Distribution network adaptations and recommendations for 2020 EV infrastructure charge development in France

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ABSTRACT

EV development is a major component of French strategy for CO_2 emissions reduction. Government plan aims at 2 millions of EV in 2020. It could build up above 8-10 millions in 2030+, therefore a potential huge power demand for electric system.

Development of charge infrastructure is a key point for the success of whole EV strategy. It is a matter of timing, space and costs. It should be done in a progressive & optimized way.

The paper will address the impact on the French Distribution network of the 2020 EV development scenario and propose clear recommendations to achieve a comprehensive optimization of charge infrastructure development :

- *in terms of private installation, connection to distribution network & reinforcements ,*
- *an emphasis on the needs for & benefits of EV charge management (short term & Smartgrids possibilities)*

INTRODUCTION : 2020 EV SCENARIO IN FRANCE

French government has established the following trajectory and repartition of the different types of EV charge points :

Thousands	2015	2020	2025
Electrical Vehicles	500	2000	4500
Private plugs: Residential (50%) Office (50%)	900	4000	9000
Public Plugs Normal charge (16A - 230V) Road network/ parking space	60	340	750
Public Plugs Fast charge Road network/ parking space	15	60	150
TOTAL	975	4400	9900

In 2020, 2 millions EV are expected, leading to 2 million Residential + 2 millions office charge points and 400 000 public charge including 60 000 fast charge points

2020 EV INTEGRATION COSTS & RECOMMENDATIONS EVALUATION

1. **Normal Charge for households**,

   normal charge 3kVA is well suited for connection to households LV installation (mostly single phase and < 12kVA in France). No additional meter is needed.

2. **Adapted connection scheme for residential buildings**

3 different solutions have been assessed (from most to least preferable)**:**

a) Individual private connection from the apartment to the parking in basement (no new meter needed)
b) Individual private connection to common services switchboard in the basement for older and/or larger buildings whenever a) scheme is impossible
c) If capacity is not sufficient, creation in the basement of a new connection point with a dedicated meter

➔ **Individual private connection from apartments to parking is recommended** (if possible) as it prove to be the most cost effective and also easy to decide & realise for recent & small – medium size buildings. It is already used for feeding other applications in new buildings (e.g. freezers in basements). .

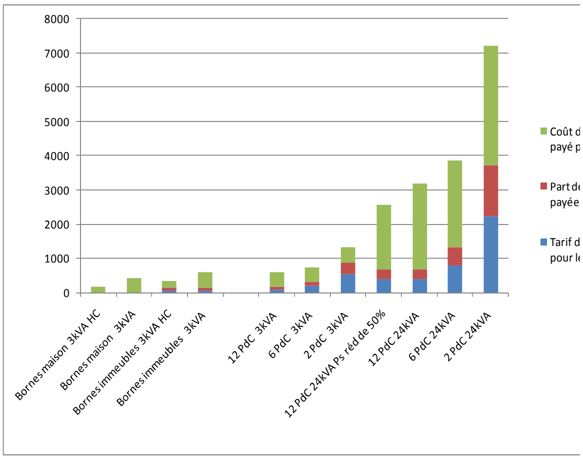
- **private residential points of charge 3kVA are the most efficient for EV integration** in terms of connection as well as network reinforcements as they take benefit of existing connections of households/buildings as well as load management (for residential)
- **office points of charge are more expensive as they are present during peak load** and leads to more reinforcement costs
- **public points of charge are clearly more expansive** and should be limited and focused to their insurance function : **to regroup them limit greatly the costs,** and also load management within the stations of public charge should optimize costs
- **EV regulation is very effective**, with residential EV recharge regulation at homes (not when users comes back from work but manage by the Distributor and started during low load night periods)

Results

A Global EV Distribution network integration cost level of € 2.4 billion (€0,9 Billions for connections, €1,5 Billions for reinforcements) has been estimated in urban zones, and with EV load regulation for residential charge

