Auto-consommation électrique, réseaux privés et microgrids : vers une décentralisation du système électrique ?

Conférence Centrale Energies

10 Janvier 2018

Luc PAYEN

ENEA Consulting ● 89 rue Réaumur, 75002 Paris ● +33 (0) 1 82 83 83 83 ● www.enea-consulting.com

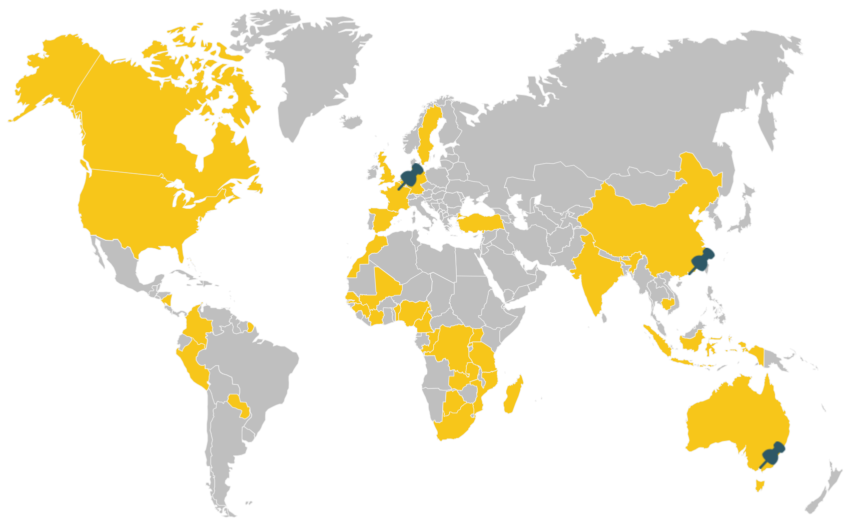
Energy & environmental transition

STRATEGY, INVESTMENT & NEW BUSINESS

INNOVATION & TECHNOLOGY

PROJECT SETUP AND DEVELOPMENT

ENEA Team
45+ people
3 offices



Project map
25 + countries
200 + clients

PARIS MELBOURNE HONG KONG

We contribute to energy & environmental transition
and to the development of energy access worldwide

This presentation is mostly based on two studies published in 2017 by ENEA

Urban Microgrids: Overview, challenges and opportunities

- Study performed to help value chain stakeholders understand where the value stands in the Microgrid business
- Available here
- Project Partners

ENEDIS, Fondation Tuck, OMEXOM, Groupe ADP, Total, Caisse des Dépôts

Microgrids for commercial and industrial companies

- Study performed to highlight the new opportunities to C&I customers
- Available here
- Project customer

wbcsd

Agenda

Current trends on decentralized energy

Review of recent projects

Takeaways from 3 urban (smart)grids case studies

Conclusion and Q&A

Agenda

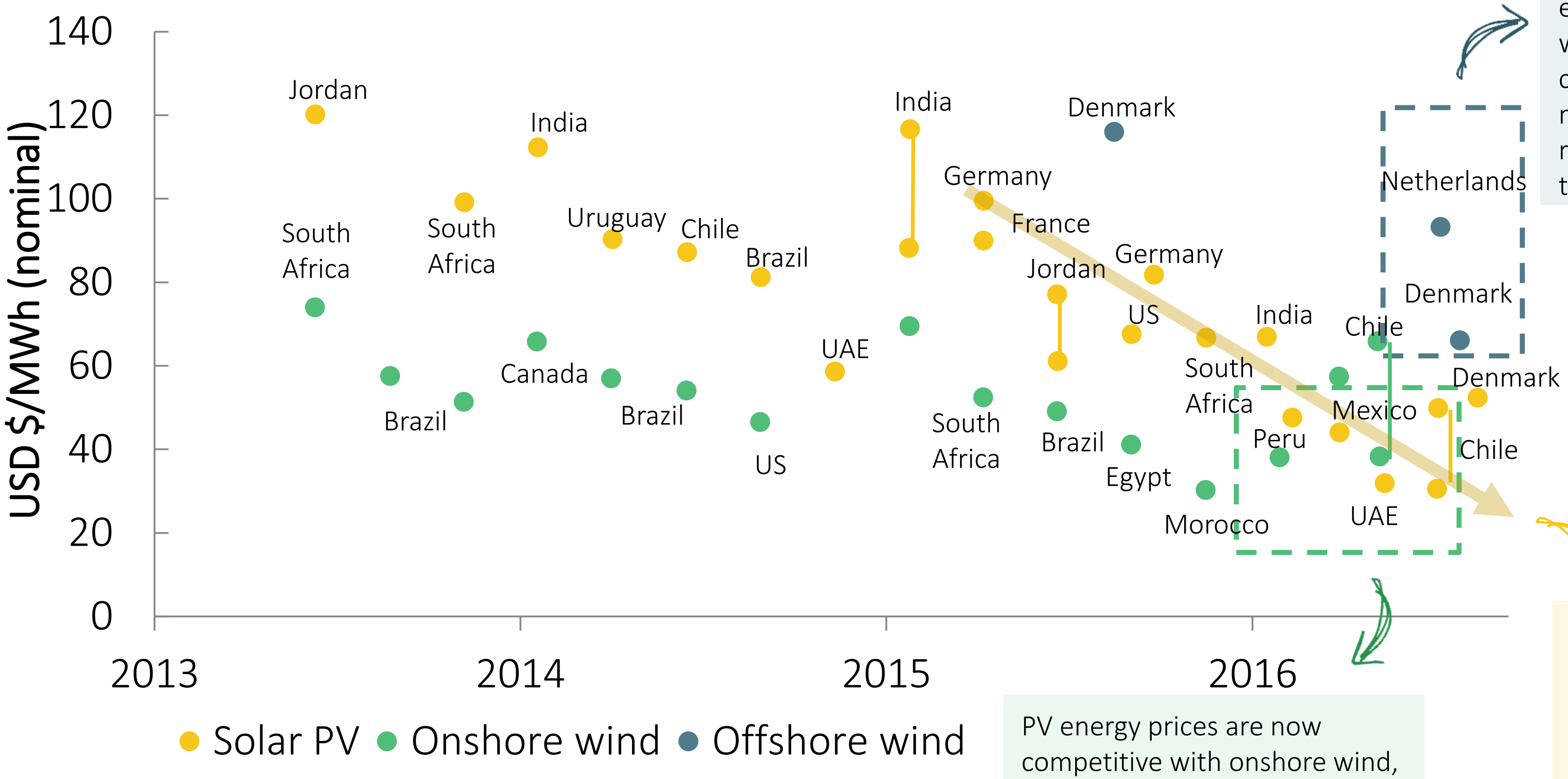
Current trends on decentralized energy

Review of recent projects

Takeaways from 3 urban microgrids case studies

Conclusion and Q&A

Utility scale renewable production price massively decreased over the last years leading the way to reach both sustainability and cost savings



Offshore wind is an emergent technology with great potential of cost reductions : it is meant to follow cost reduction curves similar to PV or onshore wind.

