An economic assessment of the residential PV self-consumption support under cost-reflective grid tariffs

Olivier Rebenaque

University Grenoble Alpes - GAEL

Climate Economics Chair

31st May - IAEE Montreal

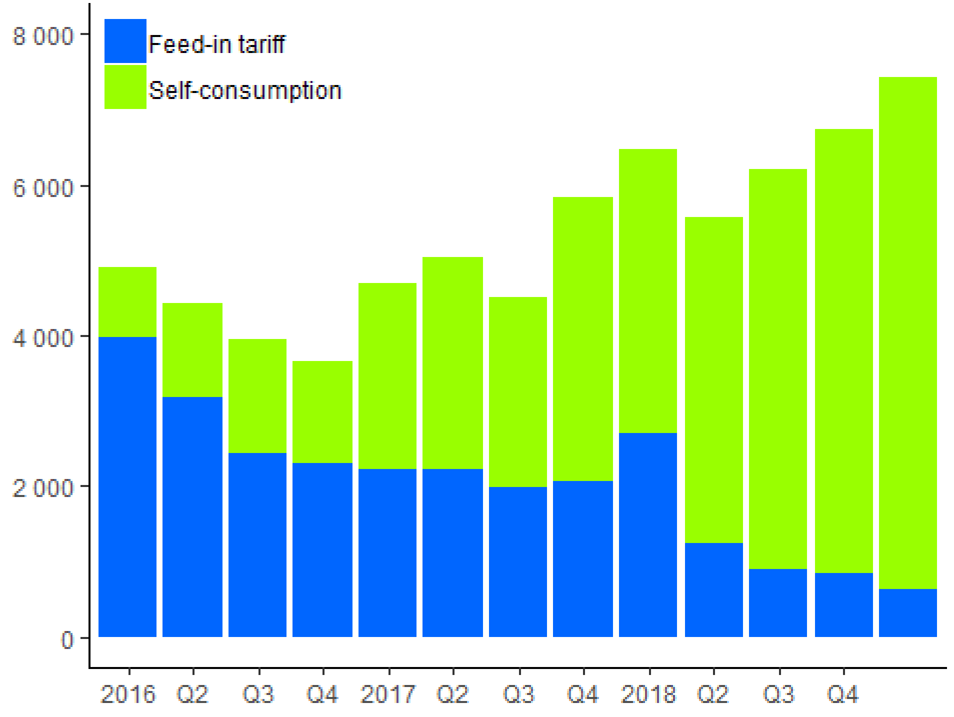
Introduction

- Developement of photovoltaic (PV) panels has been encouraged by Feed-in tariffs (FIT) in France.
- 2016: French government implemeted a regulatory framework to encourage photovoltaic (PV) self-consumption

Self-consumption scheme		
1st T - 2019	[0 – 3] kW	]3 – 9] kW
Upfront purchase subsidy	0,4 €/W	0,3 €/W
VAT	10%	20%
FIT	10 cts€/kWh	
Tax system	None	Tax applied on generation sold

Feed-in tariff scheme		
1st T - 2019	[0 – 3] kW	]3 – 9] kW
FIT	18,7 cts€/kWh	15,8 cts€/kWh
Tax system	None	Tax applied on generation sold

Quarterly evolution of PV installations < 36 kW in France since 2016



Introduction

- 2021 in France: Time-of-Use network tariffs applied to 80% of residential customers.

  → Purpose: to better reflect each network user's contribution to network costs

- But Time-of-Use tariffs decrease the profitability of PV self-consumption (O'Shaughnessy et al., 2018) because :
  - Higher tariffs occur at night and during winter whereas the PV production is diurnal.
  - Households are not willing to shift most of their consumption (Palm and al, 2018).

- Batteries can improve the profitability of PV self-consumption but FITs hinder the investiment in batteries : Barbour et González (2018), Kaschub, Jochem, and Fichtner (2016), Sani Hassan et al (2017)

- Issues with the current French policy :

  → costly due to the FIT

  → hinder battery investments while this technology could bring benefit to the grid

  → is inappropriate to challenge the future development of Time-of-Use tariffs

Research question

- How can we adapt the current French subsidy scheme applied to the residential sector to reach the following goals? :

1. Improve the PV-self-consumption profitablity under a Time of Use tariff.
2. Decrease the self-consumption policy support

- Method:
  - NPV calculations through a load flow model
  - replace the FIT applied on the excess generation by an upfront purchase subsidy for PV and batteries.

