



## NET-PRESENT-VALUE ANALYSIS OF BIDIRECTIONAL ELECTRIC VEHICLES PROVIDING FREQUENCY CONTAINMENT RESERVE

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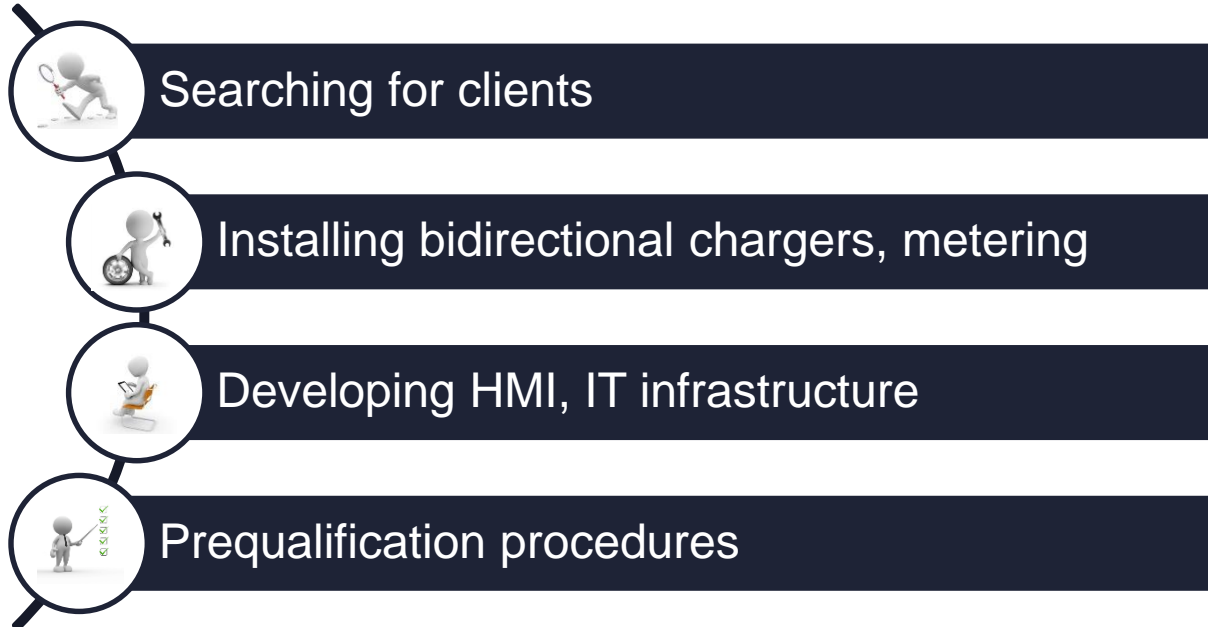


# INTRODUCTION

- EV participation to FCR reserve has been proven to be technically feasible
- Previous study showed that market rules could limit revenues for fleets of EVs
  - Temporal granularity: 1 week
  - Volume increment: 1 MW
  - Alternative market rules were proposed
- Which level of revenues allows to have a profitable business model ?
  - Which costs for bidirectional chargers?
  - Market-design?
  - Price of the service?
  - Size of the fleet?