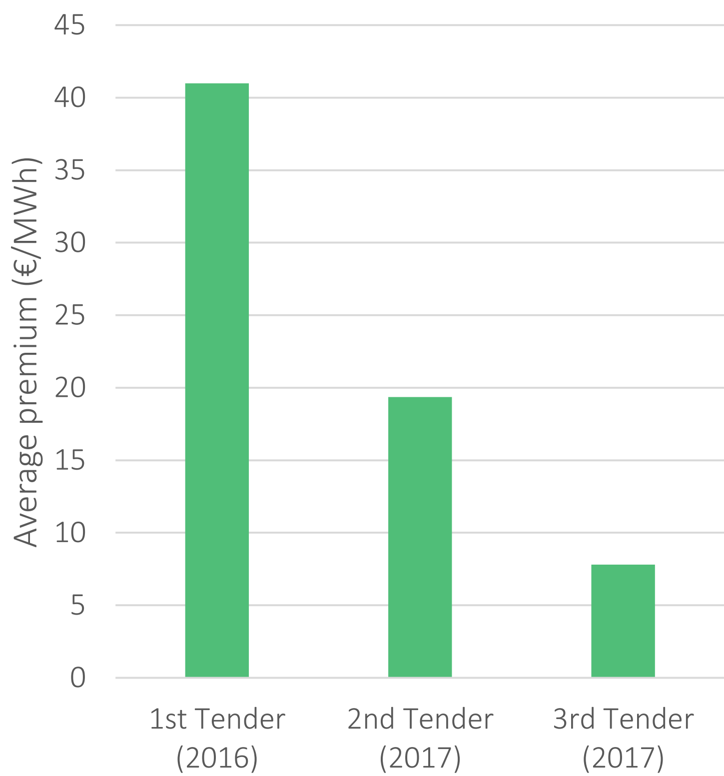
PV energy prices are now competitive with onshore wind, as solar prices benefited from sharper decrease than wind did thanks to major PV technology improvements.

Spectacular decrease in grid-connected solar prices, driven by countries with good resource availability, results from the combination of price competition through tenders, long-term contracts and falling technology prices.

Source : IRENA

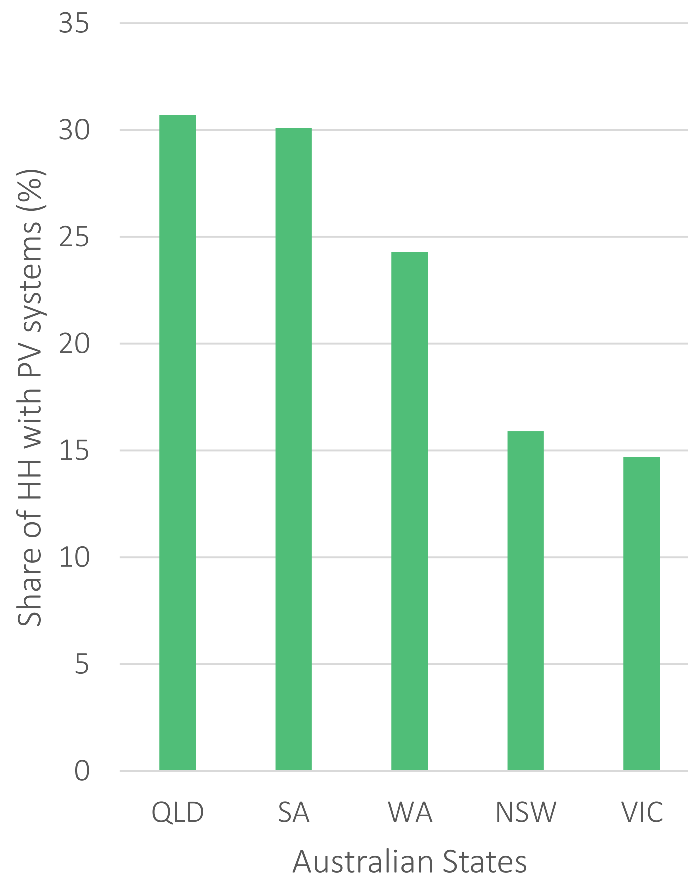
Smaller PV projects are also reaching grid parity

