Nantes Université

Lemna
Laboratoire d'Économie et de Management Nantes-Atlantique

July 2023

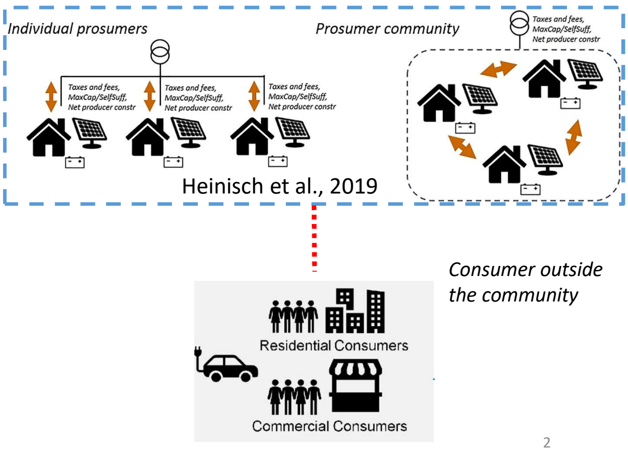
Welfare implications of renewable energy communities. Individual versus collective approach

Rodica Loisel, Lionel Lemiale

1

General context. Motivation

- EC design (183 concepts, Bauwens et al. 2022)
- **Business model as motivation** to join community
  - Surplus to share
  - Rules for surplus sharing
  - Tariff = f°(cost, market price, fees, FIT)
- **Interest issues**:
  - EC motivation when market prices are low?
  - Size of the community
  - Profit of buying/selling into the EC + to market
  - Network fees EC – outside EC
- **Intuition to join community**
  - Surplus selling price EC + Fees > FIT
  - Surplus buying price EC + Fees < Market price
  - Total Fees = no missing money for the TSO



2

Literature revue. Contribution

1) Individuals motivation to join EC in economics (collaborative economy, SSE, experimental economics)
- socio-ecological, non-monetary interest, energy + bill savings
- Sebi & Vernay, 2020; Guetlein & Schleich, 2023; Bauwens et al., 2022 etc
- ➢ Contribution: business model revisited Individual VS Community Prosumer: relationship cost-prices-fees

2) Institutional changes. Distributional impacts (industrial economics)
- TSO missing money (Clastres et al., 2019);
- ➢ Contribution: fee neutral approach

3) Regulatory instruments. Market signals. Organisational rules (ecological economics, public choice, environmental economics)
- Ostrom (2010), D'Adamo et al. (2022), etc.
- « one fits-all policy » is ineffective
- ➢ Contribution: finding decentralized solutions negociated between EC members for the surplus sharing.

3

Methodology. Individual Self-consumption

Prosumer objective function:

Max profits $CFI_i = ES_i \times T - p \times (E_i - ESC_i) - lcoe_i \times PV_i - AI_i$ (1)

- Remark: missing money for the DSO (taxes τ ---- prix p)

DSO grid operator budget neutrality:

$$\tau \times p \times E_i + A0_i = \tau \times p \times (E_i - ESC_i) + AI_i \quad (2)$$
$$\Delta A = AI_i - A0_i$$
$$\tau \times p \times ESC_i = \Delta A_i \quad (3)$$

- Revenues for grid operator remain constant;
- The welfare of the general consumers remains constant;
- The abonnement of the prosumer $A1$ increases with the missing revenues from taxes not paid on the energy self-consumed.

- $CFI_i = ES_i \times (T - lcoe_i) + ESC_i \times (p - lcoe_i) - p \times E_i - A1_i$ (4)

4

Energy Community programme

Community of prosumers objective function:

$$\text{Max } CFC_i = \underbrace{ES1_i \times p_i^{sc}}_{\text{Surplus to EC}} + \underbrace{ES2_i \times TC}_{\text{Surplus to market}} - \underbrace{EBC_i \times p_{j,tax}^{cc}}_{\text{Surplus from EC}} - \underbrace{(E_i - ESC_i - EBC_i) \times p_i}_{\text{Market bill}} - \underbrace{AI_i}_{\text{Abonnement}} - \underbrace{lcoe_i \times PV_i}_{\text{Investment}}$$