- Results : Even if a high subsidy on battery investments is implemented, the profitability is higher with the current subsidy and less costly for the government. Morevover, Time-of-Use tariff doesn't generate more savings when installing batteries.

Literature

- Many studies on the profitability of self-consumption with batteries:
  - Hoppmann et al., 2014; Truong et al., 2016; Quoilin et al., 2016; Dietrich and Weber, 2018
- Battery investments still need subsidies even in countries where the retail price is high:
  - Tervo et al. 2018; Hesse et al., 2017
- Authors argued that batteries improve profitability under a Time-of-Use rate or a Demand charge compare to a situation with PV only :
  - Kaschub et al., 2016; Schopfer et al., 2018; Davis and Hiralal, 2016; Solano et al., 2018; Sani Hassan et al., 2017
- The evaluation of public supports for the PV technology was largely studied in the literature
  - (Leepa and Unfried, 2013; Lüthi, 2010; Mir-Artigues and del Río, 2016; Pyrgou et al., 2016)

→ but they focused only on feed-in tariffs or net-metering and not on self-consumption.

I) Methodology

a) NPV formulation :

$$NPV_i = \frac{\sum_{y=1}^{Y} CF_y}{(1+d)^y} - (PV * Cost_{PV}) - \sum_{O\epsilon\{10,20\}} \frac{(PV * Cost_{inverter})}{(1+d)^O} - \left(Batt * [Cost_{Batt} + \frac{Cost_{Batt}}{(1+d)^{n_{Batt}}}]\right)$$

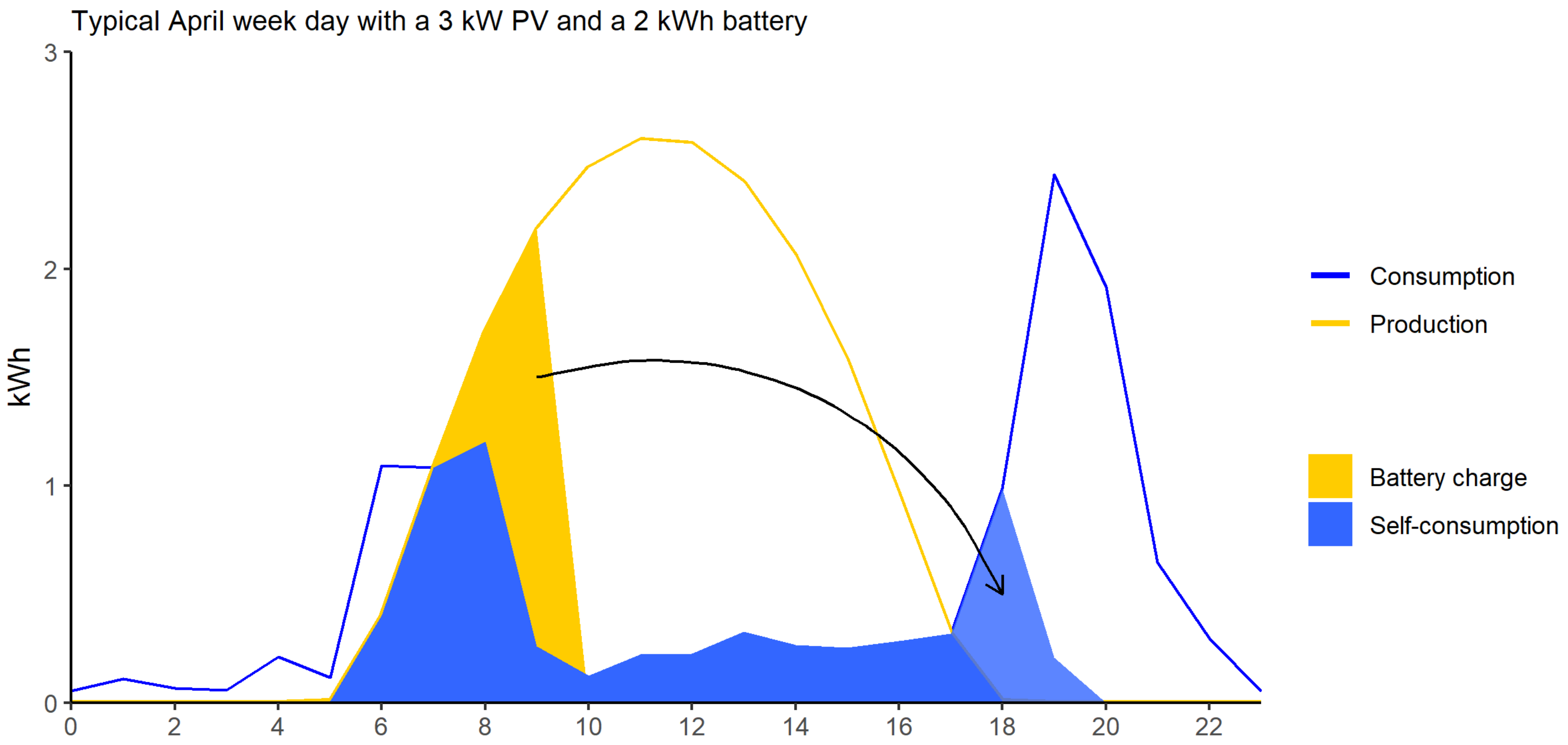
Cash-flow — PV Investment cost — Inverter cost — Battery Investment cost