French 100+ kW projects won't require any subsidy anymore*

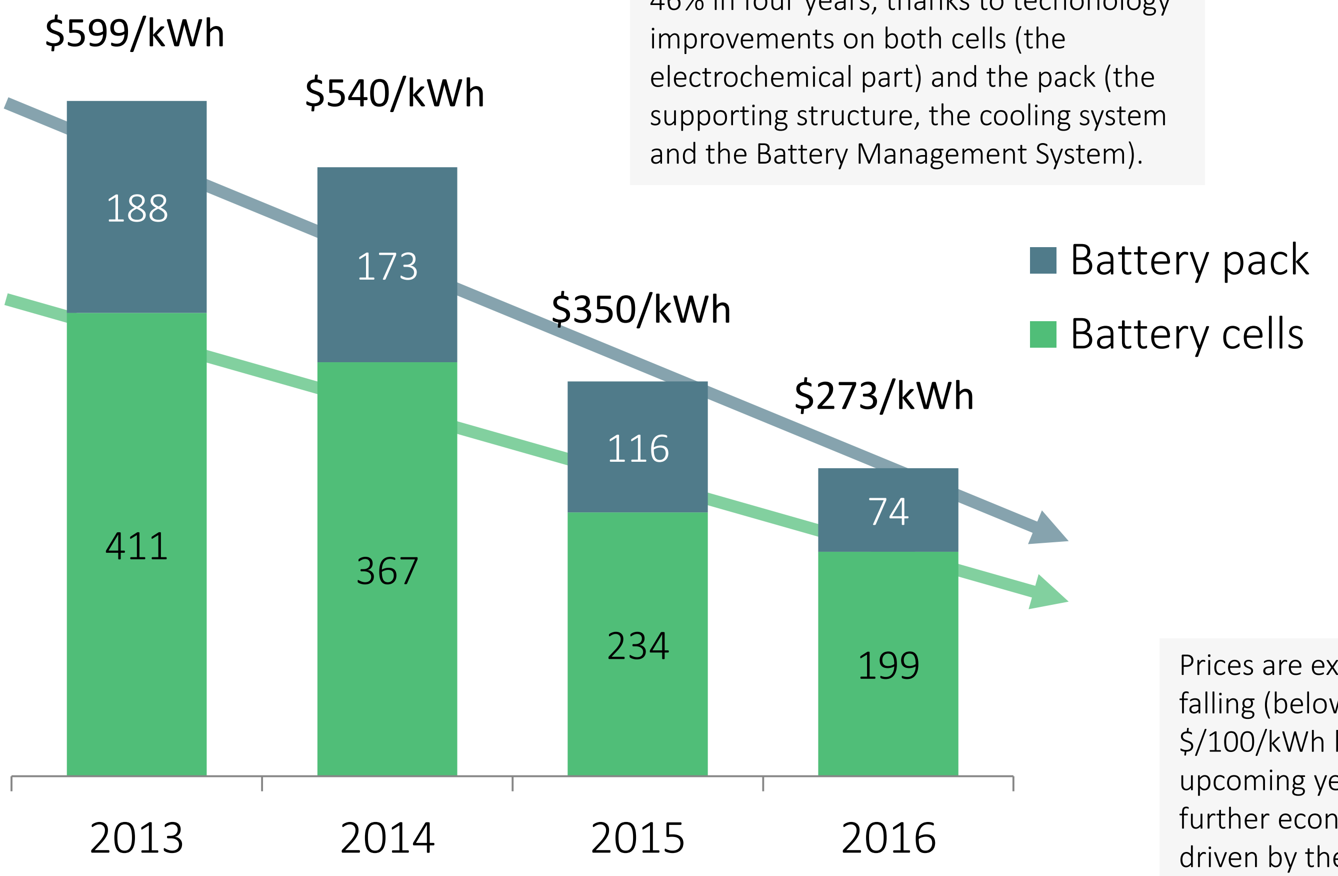


* With current regulation : No CSPE and current tariff structure

Households with PV is commonplace in Australia now



Energy storage system costs are following these same trends



Li-ion battery prices have decreased by 46% in four years, thanks to techonology improvements on both cells (the electrochemical part) and the pack (the supporting structure, the cooling system and the Battery Management System).

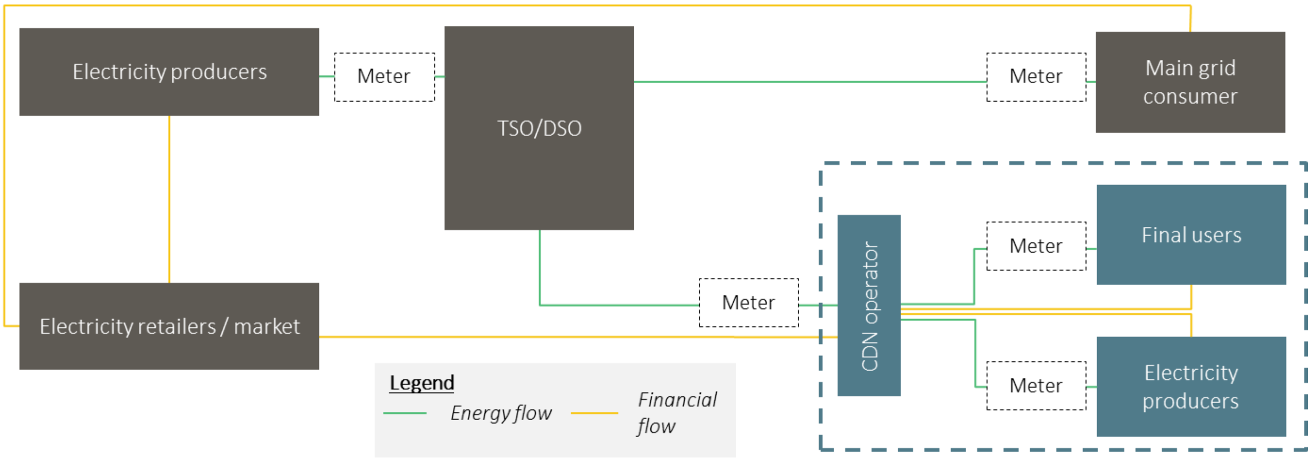
Prices are expected to keep falling (below USD $/100/kWh by 2030) in the upcoming years thanks to further economies of scale driven by the booming electrical vehicle market.

Source : Bloomberg New Energy Finance

Regulation also opens new opportunities for decentralized energy systems – two examples from the French regulatory framework

- Individual and collective self consumption (February 2017) : Self-consumption is considered as collective when electricity supply is made between one or more producers and one or more final users, linked within a legal entity, and using one single low voltage access to the grid[(1)]

- Closed distribution networks (December 2016) : "*A system which distributes electricity within a geographically confined industrial, commercial or shared services site*" and does not supply "*household customers*" (2009/72/CE)



This evolution opened the door to a cluster of solutions, from embedded networks to what is called a microgrid

	Components				Electric boundaries (1)	Islanding	Main grid interaction			Example
	Production	Storage	Load	Controller & EMS			Ancillary services	Local services to DSO	Energy market	
Embedded network	Not included	Not included	Included	Not included	Included	Not included	Not included	Not included	Not included	Shopping mall, Sydney
Virtual Power Plant	Included	Could be included	Could be included	Included	Could be included	Not included	Could be included	Could be included	Included	SmartGrid Vendée, AGL
Prosumers clustering	Included	Could be included	Included	Included	Not included	Not included	Not included	Not included	Included	EnR-Pool
Local prosumers clustering	Included	Could be included	Included	Included	Could be included	Not included	Not included	Not included	Included	FortZED, Colorado
Smart embedded network	Included	Included	Included	Included	Included	Not included	Included	Included	Included	GreenLys, Lyon
Microgrid	Included	Included	Included	Included	Included	Included	Included	Included	Included	Princeton University

Included

Could be included

Not included

(1) Centrale Energies - ENEA - Autoconsommation & Microgrid

Agenda

Current trends on decentralized energy

Review of recent projects

Takeaways from 3 urban microgrids case studies

Conclusion and Q&A

ABB Longmeadow park

Johannesburg, South Africa, completed in 2016

Owner, project developer and end-user: ABB

User case

Unreliable or unsatisfactory grid

Industrial facility

Assets

EXISTING	UPGRADE
Grid 4 x 750 kVA back-up diesel generators	Grid 4 x 750 kVA back-up diesel generators 750 kW solar 1 MVA/380 kWh PowerStore

Business case

Energy security

Production keeps running even during grid power outages

Cost savings

Achieves 27% savings in energy costs (from USD $610,000 to $460,000)

Reduction in peak demand charges

Sustainability

Decreases CO_2 emissions by 1,000 tons per year (estimated)

Boston One Campus

- Boston, United States, commissioned in April 2017
- End-user: Schneider Electric
- PPA agreement with Duke Energy (REC Solar)

User case

Reliable grid

Commercial facility

Assets

EXISTING	UPGRADE
Grid	Grid 448 kW solar 500 kW battery Back-up natural gas generator

Business case

Energy security

Powers the building in emergency grid outage cases (natural event, etc.)