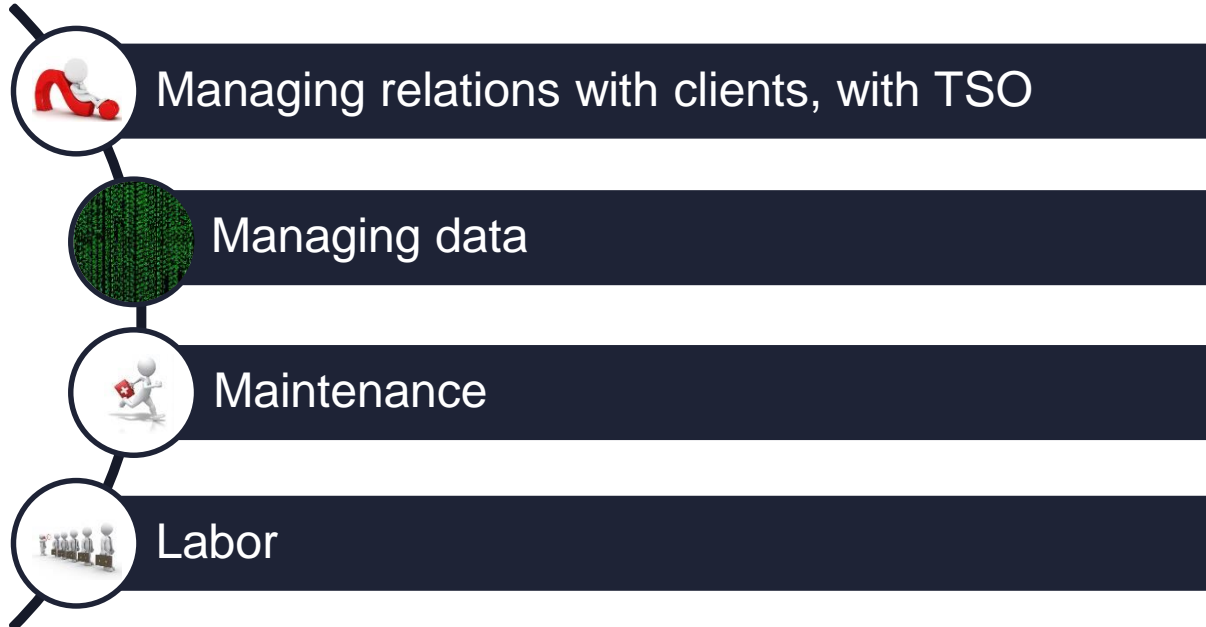
# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

- Question: Which level of revenues allows to have a profitable business model ?
- Installing bidirectional chargers and aggregating a fleet of EVs will induce some costs
  - Investment costs



# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

- Question: Which level of revenues allows to have a profitable business model ?
- Installing bidirectional chargers and aggregating a fleet of EVs will induce some costs
  - Recurrent costs



# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

- Profitability of the investment → Positive Net-Present-Value

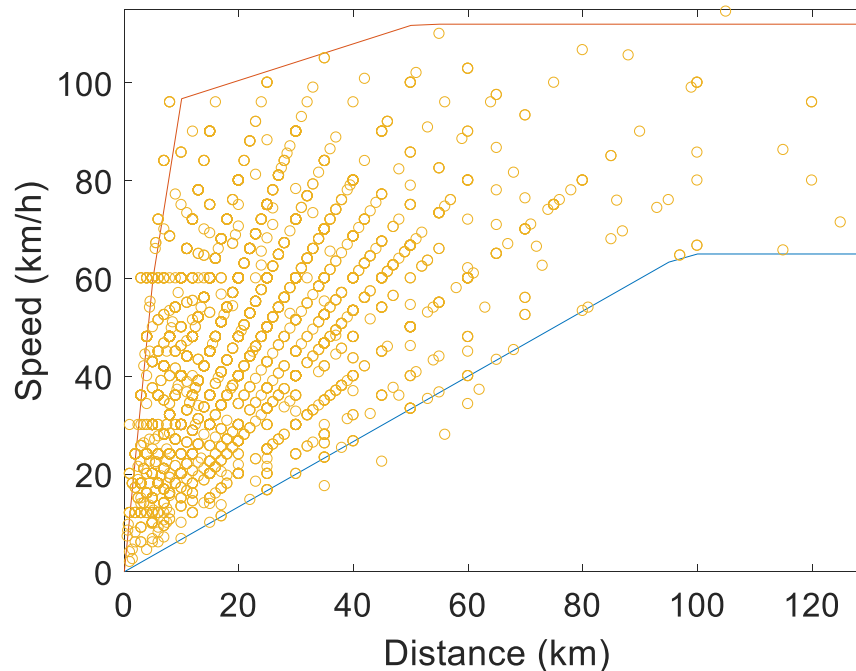
$$NPV = \sum_{t=0}^T \frac{Cash\ Flow_t}{(1+r)^t}$$