$$CF_y = \sum_{t=1}^{8760} \left(P_{autoconso}(t) * \left(Cost_{En} + Cost_{grid}(t) + taxes\right)\right) + \left(P_{surplus_y} * Tarif_{surplus}(y)\right)$$

Savings — Excess generation

I) Methodology

b) Electric flow simulation (hourly time resolution) :



II) Data

a) Profiles and technology costs

- PV generation from a simulation software : renewable ninja
- Load Profiles from a simulation software : LoadProfileGenerator
  - location : South of France (high irradiation)
  - 2 households : a couple with a child (3 MWh/y) and a couple with two children (4.6 MWh/y)

PV	
Cost (VAT included)	2.14€/W
Lifetime	25 years
Inverter cost	0.4€/W
Inverter Lifetime	12 years

Source : Enerplan (French solar actor)

Battery Lithium	Unit	2020	2025	2030
Battery cost (VAT included)	€/kWh	680	490	350
Calendar lifetime(N_{Batt})	years	13	16	18
Cycle life indicator (NB_{cycles})		2 400	3 030	3 820

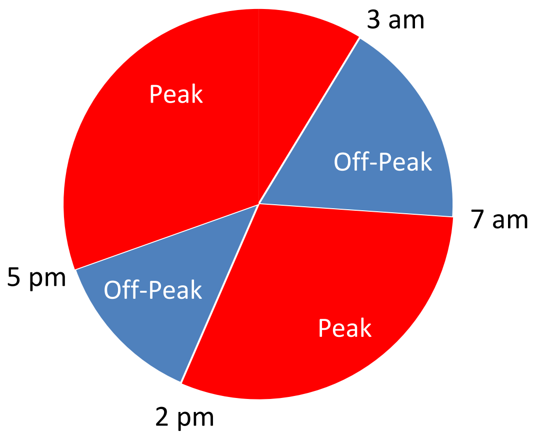
Source : IRENA

II) Data

b) Retail tariffs

- NPV is computed according to 3 different tariffs which are constant throughout the PV lifetime:

Tariffs	Flat	TOU_2P		TOU_4P			
Period	All the year	All the year		Winter		Summer	
		Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
€/kWh	0.1452	0.1580	0.1230	0.1757	0.1292	0.1327	0.1072



