

## Study Committee C5

C5 – Electricity markets and their regulation

Paper ID\_602

# VEHICLE-TO-GRID AS A TOOL TO ENSURE THE FLEXIBILITY OF DEMAND FOR ELECTRIC ENERGY

Tatiana REMIZOVA, Dmitry KOSHELEV

JSC "Administrator of the Wholesale Electricity Market trading System", PJSC "Rosseti Center"

## Motivation

The main goal of this work is to develop proposals for the use of Vehicle-to-Grid technology to ensure the flexibility of demand for electric energy during peak periods.

## Method/Approach

Methods of generalization of normative, empirical and theoretical sources were used, including general scientific and private scientific methods and general logical techniques (abstraction, analysis, analogy and others)

## Objects of Investigation

V2G is a technology of two-way use of electric vehicles, implying the connection of the car to a common electrical network to recharge the car with the possibility of issuing electricity back to the network to participate in the management of demand for electric energy

## Experimental setup & test results

Based on the results of the study, proposals were

- formed for the development of V2G in Russia, which include ensuring the regulatory foundations of the electric energy market using V2G
- the work of an aggregator agent,
- creating technical possibilities for using the V2G and working out economic incentives for its implementation.

## Discussion

- Can electric vehicles be used to ensure demand flexibility?
- What volume of electric vehicles in the country is it advisable to use V2G?
- What tariff should be set for charging electric vehicles and when using V2G?
- What is necessary to use V2G in the country?

## Conclusion

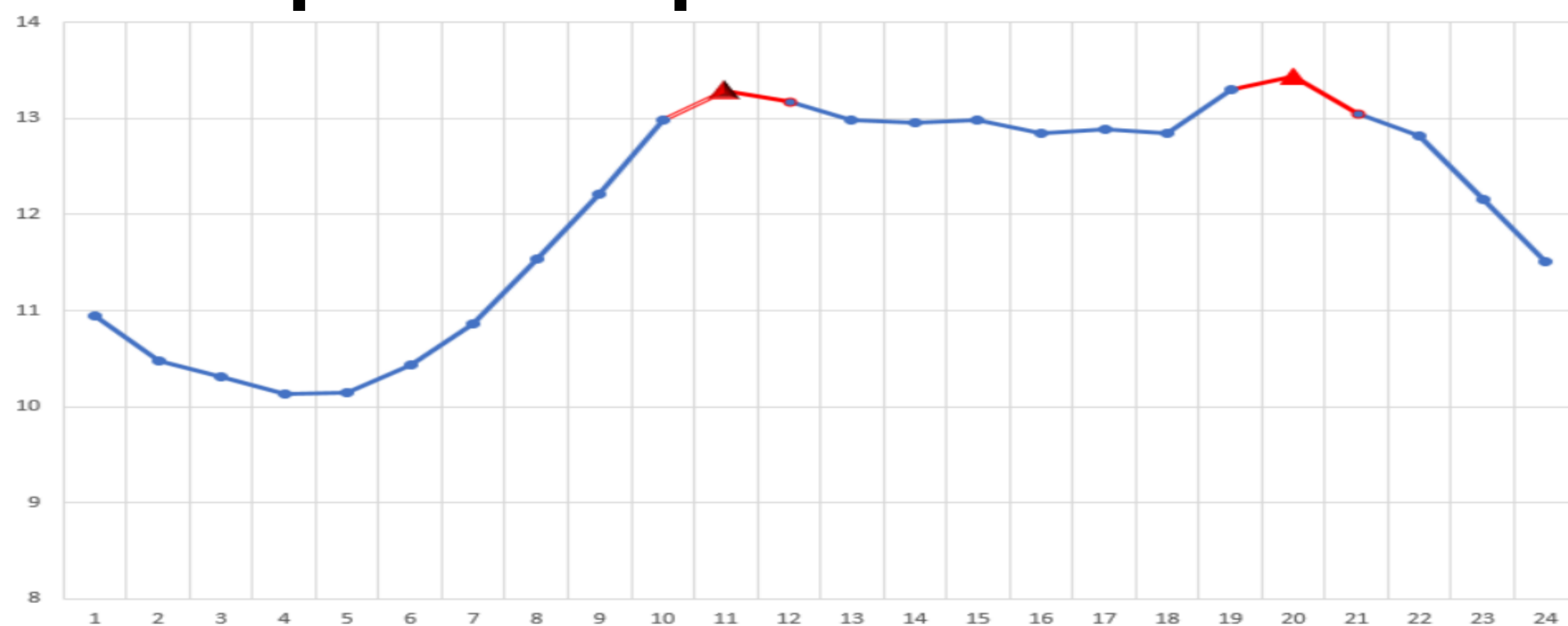
- V2G can be used to ensure demand flexibility with sufficient volume of electric vehicles
- At least 17,000 electric vehicles in the network at the same time are necessary for the expediency of using V2G in Moscow
- It is advisable to set tariffs for the use of V2G by applying the concept of "double tariffs" to provide economic incentives to owners of electric vehicles
- For the use of V2G, the territorial location of electric filling stations, the volume of electric vehicles and the use of an aggregator agent are important