Note : costs in rural areas would be significantly higher and they have not been addressed in this first scenario

The following figure gives the relative costs estimated for the different types of EV charge based on the 2020, 2 millions EV scenario in urban zone



This shows clearly that key points

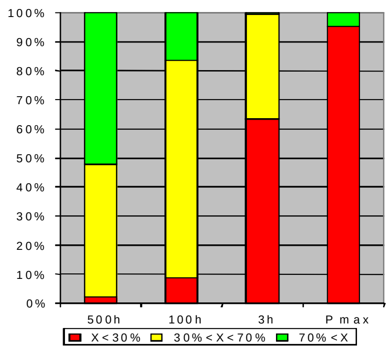
- are using existing network connection
- as well as EV load regulation (normal charge during low load hours at night)

PROPOSALS OF EFFECTIVE MODES OF EV CHARGE

Both effective for the production CO2 content of the kWhs and the local distribution impact :

- ❑ From a **generation point of view**, it may be enough to avoid national peak hours for EV charge.
- ❑ However this does not match DSO interests:
  - There is a **strong local/spatial shift of constraints at the distribution network scale**
  - local network distribution constraints/peak loads today are largely also during national production off-peak periods (see graphic below)

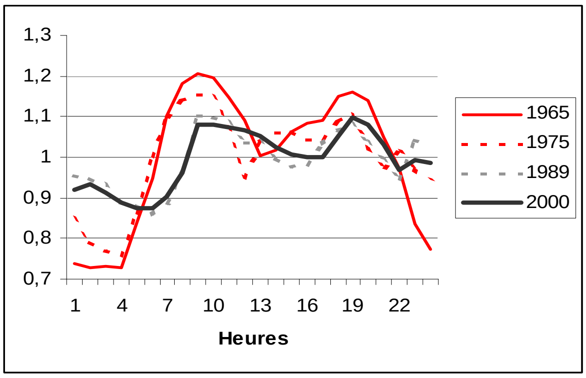
Correlation levels of peak period times : primary substations vs national peak periods



EV Charge management : How can past experience with electric water heating inspire future solutions ?

Since the 70s, electric water heating system has allowed to flatten the national load curve, by transferring loads at night and more recently during mid day periods.

National Winter Day load profile evolution



The system is based on

- ❑ **an incentive tariff with reduced kWh price during low load period and increased price during loaded hours (8-12am & 17-20pm)**
- ❑ **an automatic regulation** : the emission of 175Hz signals (coded on 40 impulsions) from primary substations down to the customers meters. A reception relay besides meter then starts/stops residential water heating electric system.
- ❑ **the distributor defines & manages the 'low load' periods** at each primary substation: up to 4 different time order to reduce the peak effect of the start of the hot water electric heater.

➔ **A short term EV charge regulation could be based on the same principles to optimize EV integration** in the distribution network and in the production system regarding Co2 emissions.

NATIONAL EVALUATION OF THE EV CHARGE REGULATION BASED ON EXISTING 'LOW LOAD' HOURS PERIODS IN FRANCE

A comprehensive national study of 2 main scenarios has been made and is presented

- **No regulation** : EV Charge 'when arriving at home in the evening '
- **EV charge regulation with 'low load period'** start signal

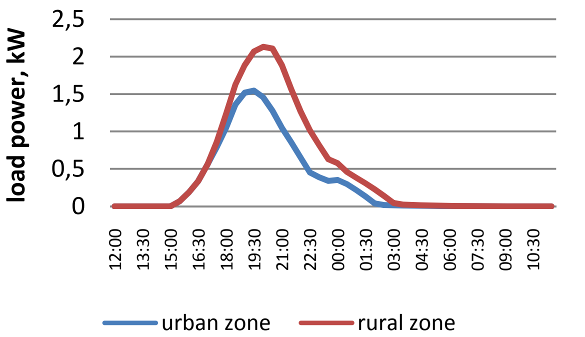
1) First step was the EV Profile construction

EDF R&D provides profiles of the EV charge in the rural and urban zone for different recharge mode.