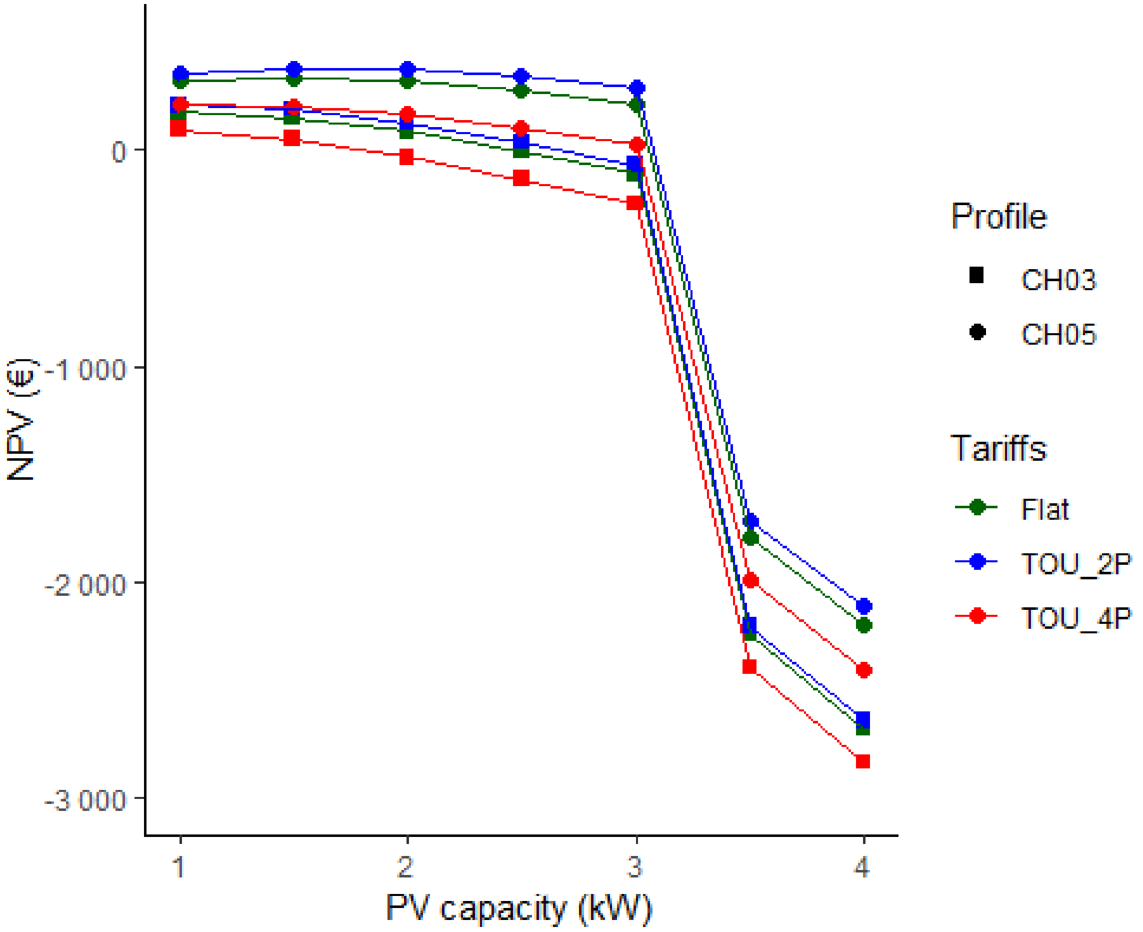
Annual households' bills : quite similar from a tariff to another

Tariffs	Flat	TOU_2P	TOU_4P
CH03	460€	476€	475€
CH05	670€	694€	697€

III) Results with the current subsidy scheme

a) NPV with the current subsidies (no battery) - *SC in net purchasing with FIT on surplus*

- PV self-consumption is profitable for both households with a capacity between 1 and 3 kW.
- Positive NPV even for low self-consumption rates: 30%
  - Incomes from FIT account from 40% to 50%.
- But the profitability is close to zero : 380€ at max.
- Above 3 kW of capacity, the levy applied on the excess generation leads to a profit drop.
- The TOU_2P exhibits higher profits than the other tariffs but marginaly.