Rational prosumer motivation to join the EC = Profit i EC > Profit i Individual Self-consumption:

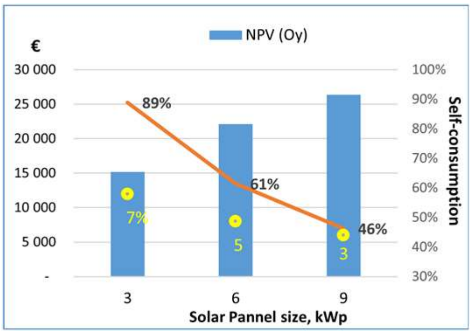
$$CFC_i > CFI_i$$

$$ES2_i \times (T - TC) + ES1_i \times \left(T - p_i^{sc}\right) < EBC_i \times \left(p_i - p_{j,tax}^{cc}\right)$$

5

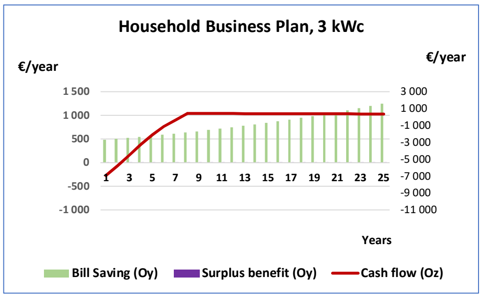
Results. Individual self-consumption
The household

- Self-consumption rate decreases with increased PV capacity.
- Energy in surplus FIT being regressive with volumes, no incentive to install more PV.



Data

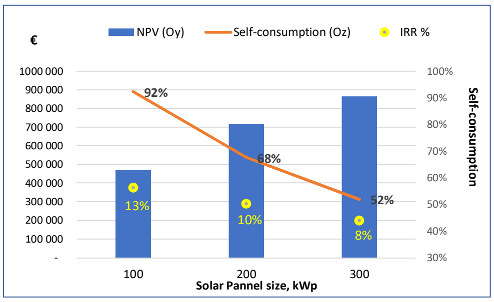
Market price, €/MWh	174
Price increase, %/yr	4
FIT HH, €/MWh	100
Invest PV HH, €/ kW	2 000
Bonus, €	1740
LCOE PV HH, €/ MWh	120



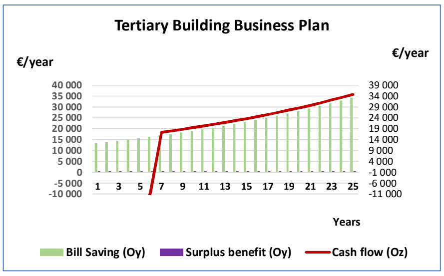
6

Results. Individual self-consumption
Tertiary sector

Tertiary Building
1 300 m², 483 MWh/yr, HV
100 kWp, 100 000 €, 9 000 € bonus, LCOE 90 €/MWh



Current FIT regulation encourages Max Self-consumption, so Min PV installation.



Payback period 6 years.

Services versus households:
- Higher rate of return on investment (12%);
- Higher bill savings;
- Lower LCOE (larger roofs = economies of scale)
- Higher energy in surplus volumes (8 MWh SV, 2.1 MWh HH).

7

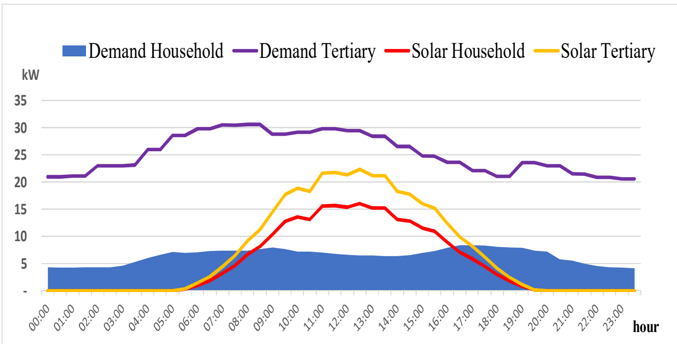
Community. 12 Households + Tertiary sector

Consumption Profiles

Households: homogenous, similar consumption and energy in surplus profiles;

Tertiary building: important surplus energy flows, correspond to the same surplus periods as HH

The trade direction within the community is from households towards tertiary.