- The recharge power is supposed to be equal 3 kVA and the average driving distance is 37.5 km and 56.25 km for urban and rural zone respectively.

- This is based on national French transportation data of vehicle use and of first inputs of experimentations.

a) EV Charge 'when arriving at home in the evening '

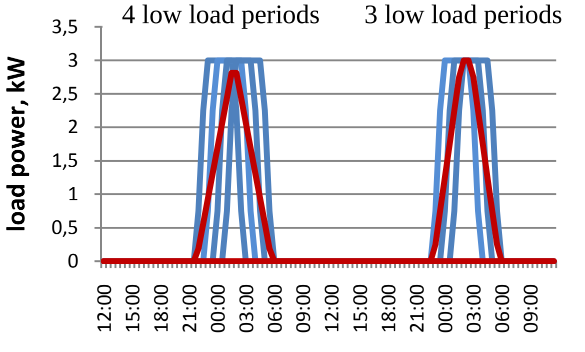


The figure above gives the load curve seen for a group a EV, and is built by taking into account the spread of arrival at home in the evening the charge time

b) EV charge regulation with 'low load period' start signal

- For each primary substation , four low load periods of 8 hours duration are defined and affected to each customer with the low load tariff
- They are started by 4 different start orders (1 order per period) within 22pm-2am

This leads to the following EV load profile, seen by a primary substation or MV feeder :



- <u>EV charge during the normal hours of low load</u> as for hot water heating (left figure). the charge are spread on the different low load periods.
- <u>alternative : restriction of EV charge to the low load periods after 23pm</u> (right figure)

2) 2020 EV distribution on primary substations

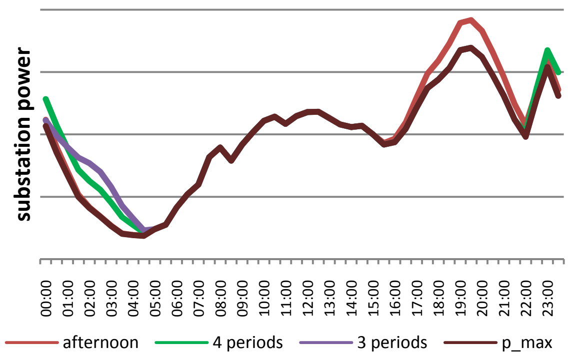
The EV distribution on Primary substations & MV Feeders was made according to the following repartition scenario for the 2 million EV in 2020 :

- 50% of EV in Urban zones (>100 000 inhabitants)
- 30% in semiurban (10000 < < 100 000 inhabitants)
- 20% in rural zones (< 10 000 inhabitants)

3) National Network impact simulation

The simulation method consists in the transformation of the load curve of primary substations or the MV feeders with additional EV based on

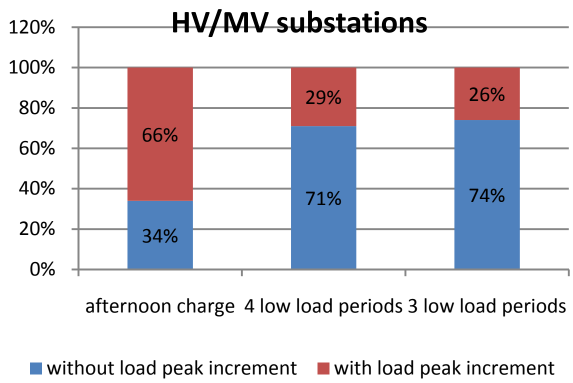
- the number of EV for each substation or feeder ,
- the recharge profile of EV was added for each substation