Cost savings

Saves 5% of energy costs (estimated)

Optimized performances based on integration of weather forecast and available storage capacities (e.g. electric vehicles)

Sustainability

Reduces greenhouse gases emissions the equivalent of those produced by more than 2,400 passenger vehicles a year

Establishment Labs

Costa Rica, commissioned in 2016

Owner and end-user: Establishment Labs

Project developer: Demand Energy and Rio Grande Renewables

User case

Unreliable or unsatisfactory grid

Industrial facility

Assets

EXISTING	UPGRADE
Grid 2 x 750 kVA back-up Diesel generators	Grid 276 kW solar 500 kW/ 1 MWh battery

Business case

Energy security
Prevents the medical manufacturing plant from suffering production losses due to the disruption of the sterilization process during power outages

Cost savings
Significant savings from prevention of production losses
5% reduction in energy bills from peak shaving

Sustainability
Reduces national use of gas peakers

Collective self consumption in France: a pilote project for a new regulatory opportunity

- Smartmagne project in Margmagne (Cher)

- Target : Be the first municipality to implement the provisions of the law on collective self-consumption and flexibility service.

Production : 220 kWc

Energy storage : 100 kW

Includes 2 EV charging stations

Capex : 1,6 M€

Les bénéficiaires

2 bornes de recharge rapide POUR VÉHICULES ÉLECTRIQUES

\+

9 bâtiments communaux producteurs (220 kWc)

\+

61 foyers HABITATIONS ET COMMERCES CONCERNÉS

\+

78 points lumineux

=

1 projet commun à construire
CONCERTATION CITOYENNE

SMARTMAGNE

OMEXOM

Agenda

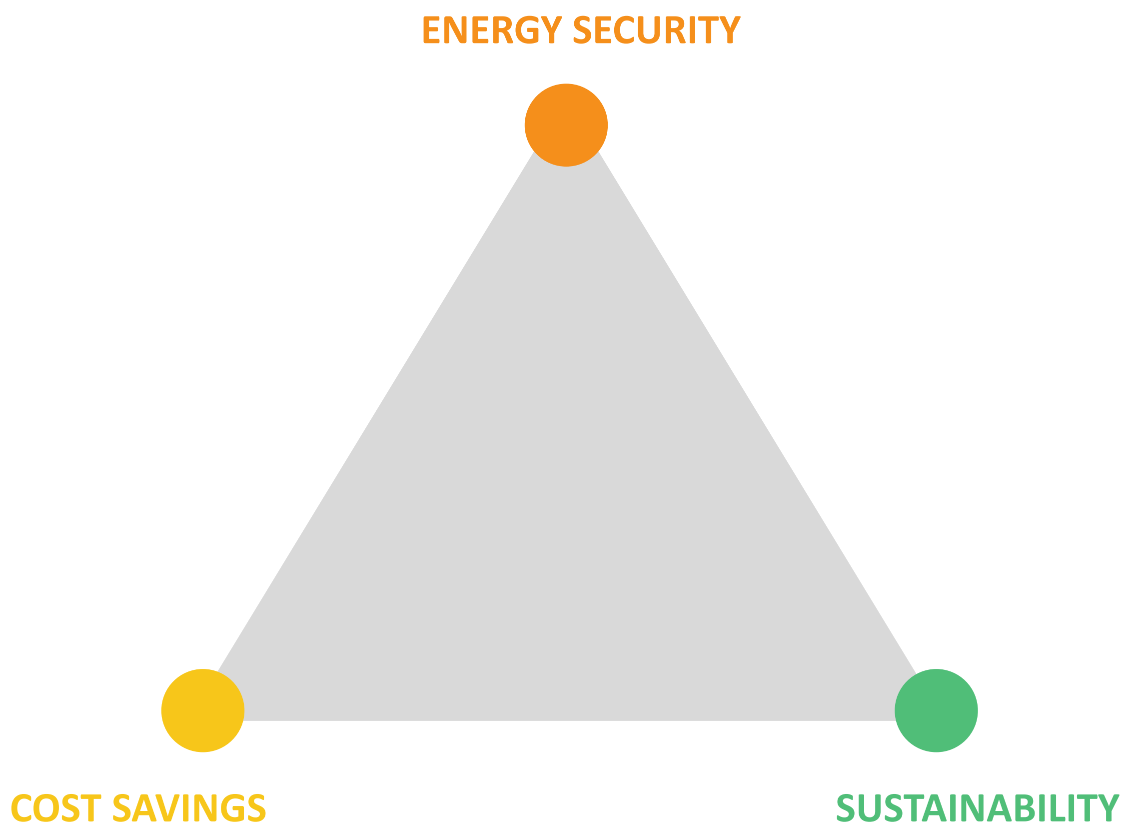
Current trends on decentralized energy

Review of recent projects

Takeaways from 3 urban microgrids case studies

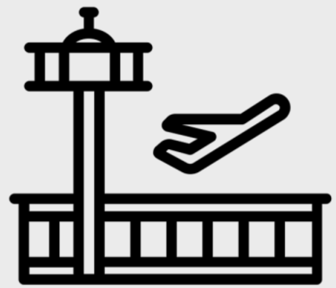
Conclusion and Q&A

Energy supply is about balancing 3 objectives: energy security, sustainability and costs reduction

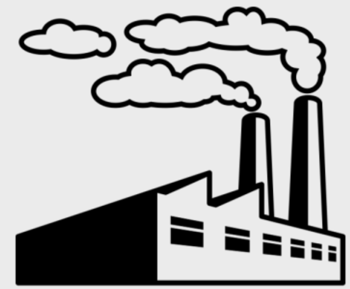


3 case studies were analyzed in the Urban Microgrid projects

ECO-DISTRICT



AIRPORT



INDUSTRIAL

Methodology

Software used:

HOMER ENERGY

HOMER optimises a microgrid design based on the desired components and a set of inputs and constraints:

- The software optimises the size of the components that have been integrated in the model beforehand.
- The model needs detailed yearly input such as load profiles, irradiance data and main grid energy and power prices.
- Optimisation results are framed by constraints on renewable penetration or the duration of islanding.