- Hypothesis: all the costs are born by the aggregator, all the revenues are for the aggregator
  - If NPV>0 possibility of a profitable business model (but only a first step)
  - If NPV<0 there is NOTHING to share
- Construction of a base-case
  - Calculation of NPV per EV value in function of the size of fleet and market-design
  - Identification of Maximum NPV per EV
  - Identification of minimum size of the fleet to have positive NPV
- Sensitivity Analysis
  - Variation of each parameter of the base case with +- 20%
  - Identification of most sensitive parameters

# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

## Base Case Scenario

Energy Capacity of the Battery	50 kWh
Minimum SOC	20%
Maximum SOC	90%
Power at Home	3 kW
Power At Work	7 kW
Consumption	0.18 kWh/km

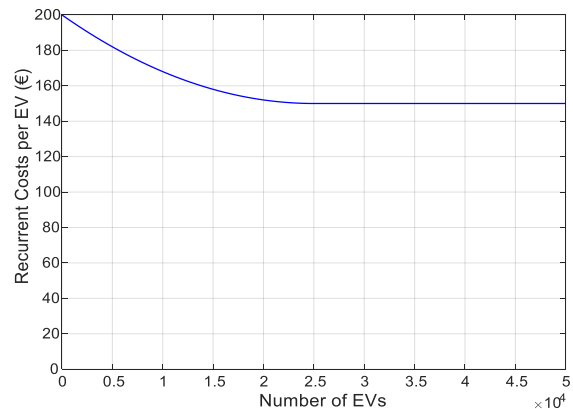
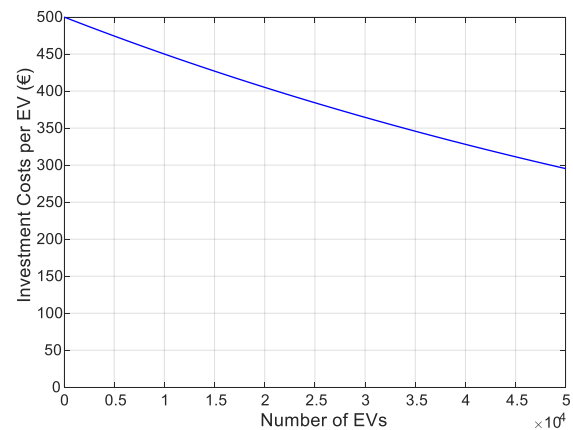


Source : « Enquête Nationale Transport Déplacement 2008 »

