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Forming solar business prosumers class: the case of Ukraine

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Introduction

- Prosumerism is a new prominent way to struggle with energy poverty and ensure energy security
- It helps implement the green energy transition and national decarbonization strategies due to self-consumption of renewable energy (RE) generated by small power producers
- The development of prosumerism contributes to the energy supply decentralization, the power market liberalization, and the spread of innovative RE technologies and smart grids.

Ukraine as a research object

- imports about half of the consumed energy, has high energy intensity and an outdated structure of the national economy.
- suffered from political and energy blackmail by Russia, which was the leading gas supplier to Ukraine until 2015
- has ambitious goals for the economy's decarbonization through RE development
- needs to increase green energy capacities to guarantee reliable and uninterrupted energy supply in any region of the country due to the Russian aggression
- has been developing RE since 2009 using feed-in tariff as the main incentive (the object of current public discussions)
- **It is crucial to determine the most profitable options for using green energy generated by RE industrial facilities and develop a state strategy to form a prosumer class involving new levers of sector regulation**

The purpose of the research

- to assess the prospects of creating a class of business prosumers in Ukraine in the solar photovoltaic (PV) energy segment

The research questions:

- How did industrial solar PV energy develop in Ukraine, and what are the results of its implementation?
- Are the conditions currently created in Ukraine sufficient for forming a class of prosumers in the solar PV energy business sector?

Contribution of the study:

- covers a gap in substantiating business prosumerism expanding in a transition economy in Ukraine's example

Methods and Data:

- Focus on business PV solar prosumers (industrial PV solar power plants (SPPs))
- The *system, structural, statistical, and comparative analysis* were applied to study solar energy development and its state support mechanisms in Ukraine in 2009-2022
- *Investment analysis* was used to substantiate the economic feasibility of prosumer transition for industrial SPPs owners depending on the options of generated green electricity use.

Methods and Data:

- **The objects of the study** are small and medium-sized ground-based industrial PV SPPs with a capacity of **100, 300, 500, and 700 kW**, which can sell the generated renewable electricity at a feed-in tariff.
- **Options for using the green energy** generated by the PV SPPs:
  1) **20/80:** self-consumption of **20%** of generated electricity and sale of **80%** at the feed-in tariff to the grid;
  2) **50/50:** self-consumption of **50%** of the generated electricity and sale of **50%** at the feed-in tariff to the grid;
  3) **100/0:** self-consumption of **100%** of generated electricity.

Methods and Data:

- The location of PV SPPs: the Sumy region, northeastern Ukraine.
- Only yearly indicators of electricity generation are considered; the monthly energy flows between an SPP and the grid are neglected.
- Industrial PV SPPs are built in 2022 and put into operation from January 1, 2023.
- PV SPPs will work under the basic taxation conditions and the feed-in tariff in peacetime.
- PV SPPs' performance indicators (NPV, PI, DPP) are calculated in euros.

Income calculation by options:

- **20/80:**

$$I_t = FIT \cdot 0.8 \cdot GE_t \cdot (1 - k_{tax}/100\%) + k \cdot 0.2 \cdot GE_t, \quad (1)$$

if t corresponds to the years 2023–2029 when the feed-in tariff is in effect;

$$I_t = k_{gs} \cdot 0.8 \cdot GE_t \cdot (1 - k_{tax}/100\%) + k \cdot 0.2 \cdot GE_t, \quad (2)$$

if t corresponds to the years 2030–2052 when the feed-in tariff does not apply;

where I_t is the income if the t-th year;

GE_t is the green electricity generation volume in the t-th year, considering the coefficient of solar battery annual capacity decline, kWh / year;

FIT is a feed-in tariff, EUR / kWh;

k_{tax} is a corporate income tax rate, %;

k is an electricity tariff (total market price for an end-consumer), EUR / kWh;

k_{gs} is the generator's sale price for electricity, EUR / kWh.