Main metrics:

- The Net Present Cost (NPC)

$$NPC = \sum_{i=0}^{n} \frac{(Costs - Income)\ in\ year\ i}{(1+WACC)^i}$$

- The Levelized Cost Of Energy (LCOE)

$$LCOE = \frac{NPC}{\sum_{i=0}^{n} \frac{Energy\ consumed\ in\ year\ i}{(1+WACC)^i}}$$

- Te renewable electricity penetration (%RE)

$$\%RE = 1 - \frac{Non-renewable\ energy\ production}{Energy\ consumed\ by\ microgrid}$$

A Californian eco-district

ECO-DISTRICT

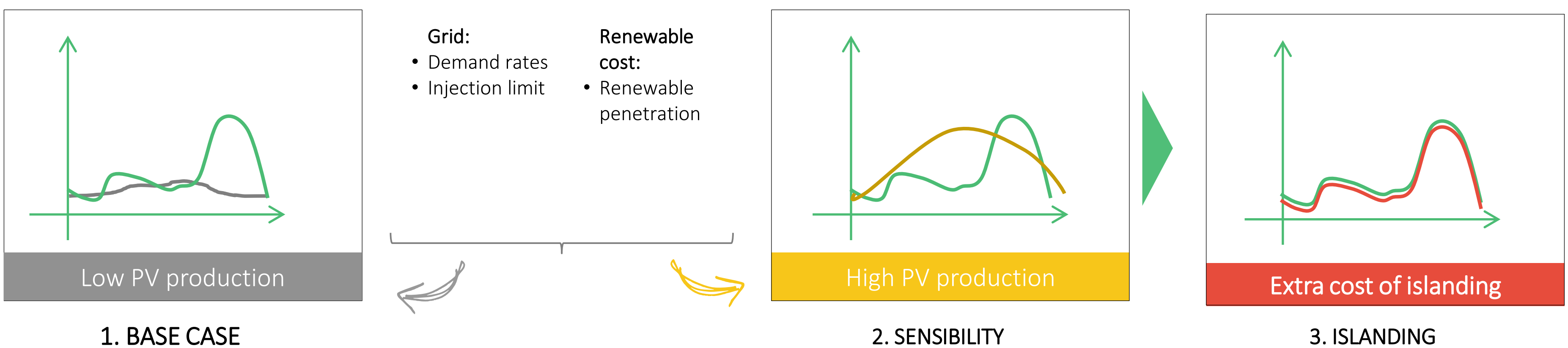
Case: Ecodistrict – Case study presentation

CONTEXT

- **Location:** San Diego, California
- **Microgrid owner:** The property developer
- **Main grid characteristics:** The Microgrid is connected to the secondary network
- **Loads:** annual ecodistrict consumption is ~4GWh
- **Generation mix:** solar panels and batteries
- **Modeling horizon:** 2020 - 2045

SIMULATION OBJECTIVES

1. Test a smart grid in an ecodistrict to evaluate the impact of drivers (cost savings vs sustainability) on the optimal generation mix
2. Determine the extra cost required to become a Microgrid – the same smart grid, that can now island from the main grid for 12 hours
3. Evaluate the influence of battery price, grid constraints and location on the key thresholds



Case: Ecodistrict – Base case

Residential customer

287 \$/MWh[1]

Not included: franchise fees and taxes

Small business customer

229 \$/MWh[2]

Not included: franchise fees and taxes

Ecodistrict pooling

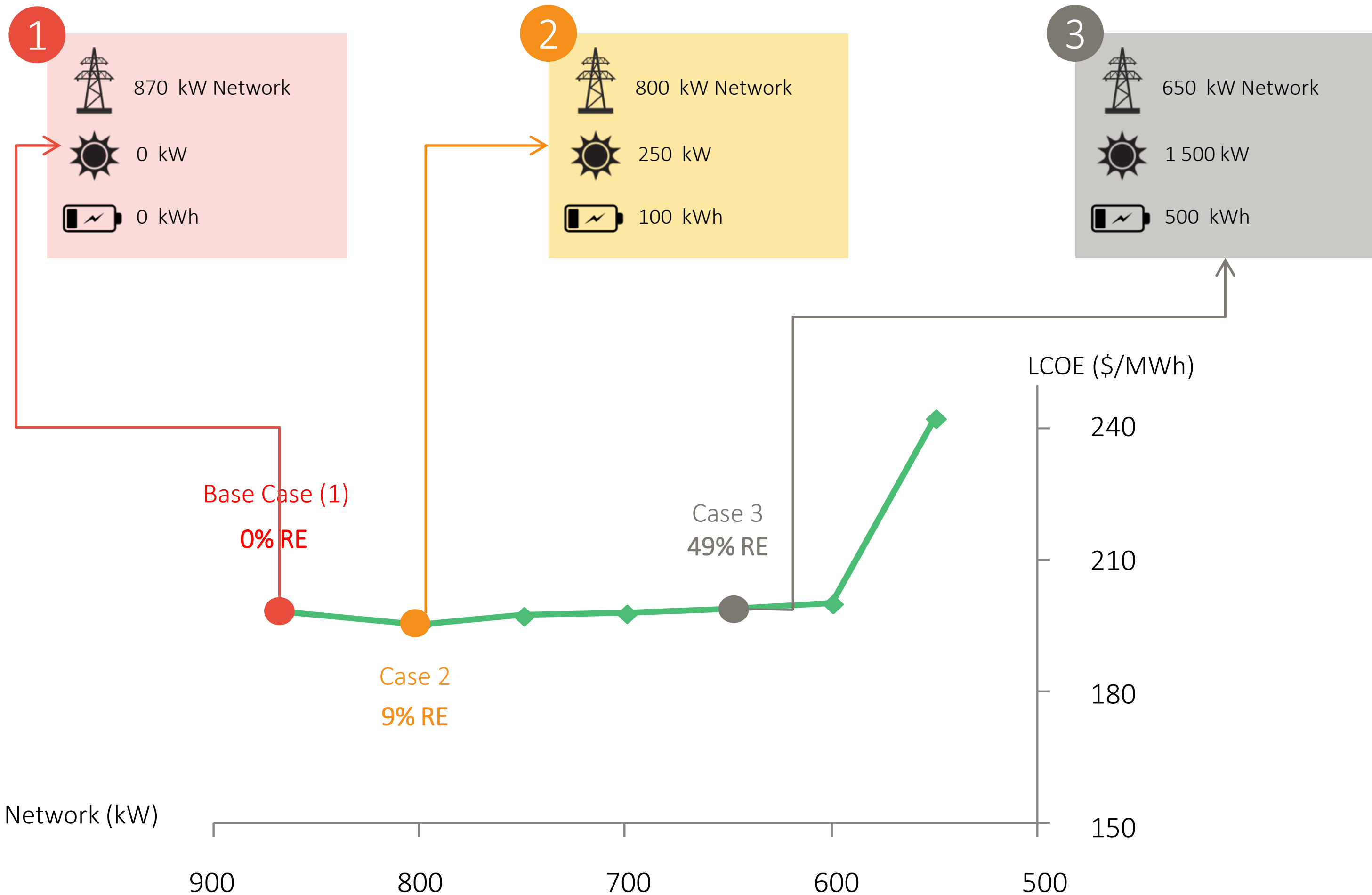
199 \$/MWh[3]