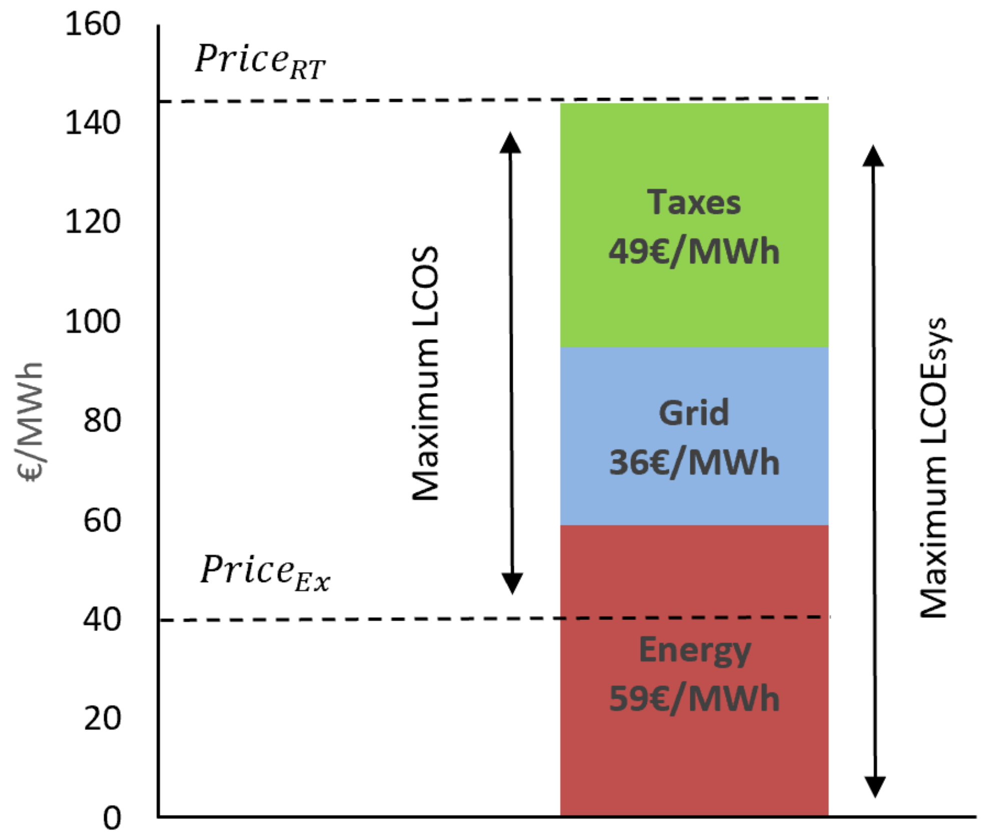


IV) New subsidy scheme

a) Methodology to set the battery subsidy

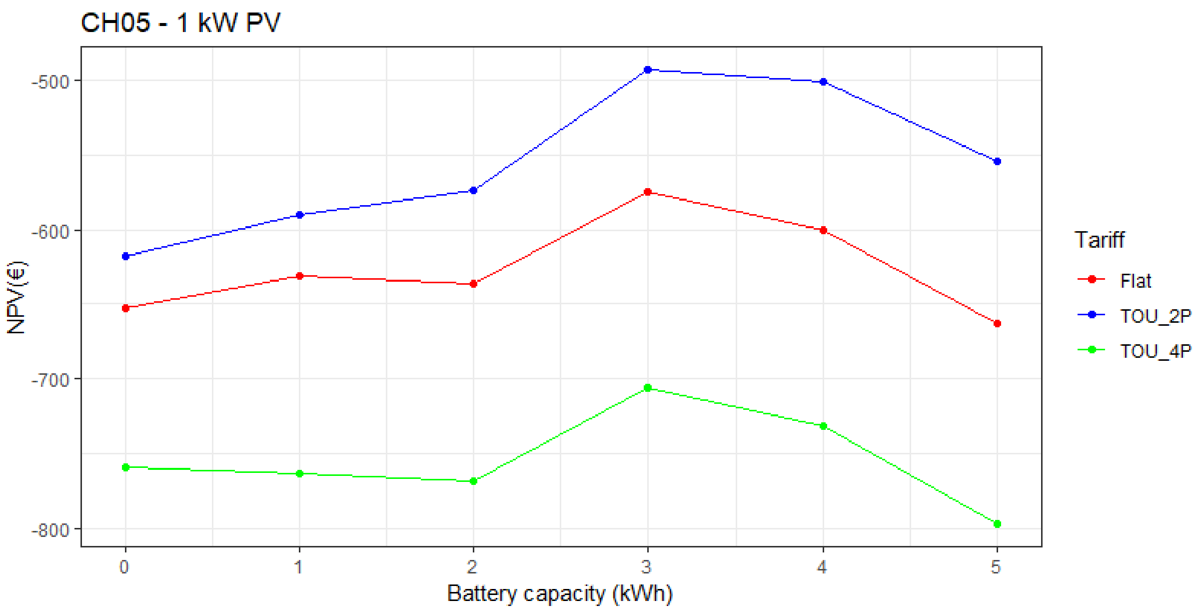
- Alternative policy :
  - same upfront purchase subsidy for PV
  - FIT are removed : surplus sold at the market price
  - premium for every battery investments
- The installation of a battery is profitable when the levelized cost of storage is below the difference between the retail rate and the spot price
- So, the upfront purchase subsidy is set to get the following result: $LCOS = Price_{RT} - Price_{Ex}$