4) Results : Distribution Network impact, without or with load management

a) Primary substations

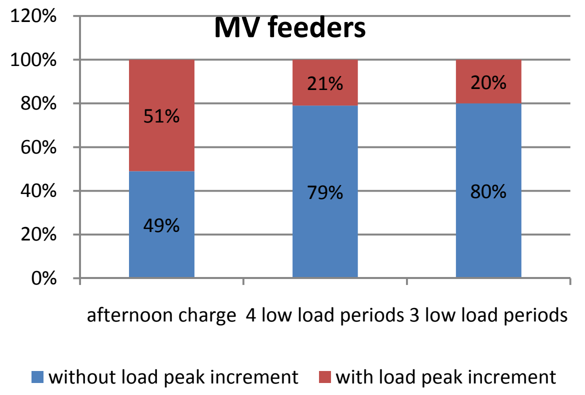
Calculation was made for 1628 HV/MV substations and for each scenario the number of substations with an increment of peak load was calculated. The result is represented on the figure below



→this shows that there is a clear necessity of charge regulation, as the number of primary substation peak demand increases are reduced by 3 with regulation

b) MV feeders

Next step was to evaluate the peak load transformation for MV feeders and to search the correlation between the substation conduct and the feeder's one.
The same kind of estimation was made for 2118 feeders of 185 HV/MV substations. The result agree with the substation calculation and it is represented on the image



<u>This shows clearly that **in France**</u>

- without regulation system, **EV residential charge, started 'when parking at home in the evening' leads to a very significant increase of local peak loads** of the distribution network

- The use of the load management based on '**low load hours' managed by the ERDF allows an efficient integration of EV charges for the 2 millions EV till 2020**. It is the same that for the DSM of the existing 10 million 3kVA electric hot water systems.

<u>Beyond 2020 and to integrate very large scale of EV</u>

- **For 10 million EV**, the low load hours regulation still reduce by 60% the constraints vs no regulation .
- However, a significant number of night periods become to be full or even exceeding traditional evening/morning peak periods.

- Therefore, **Research & SMARGRIDS are needed** to enable the development of advanced EV charge management in order to achieve an optimized EV integration at very large scale, by taking into account more precisely and dynamically the local network possibilities & constraints (also down to LV)

<u>Research & validation through experiments should focus though Smartgrids development on</u> :

- what **EV load management / incentive tariffs** & regulation system are needed acceptable by customers to mitigate distribution network local constraints and national generation optimization ?
- use of the **smart meters,** (ERDF 'linky' from 2017 in France) to enable the Smartgrids functionalities and locally manage the network capacity and integrate/combine the EV and the DER

4. SYNTHESIS & CONCLUSION

For the 2020 2 millions EV scenario, a Global EV Distribution network integration cost level of € 2.4 billions (€0,9 Billions for connections, €1,5 Billions for reinforcements) has been estimated <u>in urban zones</u>, with EV load regulation for residential charge

An EV efficient & sustainable integration is needed :
10 Millions EV in 2025-2030, even with 3kVA charge, could lead up to 15-20 GW of additional peak load on distribution network primary substations (85GW today)

This should be based from the start on taking full benefit of existing network connection and use EV load regulation, and more precisely on the following recommendations :

- ❑ **Promote Normal charge at 3kVA** for residential recharge & mainly for offices and public parking as a good compromise between economy and needs (use of existing connection is the most effective) and **take benefit** as much as possible **of existing network connections**

- ❑ **Regroup public charges points & Limit fast charge installation within/to some public charge stations** accordingly with its purpose of 'insurance' of energy for specific situations of EV use. Dedicated Fast charge stations should also preferably connected on MV level.

- ❑ **Regulation of EV charging** should be developed **through tariff incentive and real time automation** between different interacting levels of aggregation, customer side and network side, **to avoid local as well as global peak demand** and minimise network costs and carbonated electricity.

Therefore **Smargrids** with observability & operability of networks and loads management are needed for the long term and very large scale integration of EV optimization :

- **to invest more in intelligence than heavy & capital intensive network infrastructure**
- and bring significant value to society

However impact/adaptations will be real and deep in the next ten years within an existing network that faces also a growing & significant long term challenge of ageing components maintenance and renewals.