Not included: franchise fees and taxes
Included: 20 \$/MWh for private network

MAIN ASSUMPTIONS

- A 300-household Californian ecodistrict: all-electric, composed of residential and small businesses customers
- 2015 grid and market prices
- 2020 forecast technology prices

Case: Ecodistrict – Pushing up the renewable share



GRID SUPPLY AND INJECTION LIMIT DECREASE

Included in embedded network case: 20 $/MWh for private network
Included in smart grid cases: 27 $/MWh for private network and smart grid equipment

Case: Ecodistrict – Smart embedded networks

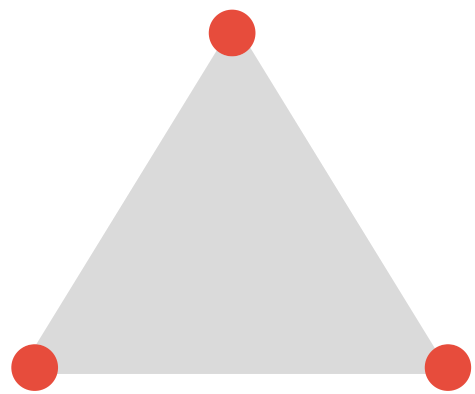
Microgrid

ENERGY SECURITY

- 800 kW demand
- 250 kW installed
- 100 kWh & 9.25 MWh installed

335 $/MWh
9% RE
12 hours islanding in peak summer day

Included: 51 $/MWh for private network, smart grid and islanding equipment



COST SAVINGS

- 800 kW demand
- 250 kW installed
- 100 kWh installed

196 $/kWh
9% RE
No islanding

Included: 27 $/MWh for private network and smart grid equipment

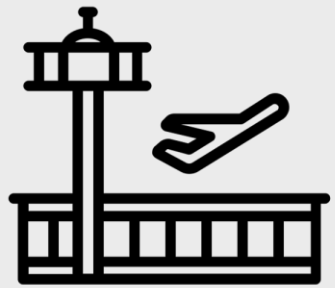
SUSTAINABILITY

- 650 kW demand
- 1 500 kW installed
- 500 kWh installed

199 $/MWh
49% RE
No islanding

Included: 27 $/MWh for private network and smart grid equipment

A French airport



AIRPORT

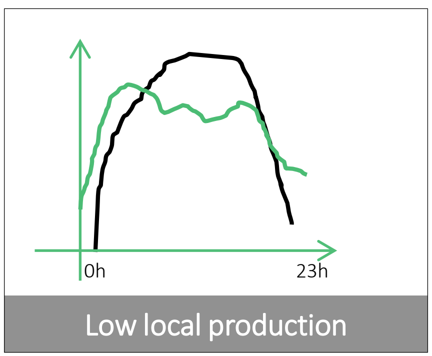
Case: Airport – Case study presentation

CONTEXT

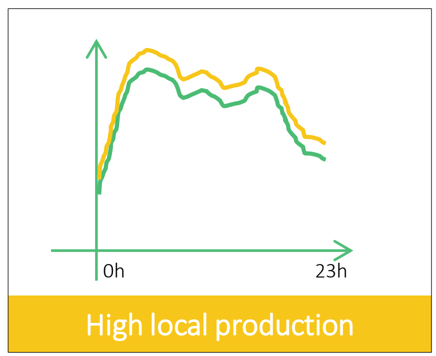
- **Location:** France
- **Microgrid owner:** A small airport's authority
- **Main grid characteristics:** The Microgrid is connected to the French main grid
- **Loads:** annual airport consumption is ~4GWh
- **Generation mix:** solar panels
- **Modeling horizon:** 2025 - 2050

SIMULATION OBJECTIVES

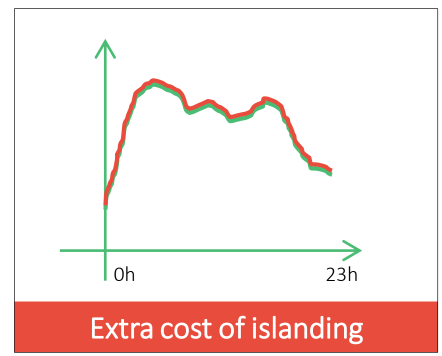
1. Test a smart embedded network in a 100% electric airport that wants to produce as much renewable electricity as it could
2. Evaluate the impact of electrical vehicles and grid interconnexion capacity to optimize the system
3. Determine the extra cost required to become a Microgrid – the same smart embedded network, that can now island from the main grid