8

Community. 12 Households + Tertiary sector

- Each actor (HH, SV) maximizes its own self-consumption by minimizing its own PV.
- Each actor is interested in the surplus generated by the others.
- Each actor maximises profits by undersizing its own PV and oversizing the PV of the others to maximize the others surplus.

	Collective self-consumption					Individual self-consumption			
Size, kWp	Household		Tertiary		CE Trade	Household		Tertiary	
(Household, Tertiary)	NPV, €	IRR	NPV, €	IRR	MWh/yr	NPV, €	IRR	NPV, €	IRR
(3 x12, 100)	6 096	6.3%	243 961	13.1%	2.0			229 014	12.5%
(3x12, 200)	7 381	7.5%	354 469	10.3%	3.8	6 262	6.5%	334 591	9.9%
(3x12, 300)	**8 789**	**8.7%**	408 226	8.5%	7.9			383 743	8.0%
(6x12, 100)	5 668	3.3%	257 538	13.6%	10.3			229 014	12.5%
(6x12, 200)	6 528	3.7%	354 761	10.3%	1.6	7 990	4.5%	334 591	9.9%
(6x12, 300)	7 006	4.0%	405 420	8.4%	1.7			383 743	8.0%
(9x12, 100)	3 491	1.4%	**272 839**	**14.0%**	20.1			229 014	12.5%
(9x12, 200)	4 729	1.9%	359 538	10.4%	4.4	8 228	3.3%	334 591	9.9%
(9x12, 300)	5 101	2.1%	406 310	8.4%	1.4			383 743	8.0%

Energy sharing rules

Household (*h*) utility:

$$ES2_h\,(TC - T_h) + ES1_h\,(lcoe_h - T_h) + EBC_h\,(pmarket_h - p_{sv}) > 0 \qquad (12)$$

- Numerically

$$ES2_h\,(60\text{-}100) + ES1_h\,(120 - 100) + EBC_h\,(174 - 90 - Tax_{sv}) > 0$$

$$20\,ES1_h - 40\,ES2_h + (84 - profit_{sv} - Tax_{sv})\,EBC_h > 0$$

- The surplus sold to the market ($ES2_h$) at reduced feed-in tariff should be compensated by the surplus sold to the community and also bought from the community.
- Revenues from selling energy to EC is positive if taxes set on the community price are lower than market price (net of average cost of solar from tertiary sector).

Energy sharing rules

Tertiary (*sv*) building utility:

$ES2_{sv}\ (TC\text{-}T_{sv}) + ES1_{sv}\ (lcoe_{sv} - T_{sv}) + EBC_{sv}\ (pmarket_{sv} - p_h) > 0$ (14)

- Numerically

$ES1_{sv}\ (60 - 90) < EBCsv\ (135 - 120 - profit_h - Tax_h)$ or

$(15 - profit_h - Tax_h)\ EBCsv + 30\ ES1_{sv} > 0$

- For taxes > 15 €/MWh, the business model is less interesting at current prices (135 €/MWh).
- If taxes = 100 €/MWh as today, the tertiary market price should by > 220 €/MWh to make profitable EC.
- it is more interesting to buy within the community at a solar panel cost and to sell the surplus at a level covering the long-run cost of the panel than at low feed-in tariff.

