INTEGRATED ELECTRIC VEHICLES AND BATTERIES TO EMPOWER DISTRIBUTED AND CENTRALISED STORAGE IN DISTRIBUTION GRIDS

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INVADE - a Horizon 2020 project

INVADE has been established to investigate new possibilities associated with distributed, renewable energy sources, intelligent control devices and batteries. Europe's current electrical infrastructure face several challenges in the coming years. One is to manage the greater share of renewable energies, another is an aging infrastructure. These challenges should be resolved in a cost-efficient manner. Renewable energies set higher demands to system resilience and flexibility, as we deal with intermittent energy resources, and it is often produced locally in the distribution grid. New system infrastructure is very expensive, urging for better use of existing infrastructure in conjunction with new inexpensive technologies. INVADE seeks to solve these issues by combining already existing technologies into a new framework to create energy cells. Each cell defines an ecosystem and is operated like a virtual microgrid.

The Flexibility Operator

At the core of an ecosystem is a cloud-based flexibility management system. This caters for platform based business models where different parties are invited in to share assets and energy flexibility. Technically the platform manages one or more virtual microgrids. Thus the INVADE system is a peer-to platform based on direct control of demand and supply. The platform connects parties who wish to engage in various forms of exchange (Fig 1). This includes the consumer, prosumer, the DSO and the BRP. A local ecosystem is supervised by a Flexibility Operator (FO). The FO takes decisions based on flexibility contracts. This implies internal trade of energy flexibility to assure best possible local balance between supply and demand in a cell. At the same time it should be able to deliver flexibility services to external parties such as DSOs and the BRPs.

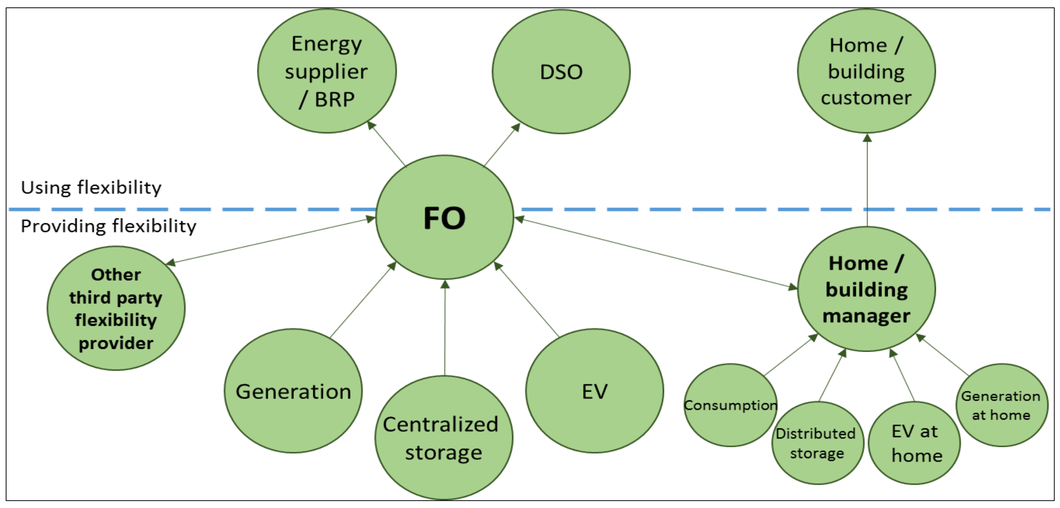

Figure 1 A Flexibility Operator manages one or more energy cells

Scalability is catered for. A franchise of consolidated, local FOs are possible to create based on the basic concept. Hence, multiple ecosystems can be connected under one management that will facilitate exchanges of energy and other assets such as data, across different ecosystems in addition to local trade (Fig 2).

Smart control

Smart control of domestic appliances, stationary batteries and charging stations for EVs that apply smart charging and vehicle-to-grid/building (V2G/B) will aid load-balancing during the course of a day. Combining physical batteries with state-of-the-art data technology opens new marketplaces for trade in energy and energy services, which in turn will provide the end-users with better services while investments in traditional infrastructure is reduced. The FO benefits from the use of AI and advanced Operation Research to optimize operations and predict future loads and expected production from local resources. The smart control targets multiple use cases as shown in Table 1. Each one dedicated to one or more flexibility services.