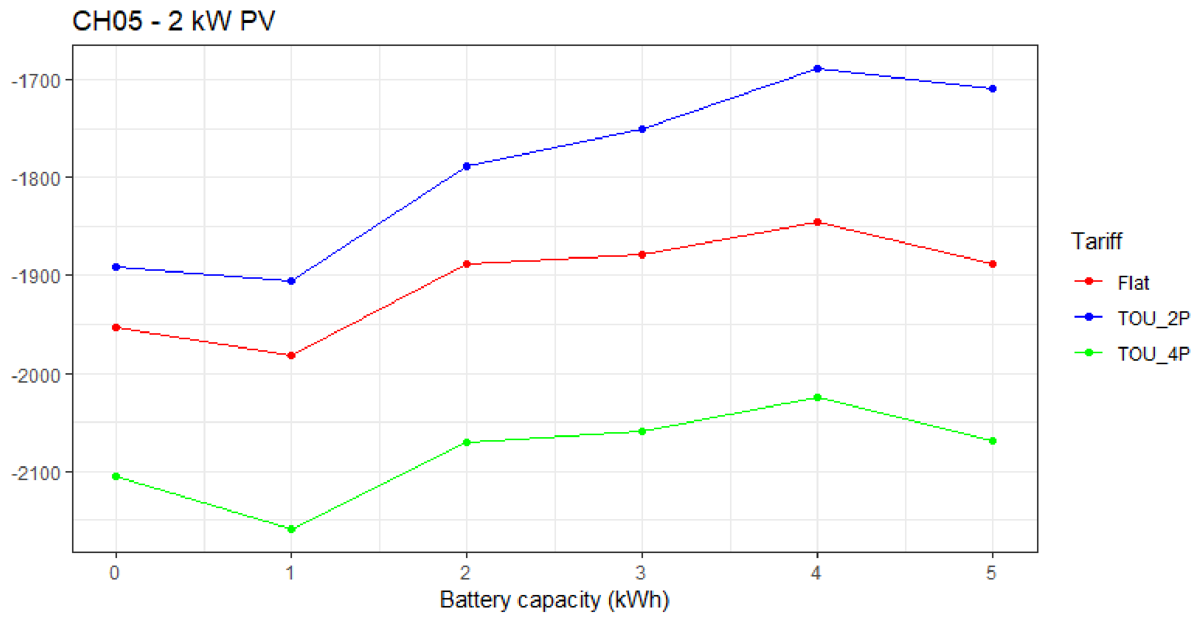
  → 525€/kWh ≈ 80% battery cost



IV) New subsidy scheme

b) NPV with the new subsidy scheme – *Upfront purchase subsidy for PV and batteries, no FIT*





1) PV-battery investments are not profitable in any case with the alternative policy.

2) If battery costs less per kWh then encourage to oversize this technology rather than PV
(Solano et al, 2018; Dietrich and Weber, 2018).

3) The network tariff structure has the same impact as with the current policy because:

- In TOU_2P peak prices occur mainly during sunny hours
- In TOU_4P batteries don’t store PV generation in summer to release it in winter when the tariff is higher than the flat tariff

V) Cost comparison

- Case – investment which maximizes the profitability of the household CH05 :
  - Current policy : 1.5 kW PV without battery
  - Alternative policy : 1 kW PV with 4 kWh battery

CH05	Current policy	Alternative policy
FIT costs	580 €	0€
PV upfront purchase subsidy	585€	390€
Reduced VAT (10%)	320€	215€
Battery upfront purchase subsidy	0€	2 870€
Total	1 485 €	3 475€

- The alternative policy is more costly than the current one and is less profitable for the prosumers

Conclusion

- The profitability of a PV-battery investment is not profitable even with the implementation of an upfront purchase subsidy which represents 80% of the battery cost. On top of that, this policy costs more than the current policy.

- In countries where retail rates are low, the investment costs are the key driver of PV self-consumption investment.

- The price gap between the different periods is too low (a few cents) to encourage battery investments.

- Cost reflective network tariffs such as dynamic pricing or critical pricing could improve the PV-battery investment.

Thank you very much for your attention