- **The boundaries of negotiation:**

$20\ ES1_h - 40\ ES2_h + (84 - \mathbf{profit_{sv}} - Tax_{sv})\ EBC_h > 0$

$(15 - \mathbf{profit_h} - Tax_h)\ EBCsv + 30\ ES1_{sv} > 0$

Final remarks

- ECs need limited sizes to make negociation possible.
- EC viable business case: similar PV orders of magnitude, but complementary load profiles.
  - Higher profits if based on the loads heterogeneity rather than on the PV cost difference due to taxes.
- Institutional theories show that first EC rationality is to renounce to the market, then EC should not be based on other market opportunist rules (no high profit making).
- Why incentivizing EC?
  - To involve consumers into financing the transition, into DSM and scarcity of resource management.
- Ecs remain connected to the grid, but members pay network fees:
  - to maintain the security of supply (RTE, 2019);
  - support social values of tarif equalization (péréquation tarifaire; CRE, 2018);
  - promote energy community values (trust) but are against communautarisme (Fonteneau, 2021).

Lemna
Laboratoire d'Économie et de Management Nantes-Atlantique

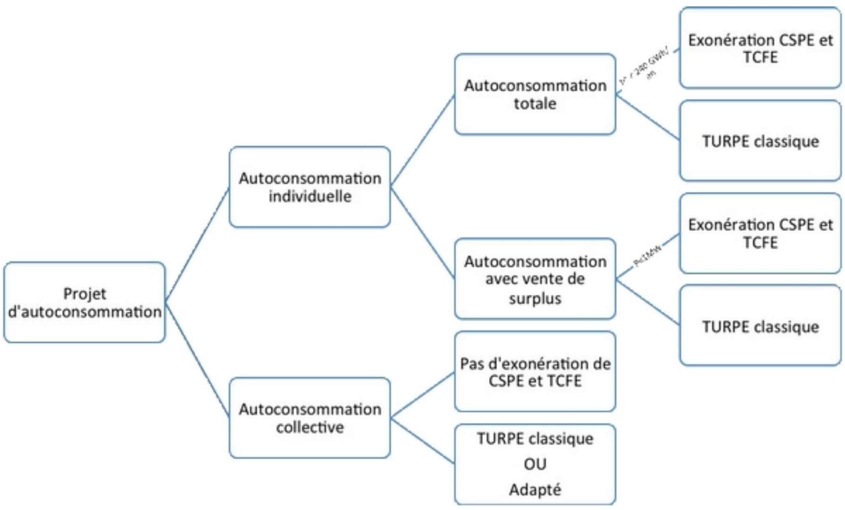
Welfare implications of renewable energy communities.
Individual versus collective approach

Rodica Loisel, rodica.loisel@univ-nantes.fr

Nantes Université

13

L'autoconsommation PV en tertiaire : une fiscalité complexe



https://www.vertsun.com/2020/07/photovoltaique-nombreux-avantages-de-lautoconsommation-mais-de-obstacles-tertiaire/

14

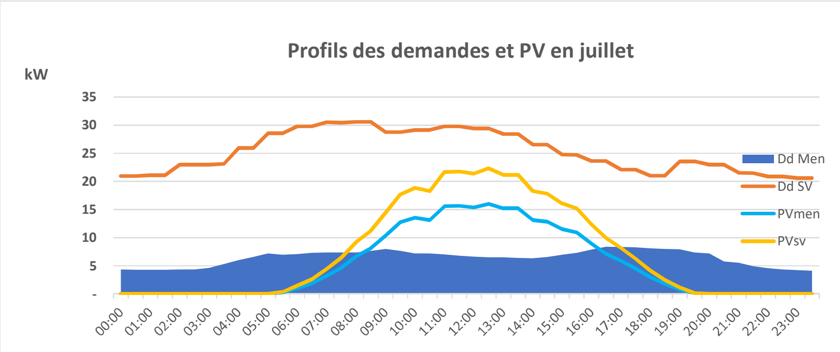
Auto-consommation collective

L'autoconsommation collective étendue (l'arrêté du 21 novembre 2019) entre plusieurs producteurs photovoltaïques et consommateurs, proches physiquement (<2km), d'une puissance maximale cumulée des installations de production de 3 MW, dont les points d'injection et de soutirage sont situés en aval d'un même poste de transformation d'électricité (art L 315-2 du Code de l'Energie).

Conditions favorables :
- Gisement solaire important ;
- Bâtiments tertiaires climatisés ;
- Tarifs électriques élevés ;
- Tarifs revente totale < TRV.