1. BASE CASE



2. SENSIBILITY



3. ISLANDING

Case: Airport – Smart embedded networks

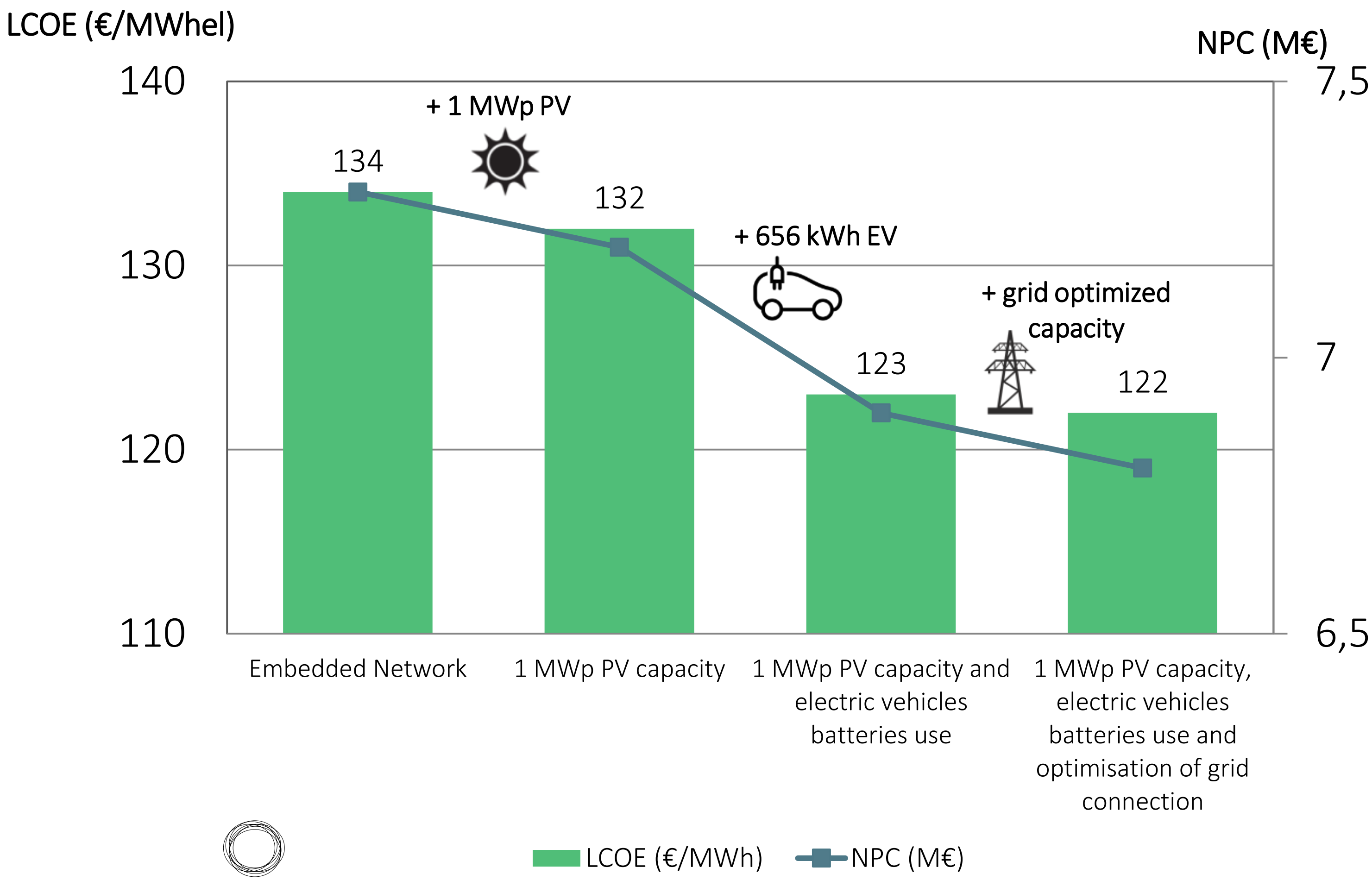
MAIN ASSUMPTIONS

- A 100% electric airport: consumption does not include the air traffic control
- The airport is equipped with electric charging points for electric vehicles
- Energy production: solar parking shelters (up to 5.6 MWp) and batteries (16 electric vehicles – 656 kWh)
- Loads: lighting, HVAC, elevators, baggage sorting systems, sanitary, invertors, electric vehicles, etc.
- 2015 grid and market SPOT prices
- 2025 forecast technology prices
- Costs linked to electric vehicles batteries were assumed to be zero. Each day, an average of 16 vehicles are parked 24/24 which represents an available battery of 656 kWhel

+ 4.2 GWh_{el} purchased

NPC	M€ 7.33
LCOE	€134,4/MWh

Case: Airport – Costs saving levers



Case: Airport – Conclusions

ENERGY SECURITY

- Islanding duration depends on battery size: the longer it lasts, the higher the cost of energy. In France, grid outages are very rare and, when they occur, they last for under **1 hour**

LCOE = € 212/MWh (5.6 MWp PV)

COST SAVINGS

- Costs saving is possible through the installation of a **limited PV capacity** for auto consumption only, with **grid optimization interconnection capacity** and the use of electric vehicles batteries for **vehicle to grid**

LCOE = € 122/MWh (1 MWp PV)

SUSTAINABILITY

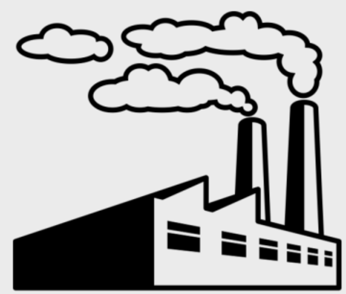
- The maximum renewable achievable with land constraint is 42.4% (5,6 MWp PV)

LCOE = € 186/MWh(5.6 MWp PV)

- Without land constraint, and for an installed capacity of 10 MW (47.5% of RE)

LCOE = € 223/MWh (10 MWp PV)

A French industrial park



INDUSTRIAL

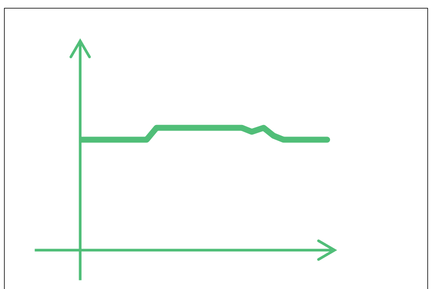
Case: Industrial – Case study presentation

CONTEXT

- **Location:** France, Bretagne
- **Microgrid:** Industrial zone (agribusiness) with growing activity
- **Main grid characteristics:** HTB1 connection
- **Loads:** Electric: 70 Gwh_e-Heat: 106 GWh_{th}-Cold: 53 GWh_{th}
- **Peak for electric load:** 10,9 MW_e
- **Generation mix:** trigeneration unit and solar panel
- **Modeling horizon:** 2020

SIMULATION OBJECTIVES

1. Test a smart grid for a growing industry with HVAC loads, located in a congested region, with a distribution network that cannot provide 100% of the needed electricity for its loads
2. Evaluate the impact of electricity price and load suitability for trigeneration and flexibility
3. Determine the extra cost required to become a Microgrid – the same smart grid, that can now island from the main grid for 24 hours

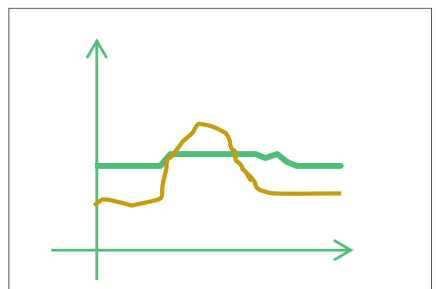


Grid reinforcment

1. BASE CASE

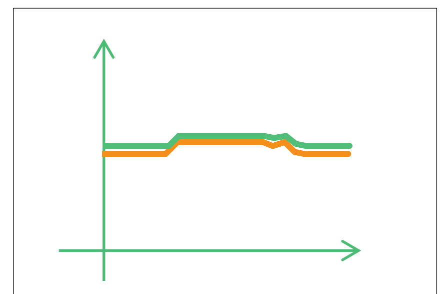
Grid electricity
- SPOT price
- Grid subscription tariff