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**continued**

**An electric car can reduce the load on the network from 8 a.m. to 10 a.m. and from 6 p.m. to 8 p.m.**



Schedule of electric energy consumption in Moscow, MW (data from the EOS Center)

Peak periods fall on the hours from 8a.m. to 10a.m., and from 6p.m. to 8p.m., the need for additional power during this time period is about 1000 MW of the average value.

**At least 17,000 connected electric vehicles are needed to unload the network**

Typical parameters of an electric vehicle

Metrics	value
Electric vehicle battery capacity	60 kWh
Average charge time at a slow station to fully charge the battery	11.4 hours (5.25 kW per hour)
Average possible connection time of an electric vehicle to the network	18-22 hours
Estimated additional capacity of 2000 electric vehicles	120 MWh

- one electric vehicle cannot provide enough power to the network during peak
- About 17,000 electric vehicles connected to the grid at the same time can provide additional power of 1000 MW required during peak periods

**Each owner of an electric car can participate in reducing the load of the network**

The behavior of the owner of an electric car is typical:

- lives outside the city;
- every morning at 9 a.m. goes to work and spends 1 hour on the road;
- every evening at 7p.m. goes from work and spends 1 hour on the road;
- every evening leaves the electric car on a charging station located in the house, prefers that the electric car be fully charged by morning



**It is necessary to define the concept of pricing**

Three charging concepts are known

Concept	Basic principles
<b>Simple charging</b>	Owners of electric cars charged them at any time. Charging starts automatically when it connected to the network and during at least 3 hours
<b>The concept of double tariffs</b>	The consumption of electric energy by electric vehicles is carried out at the choice of the owner. The owner prefers a period when electricity is cheaper
<b>Intelligent charging</b>	1.It is carried out automatically and there is continuous monitoring of all units connected to the network  2.The most efficient use of resources is ensured, the operator is used

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**continued**

### It is expensive to charge an electric car with a "simple" charge

#### Calculation of the cost of charging an electric car with a simple charge

Time period, h.	Power kW.h	Battery consumption, kW	Charge, h.	Tariff, EUR/kW	Cost EUR
9.00	60	-	-	-	-
9.00-10.00	60	6,42	-	-	-
10.00-19.00	53,58	-	-	-	-
19.00-20.00	53,58	6,42	-	-	-
20.00-21.00	-	-	1	0,10	0,52
21.00-23.00	-	-	2	0,07	0,53
23.00-7.00	-	-	-	0,03	-
<b>Total</b>					<b>1,05</b>

With a "simple" charging, the owner of an electric car will spend 1,05 EUR per day on charging an electric car

### "Double tariffs" and V2G are cost-effective

The owner of an electric car can sell electric energy to the grid under the following conditions:

- sell electrical energy to the grid at peak for 0,10 EUR/Kw, from 5 kW to get 0,50 EUR;
- restore the battery charge during the night period by spending 0,14 EUR;
- get a profit in the amount of 0,35 EUR for 5 kW.

But! When there are a lot of electric vehicles, the use of V2G requires the participation of an aggregator agent. The work of the aggregator agent should be considered when charging.

### Charging of electric car with "double tariffs" it is 2 times cheaper

#### Calculation of the cost of charging an electric vehicle with the concept of double tariffs

Time period, h.	Power kW.h	Battery consumption, kW	Charge, h.	Tariff, EUR/kW	Cost EUR
9.00	60	-	-	-	-
9.00-10.00	60	6,42	-	-	-
10.00-19.00	53,58	-	-	-	-
19.00-20.00	53,58	6,42	-	-	-
20.00-21.00	-	-	-	0,10	-
21.00-23.00	-	-	-	0,07	-
23.00-7.00	-	-	3	0,03	0,37
<b>Total</b>					<b>0,37</b>

"Double tariffs" are much more profitable, the difference in the cost of a charge with a "simple" charge is more than 2 times

### Conclusion

- The V2G concept can be applied at a certain numbers level of electric vehicles. For example, Moscow – at least 17,000 simultaneously connected to the network.
- To obtain benefits, it is necessary to apply the concept of double tariffs, which is confirmed by the calculations of the authors
- To be able to manage connected electric vehicles and ensure demand flexibility, an aggregator agent is needed. Tariffs should be set considering of the aggregator agent.
- In order to implement V2G, it is necessary to develop an electric charging infrastructure and form regulatory working conditions on the market for both electric vehicles and an aggregator agent.