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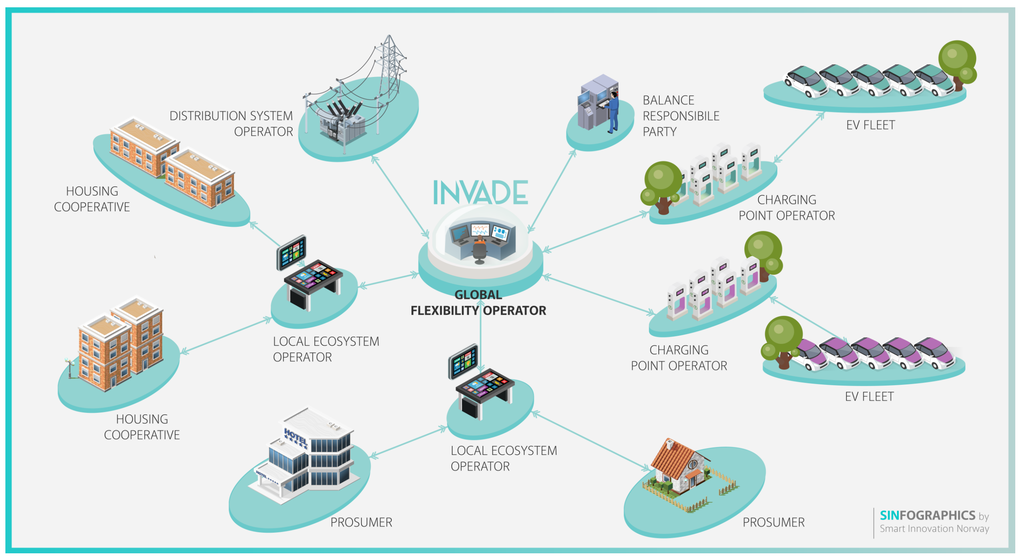

Figure 2 A Global Flexibility Operator manages one or more energy cells

Flexibility customer	Flexibility services INVADE	Description (Flexibility usage)
DSO	Congestion management	Avoiding the thermal overload of system components by reducing peak loads where failure due to overloading may occur.
	Voltage / Reactive power control	Using load flexibility by increasing the load or decreasing generation is an option to avoid exceeding the voltage limits. Voltage control is typically requested when solar PV systems generate significant amounts of electricity.
	Controlled islanding	Preventing supply interruption in a given grid section when a fault occurs in a section of the grid feeding into it
BRP	Day–ahead portfolio optimization	Shifting loads from a high-price time interval to a low-price time interval before the day-ahead market closure. It enables the BRP to reduce its overall electricity purchase costs
	Intraday portfolio optimization	Enabling value creation on intraday market, equivalent to the day-ahead market
	Self-balancing portfolio optimization	Reducing imbalance by the BRP within its portfolio to avoid imbalance charges. The BRP does not actively bid on the imbalance market using its load flexibility, but uses it within its own portfolio.
Prosumer	ToU optimization	Flexibility from high-price intervals to low-price intervals or even complete load shedding during periods with high prices.
	KWmax control	Reducing the maximum load (peak shaving) that the Prosumer consumes within a predefined duration (e.g., month, year), either through load shifting or shedding.
	Self-balancing	Value is created through the difference in the prices of buying, generating, and selling electricity (including taxation if applicable).
	Controlled islanding	during grid outages.

Table 1 Flexibility services incorporated in a set of use-cases tested in full-scale pilots

Pilot testing in five countries

The different use-cases (Table 1) are tested full-scale under different regulatory regimes in Bulgaria, Germany, Norway, Spain and The Netherlands. The test sites involve charging stations, groups of private residences, parking houses, office buildings and extensive hotel facilities.

Preliminary results

- Prosumer directed use-cases under Time-of-Use (ToU) regimes or capacity oriented tariffs (e.g. KWmax control) have proven economically and technically viable. Self-consumption to reduce peak loads and to increase economic yield for prosumers constitutes a basis for interesting business cases.
- This benefits both the local DSO, the prosumers and the consumers involved.
- The project has already triggered 5 full-scale investment/business cases based on the INVADE concept.
- Creation of ecosystems set in a virtual microgrid to benefit self-consumption and collective peak load management is economically attractive also in regions with low energy prices.
- An INVADE controlled, self-sustaining energy cell organized as an ecosystem produces increased negotiating power with the local DSO. It increases the possibility of achieving status as a dispatchable load ("non-priority load") with lower monthly grid tariffs.
- BRPs have been apprehensive in co-developing the INVADE concept, but appear attracted to the use of consolidated, self-sustaining energy-cells already in place.

The INVADE Consortium