Communauté Energ SV-Men	**12**
TAp	24%
TAc	85%
Echange CE MWh/an	**10.3**
SV - Men MWh/an	0
Men - SV, MWh/an	10
Demande CE MWh/an	628
Auto-C men indiv MWh/an	46
Auto-C men CE	46
Auto-C SV indiv	97
Auto-C SV CE	107
Surplus CE MWh/an	27
Surplus Men MWh/an	19
Surplus SV MWh/an	8
Soutirage men	98
Soutirage SV	376
EcoFacture SV €an / TRV	13 568
EcoFacture Men €an / Auto-C inc	0
EcoFacture SV €an / Auto-C indiv	185
EcoFacture Men €an	8 132
REV CE €an	1 620
Rev Men €an	1 131.15
Rev SV €an	489
Utilité 1 men CE €/an	-148
Utilité SV CE €an	185

Auto-consommation collective favorable au tertiaire



12 ménages : 12 MWh/an, 6 kWc
Bât Tertiaire : 483,6 MWh/an, 100 kWc

TRV men, €/MWh	175		
TAG mén, €/MWh	100		
TRV pro, €/MWh	138	https://entreprises.selectra	
TRV pro, €/MWh	60		
Hausse annuel TRV	4%	LCOE PV €/MWh à 6%	
Cout PV men, €/kW	1 500	120	
Prime Men, €	1 740		
Cout PV sv, €/kWc	1 000	90	
Prime Sv, €	9 000		
TAG CE €/MWh	60		

Matrice des impacts socio-économiques

Analyse financière	Sociale / Environnementale
- Rentabilité, retour sur investissement - Impact sur la facture électrique - Gain de l'autoconsommation (revente) - Dimensionnement : Analyse des courbes de charge - Fonctoin-objectif : Max profit / Max taux d'autoconsommation - Pilotage de la demande : Quelles options techniques ? Analyse des usages - Hypothèses : hausse tarif réglementé de vente - Évaluation des pertes T&D évitées grâce à l'autoconsommation - Quid de l'extension du périmètre ?	- Modification des caractéristiques naturelles (au sol / sur toitures) - Effets du chantier : organisation - Bilan énergétique : temps de récupération de « l'énergie grise » - **Bilan CO2 : émissions évitées** - Recyclage panneaux - Gestion des débats autour du projet - Objectifs territoriaux climatique, énergétique, qualité air (SRCAE) - Impact sur la facture électrique des non-participants (coûts du réseau, TURPE)
Économique - Impact sur le comportement du consommateur - Impact sur la croissance économique (Analyse via les taxes) - Création d'emploi / Destruction d'emploi - **Complémentarité avec d'autres énergies : éolien terrestre** - Échanges avec d'autres communautés énergétiques - Robustesse du modèle économique à une hausse de la demande - Retombées économiques locales : quelle attractivité territoriale ?	**Politique** - Rôle informatif et d'éducation - Rôle fédérateur autour du projet collectif - **Mimétisme régional** - Acceptation du projet par les locaux - Participation des locaux au projet - Réflexion sur l'extension du projet - Contribution à la diversité du mix électrique - **Indépendance énergétique** - Leviers d'incitation / désincitation

17

Objectifs des acteurs

Objectif économique	Abordabilité Retour sur investissement Facture énergétique plus faible Validation commerciale des produits et services Optimum social pour les investissements de réseau
Objectif technique	Augmenter l'efficience de l'énergie Stabilité réseau. Continuité à la capacité et fiabilité Sécurité. Sûreté Réplicabilité
Objectif environnemental	Augmenter la pénétration des énergies renouvelables Réduction des émissions Réduction des bruits
Objectifs sociaux	Participation des utilisateurs/ des citoyens. Changement des comportements Innovation Emploi. Inclusivité Bâtiment communautaire Indépendance énergétique/autonomie Coopération Répartition équitable des coûts Coordination avec processus de planification et d'élaboration des politiques Démocratisation du marché de l'énergie

18