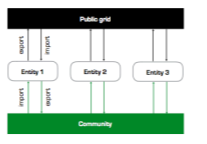


Figure 1: Community model

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Sensitivity Analysis of a Local Market Model for Community Microgrids

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Abstract—A community microgrid is a microgrid composed of several entities, or members, that can share energy among themselves. The members of the community can match their demand and supply through an internal local market with a significant reduction of the exchanges with the main grid. As a consequence each participant can benefit from a reduction of its energy costs when the energy available locally is cheaper than the energy from the grid, from a drop of the energy peak demanded from the main grid, and from the new capability to provide energy reserve at aggregate level. In this paper, we analyze how the changes of the community market model parameters can affect both the community as a whole, and the welfare of each participant. The analysis is performed by varying the main drivers of the community market model, the community and storage fees, and the storage capacity. The numerical results are obtained by using real data based on the MeryGrid project.

Index Terms—community microgrid, community market, energy market, marginal pricing, sharing economy.

I. INTRODUCTION

The increasing share of renewable energy sources and storage systems in distribution grids opens the possibility for new market models that favor a local usage of the generated electricity. Local energy communities, and more specifically community microgrids, constitute one of these options. A microgrid is a set of loads, generators and storage devices connected by an electric grid within a clearly defined neighborhood, able to work either connected or disconnected from the main grid. It becomes a community microgrid when several legal entities constitute the microgrid, e.g. a set of small and medium-sized enterprises.

In the literature, microgrids have been explored under different aspects, however references related to community market models are limited. Reference [1] shows how to model and price co-generated energy within a local heat district, managed by a monopolistic public utility. Reference [2] proposes a microgrid model with internal exchanges formalized as a Nash bargaining problem, where the community prices are restricted to predetermined, discrete price levels. Reference [3] describes a community model where the participating units act in a collaborative manner. The optimal solution is obtained through a distributed algorithm by exploiting the alternating direction method of multipliers. Reference [4] presents a blockchain-based microgrid based on a pilot project built in Brooklyn, where blockchains appear to be an eligible technology to manage local microgrids. Reference [5] reviews and analyzes the most important market architectures for community microgrid, including decentralized peer-to-peer structures with direct trades among participants, and local community of aggregated units either connected to the main grid or islanded. Reference [6] proposes a peer-to-peer microgrid model where the internal community prices are determined heuristically depending on the ratio between the energy supplied and demanded within the community. Reference [7] describes a novel market model for community microgrids that is formalized as a bilevel problem. By using the proposed architecture, the community participants can allocate efficiently their resources with a significant reduction of the energy costs. Furthermore, the entities can pool their resources to provide ancillary services to the main grid. Moreover, by exploiting the netting effects at aggregate level, they can reduce the energy imported from the main grid, with a considerable drop in the energy peak costs. By using predetermined profit and cost sharing policies, a community operator ensures no participating entity is penalized.

The aim of this paper is to perform an in-depth sensitivity analysis, by measuring the effects of changing the main parameters of the community microgrid market model introduced in [7], in order to assess the soundness, reliability, and robustness of the proposed market architecture. In particular, we focus on the change of welfare for

- the community and community members,
- the storage owners,
- the community operator.

The analysis is performed by varying the following parameters:

- the fee collected by the storage owner,
- the fee collected by the community operator to manage the community,
- the amount of storage capacity available.

The remaining part of this paper is organized as follows. Section II briefly summarizes the model proposed in [7]. Section III describes the analysis performed and reports the numerical results. Finally, Section IV outlines the main conclusions.

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