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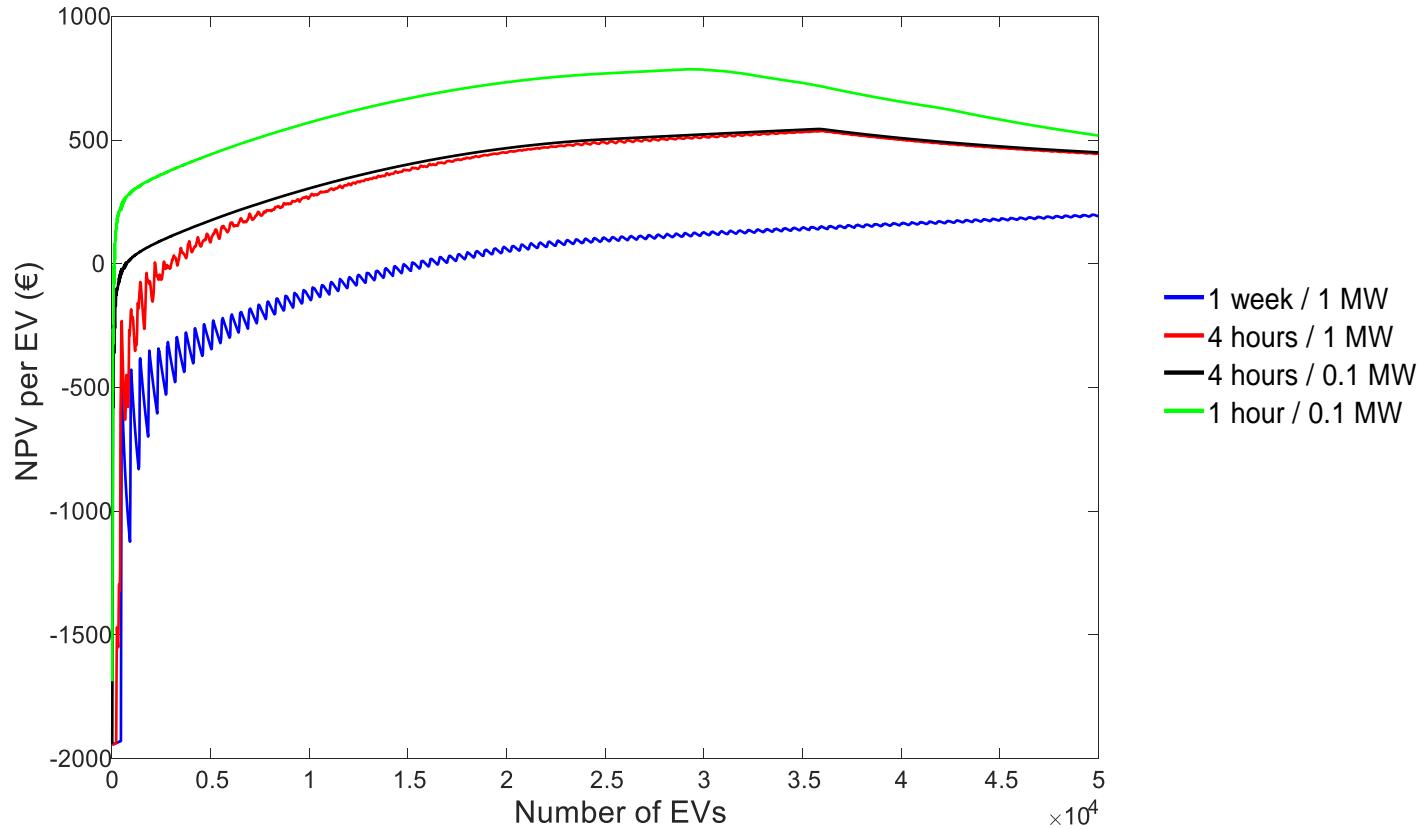
## Base Case Scenario

<b>Investment Costs</b>	$I_0$	500 €/EV
<b>Scale Factor</b>	$\alpha$	10 % every 10,000 EVs
<b>Recurrent Cost</b>	$C_0$	200 €/EV
<b>Minimum Recurrent Cost</b>	$c_n$	75 % of Recurrent Costs
<b>Size where <math>C = C_n</math></b>	$N_n$	25,000 EVs
<b>Margin Security</b>	$\beta$	20 %
<b>Lifetime</b>	$T$	10 years
<b>Inflation</b>	$\tau$	1 %/yr
<b>Average Price of Reserve</b>	$p$	12 €/MW/hr
<b>Discount Rate</b>	$r$	8 %/yr



# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

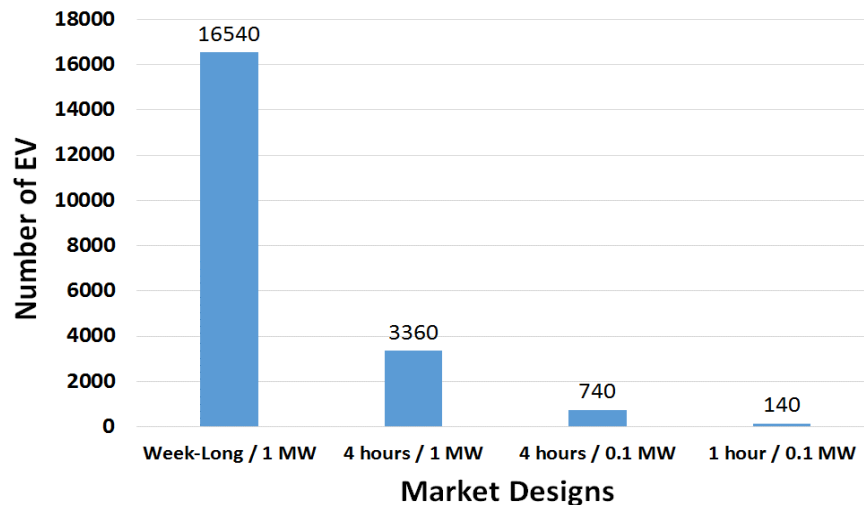
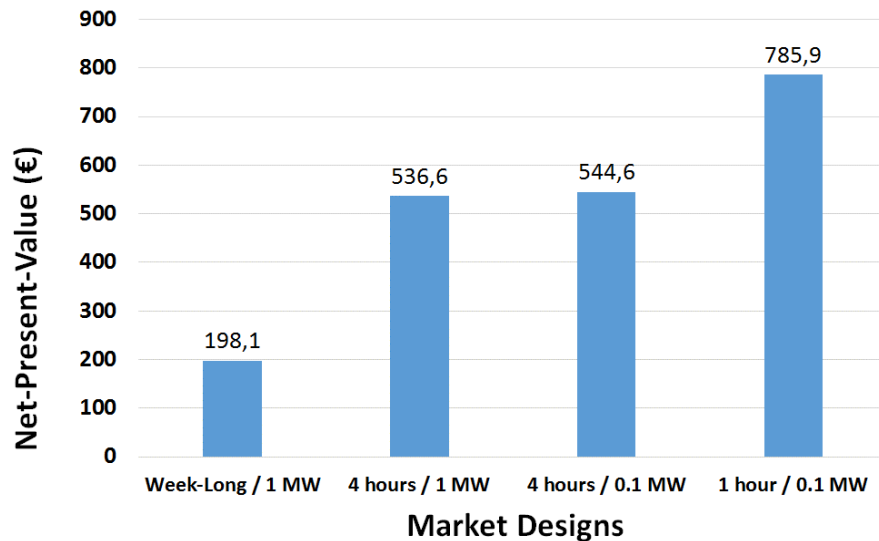
## Base Case Scenario





# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

## Base Case Scenario



# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

## *Sensitivity Analysis*

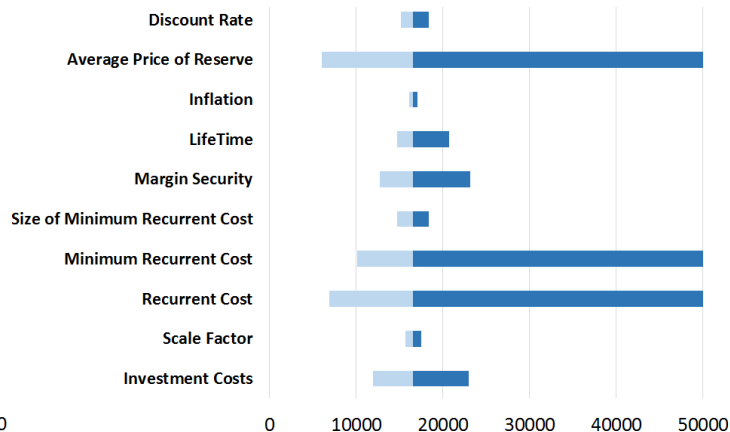
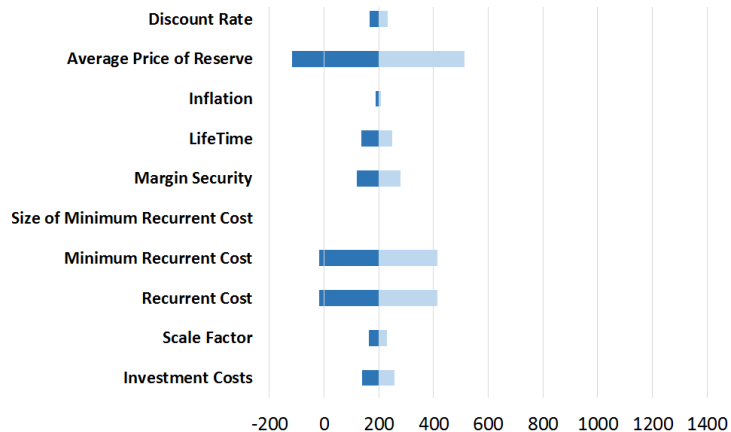
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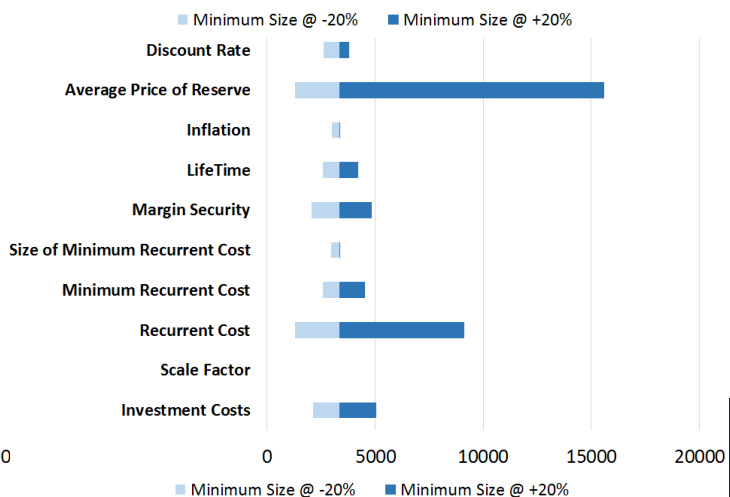
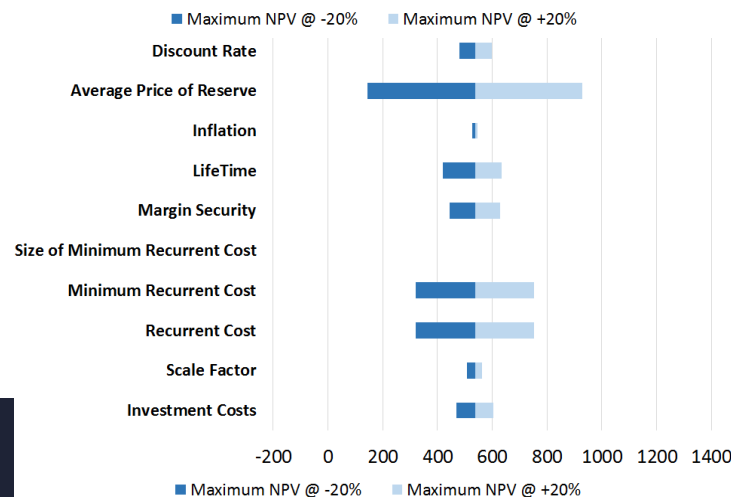
# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

## Sensitivity Analysis

1 week  
1 MW



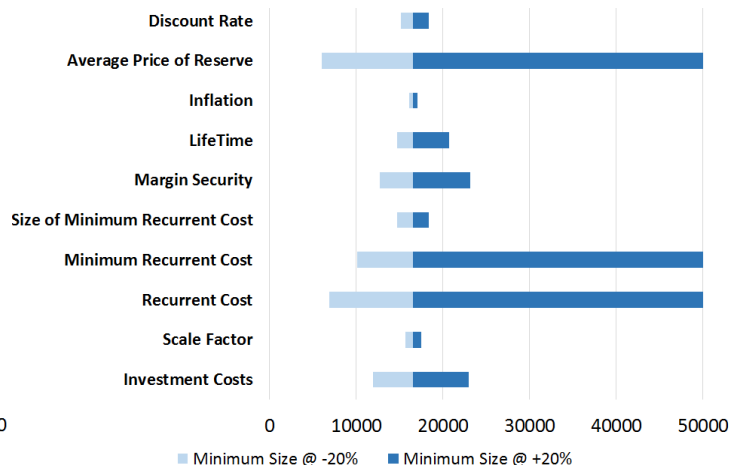
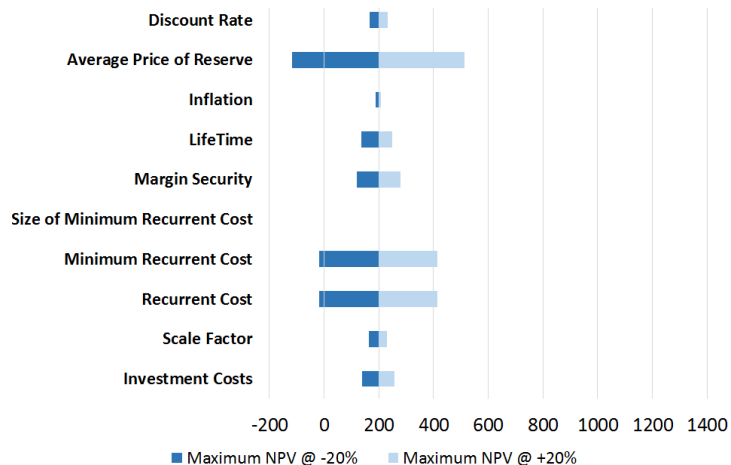
4 hours  
1 MW