Load profile
- Ratio between electricity, heating and cooling loads
- Shortage time allowed for non-critical load



Low Grid depency

2. SENSIBILITY

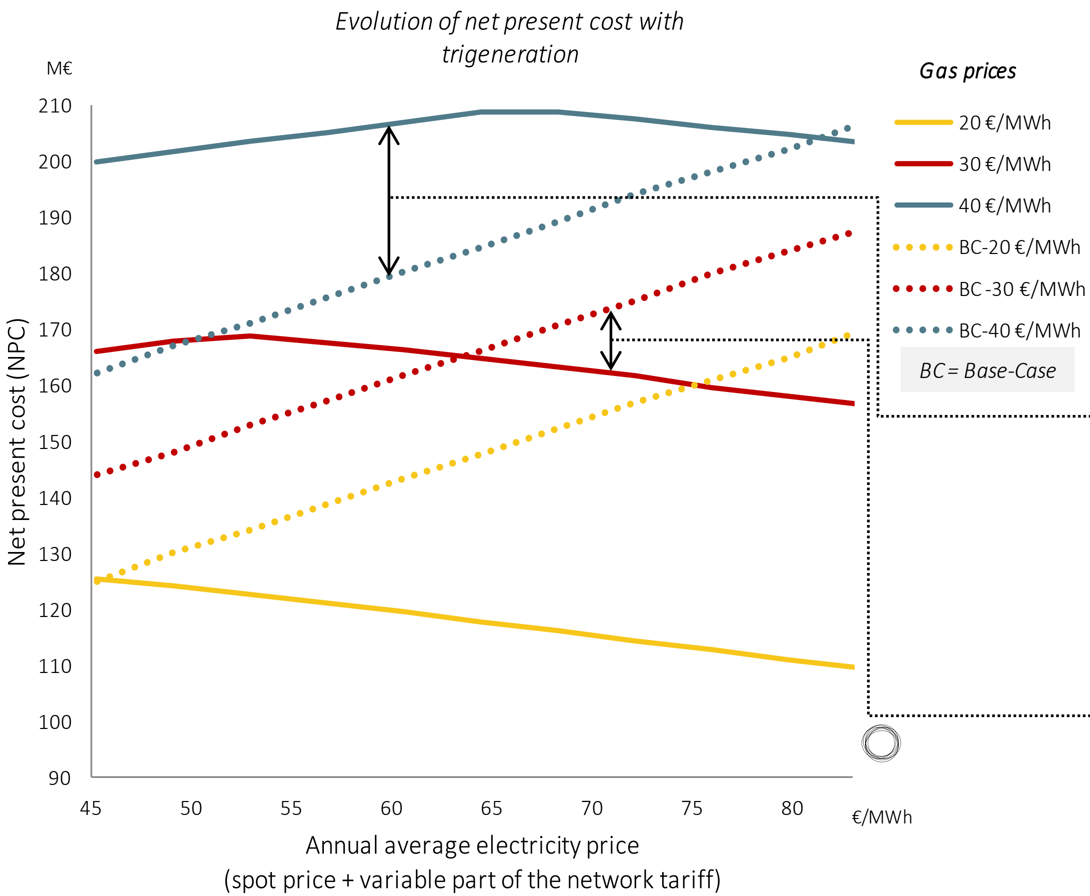


Extra cost of islanding

3. ISLANDING

Case: Industrial – Sensitivity analysis

Cost of grid reinforcement has a low impact on the choice of trigeneration, which depends mostly on electricity and gas prices[1]



ANALYSIS

- Once trigeneration unit reaches 12 MW_{el}, incomes from energy sales to the main grid increase with electricity prices, leading to a decreasing NPC. Before that, system optimization leads to a 4 MW_{el} with 2 MW_p of solar panels because of gas prices.
- Installing trigeneration unit protects the owner of the grid of electricity spot prices variation

EXAMPLE 1

- For a gas price of 40€/MWh_{PCS}, trigeneration unit is not valuable regarding electricity prices. This is true as long as the grid reinforcement costs are not higher than the difference between the 2 curves [2]

EXAMPLE 2

- For a price of 30 €/MWh_{PCS}, installing a trigeneration onsite is valuable once electricity price is over 63 €/MWh_e

Main takeaways from the case studies

Embedded smart networks (no islanding) are more adapted than microgrids (islanding) in presence of a high share of intermittent energy production in urban areas

- Local production of greener and more affordable energy can also be achieved without introducing the islanding capability of microgrids
- Grid tariff structure, origin of the yearly peak demand (heating or A/C) and availability of renewable resources are the three significant sizing factors in the economic optimisation of such networks
- Vehicle-to-Grid technologies can optimize the power demand profile of the microgrid and decrease costs

Microgrids can be economically profitable in presence of a high share of dispatchable energy production and thermal energy demand

- Microgrids capabilities (including islanding) have been found economically relevant in this study only for applications with a strong heat demand (or heat and cold demand), such as demonstrated in industrial zones

Agenda

Current trends on decentralized energy

Review of recent projects

Takeaways from 3 urban microgrids case studies

Concluding remarks

Some regulatory changes need to be made in the grid regulatory framework in order to allow operational implementation of decentralized energy/microgrids

- Current **network tariffs structure** should evolve to reflect more adequatly the service provided.

- Microgrid operators should work under an adequate regulatory regime, especially regarding **unbundling requirements** for vertically integrated structures.

- **Status of microgrid stakeholders** (operators, prosumers, etc.) should be adapted to prevent an excessive administrative and financial burden.

- **Final users rights** within the microgrid, especially the right to **freely choose suppliers**, may be more efficiently ensured by a dedicated regulatory framework.

Conclusions

- Embedded smart networks (no islanding) opens great opportunity in presence of a high share of intermittent energy production in urban areas

- Microgrids (islanding) can be economically profitable in presence of a high share of dispatchable energy production and thermal energy demand

- Decentralized energies can be a solution to reach the 3 energy system targets (energy security, cost savings, sustainability)

- Both microgrids and embedded smart networks face major regulatory obstacles today, limiting the emergence of new promising business models

Luc PAYEN
Manager
luc.payen@enea-consulting.com
+33 1 82 83 83 91