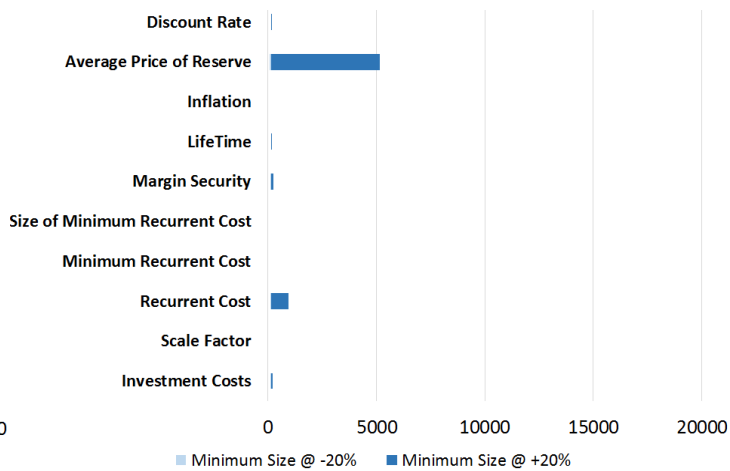
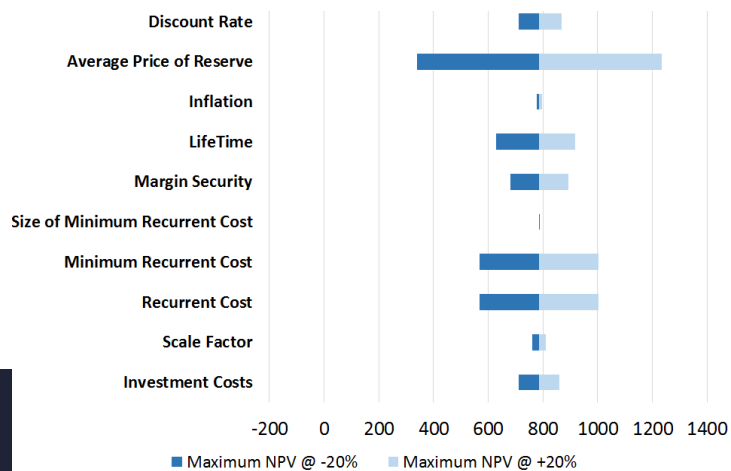
# PROFITABILITY OF AN INVESTMENT IN BIDIR CHARGERS

## Sensitivity Analysis

1 week  
1 MW



1 hour  
0.1 MW



# CONCLUSIONS

- A framework to assess profitability of bidirectional EVs providing FCR
  - Which can be extended to other assets, other types of services
  - Effects of market-design on level of profitability but also on size on the fleet are important
- Large uncertainty in the parameters of the framework
  - Need of large scope for sensitivity analysis
- A first step before a business model
  - Many roles beyond the aggregator → providing bidirectional chargers, enrolling clients, managing contracts, collecting data, bidding on the markets etc.
  - Which costs and which revenue sharing beyond each role ?
  - And which remuneration for the end-user ?