Income calculation by options:

- **50/50:**

$$I_t = FIT \cdot 0.5 \cdot GE_t \cdot (1 - k_{tax}/100\%) + k \cdot 0.5 \cdot GE_t, \quad (3)$$

if t corresponds to the years 2023–2029 when the feed-in tariff is in effect;

$$I_t = k_{gs} \cdot 0.5 \cdot GE_t \cdot (1 - k_{tax}/100\%) + k \cdot 0.5 \cdot GE_t, \quad (4)$$

if t corresponds to the years 2030–2052 when the feed-in tariff does not apply;

- **100/0:**

$$I_t = k \cdot GE_t. \quad (5)$$

Initial data on projects for constructing industrial PV SPPs

Indicator	Capacity of PV SPP, kW			
	100	300	500	700
Annual green electricity generation, kWh/year	114,290	342,870	571,450	800,030
Investment costs, EUR	88492.76	187,119.22	269,111.00	339,675.58
Annual operating costs, EUR/year	1327.39	2806.79	4036.67	5095.13
Decommissioning cost, EUR	4424.64	9355.96	13455.55	16983.78

Initial data on projects for constructing industrial PV SPPs

- The **costs of connecting PV SPPs to the grid** are included in the investment costs.
- **Annual operating costs** are assumed at **1.5%** of investment costs and the **decommissioning cost** at **5%** of investment costs.
- The **lifecycle** of the projects is **30** years.
- The **feed-in tariff** is assumed at **0.135** EUR/kWh as of June 1, 2022.
- The **generator's sale price for electricity** k_{gs} is **0.076** EUR/kWh (the average price in the day-ahead and the intraday markets).

Initial data on projects for constructing industrial PV SPPs

- **The electricity tariff k** is **0.115** EUR/kWh (the weighted average value of the total market electricity prices for end-consumers of the first and the second voltage classes on the day-ahead and intraday markets)
- The income from green electricity sales at the feed-in tariff is subject to an **18% corporate income tax**
- **Annual electricity generation decline** is **0.8%** due to a decrease in the productivity of solar panels.
- The **discount rate r** is **11%** following the assumption of forming the projects' investment costs in a **50/50** ratio of own and borrowed resources in peacetime

Results & Discussion

Research question No. 1: How did industrial solar PV energy develop in Ukraine, and what are the results of its implementation?

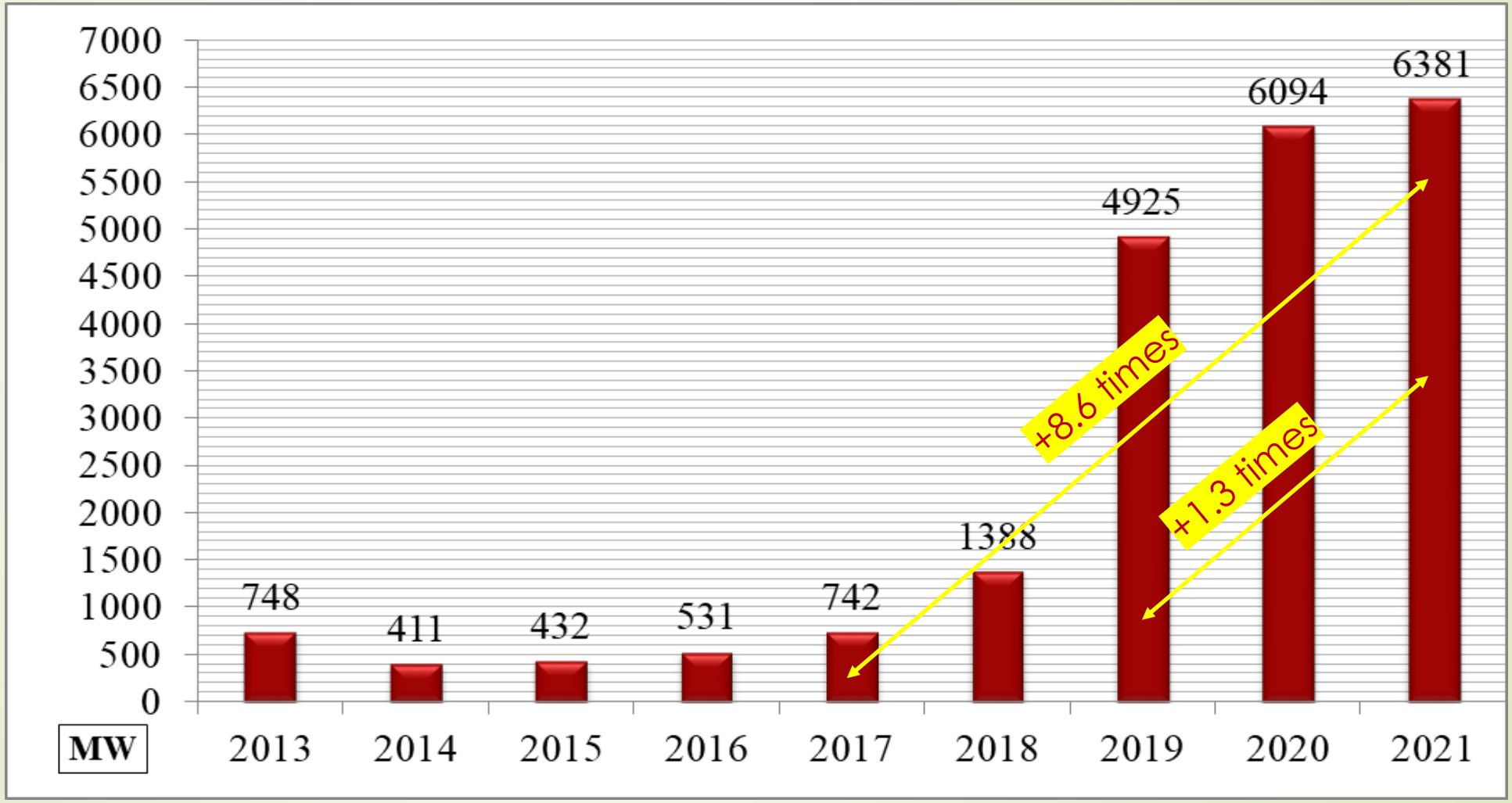
National targets to develop RE in Ukraine:

- the green power share in the country's final energy consumption should increase to **12%** and **25%** in **2025** and **2035**, respectively;
- the Energy Strategy of Ukraine does not contain targets specified for solar energy development

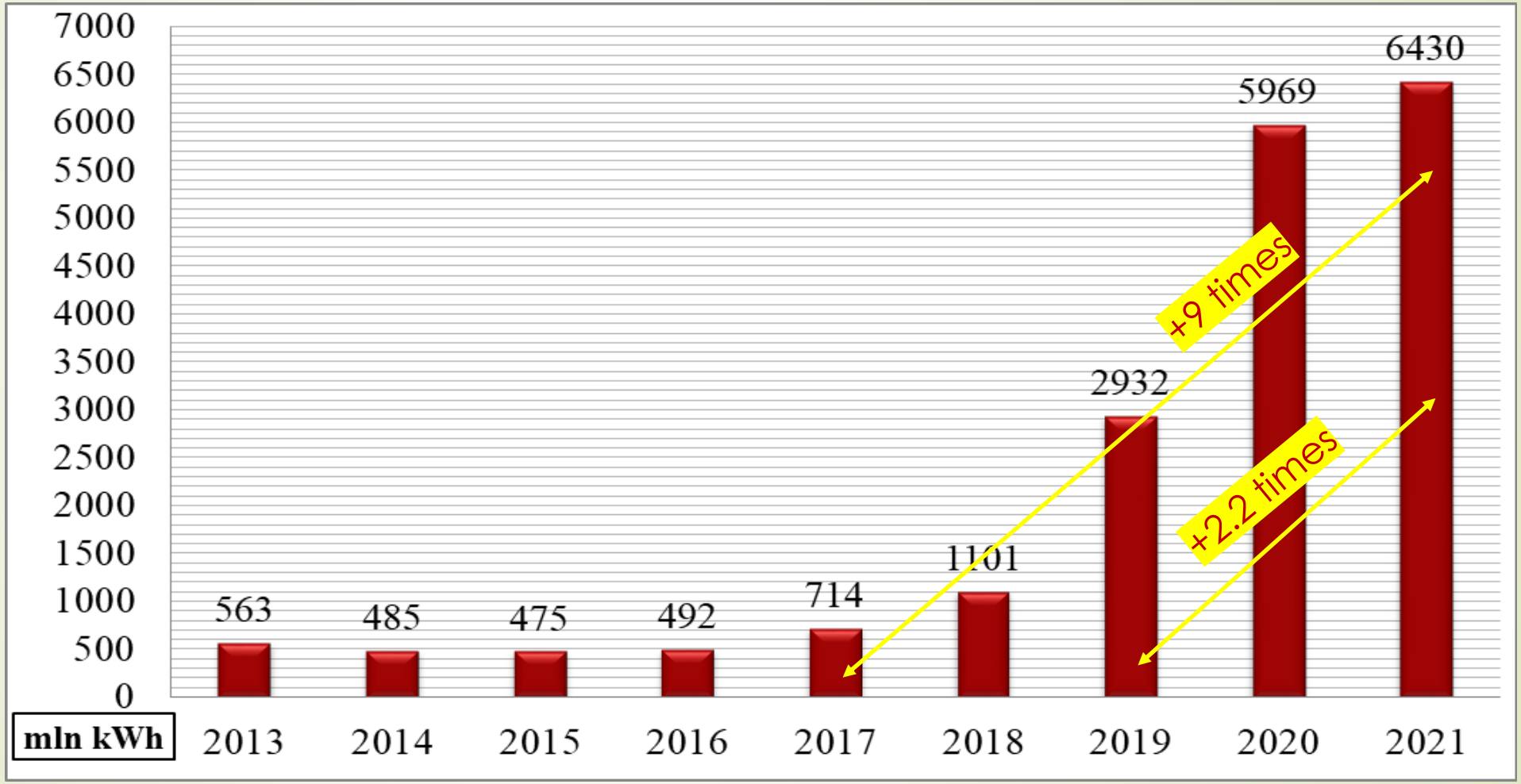
Motivational levers to develop RE in Ukraine:

- feed-in tariff (fixed in EUR)
- a fixed surcharge to it (5 and 10%)
- exemption from payments of Value Added Tax and import customs duties for materials, equipment, and components used to generate electricity from solar radiation (if they have no analogs in Ukraine)
- green auctions

Installed capacity of industrial SPPs in Ukraine in 2013-2021, MW (SAEE, 2022)



The amount of electricity generated by industrial SPPs in Ukraine in 2013-2021, million kWh (SAEE, 2022)



Results of RE development in Ukraine:

- Renewable energy share accounted for about **14%** (including large hydropower) of Ukraine's power output in **2021**
- Payments for the feed-in tariff is a *great burden for the state budget*: the share of renewable energy in the market increased to **8 % in 2020**, which is **26%** of the market money turnover. It caused problems with payments during **2020-2021**.
- *Disproportion of solar PV development* compared to other green power technologies: about **80%** in the structure of renewable energy installed capacities (without large hydropower) in **2021**
- *Increasing imbalances in the United Energy System of Ukraine* due to growing share of green energy

RE development in Ukraine in 2020-2022:

- Delays with payments for feed-in tariff and its reduction by **15%** for green energy producers in **2020-2021**
- Regulatory restrictions on the operation of RE facilities in **2022** due to the discreteness of their energy generation
- **40%** reduction of green energy generation by solar capacities in Ukraine in **May 2022** compared to the same period in **2021** due to the RE facilities destruction in the war
- nearly **30%** of Ukraine's solar power capacity are impacted by the war as of **October 2022**.
- **Reducing feed-in tariff rates decrease the role of this instrument in renewable energy development in Ukraine**
- **Rising electricity prices motivate energy producers to become prosumers**

Research question No. 2: Are the conditions currently created in Ukraine sufficient for forming a class of prosumers in the solar PV energy business sector?

Indicators of economic efficiency of the projects for constructing PV SPPs with a capacity of 100 and 300 kW

Indicator	Option of generated green electricity use (Self-consumption / Sale at the feed-in tariff)		
	20 / 80	50 / 50	100 / 0
SPP with a capacity of 100 kW			
NPV, EUR	-9735.05	-2637.40	9192.01
PI	0.8902	0.9703	1.1036
DPP, years	more than 30	more than 30	18.43
SPP with a capacity of 300 kW			
NPV, EUR	57704.29	78997.23	114485.47
PI	1.3077	1.4213	1.6105
DPP, years	9.64	8.85	8.12

Indicators of economic efficiency of the projects for constructing PV SPPs with a capacity of 500 and 700 kW

Indicator	Option of generated green electricity use (Self-consumption / Sale at the feed-in tariff)		
	20 / 80	50 / 50	100 / 0
SPP with a capacity of 500 kW			
NPV, EUR	143593.44	179081,67	238228.73
PI	1.5324	1.6640	1.8833
DPP, years	6.70	6.58	6.39
SPP with a capacity of 700 kW			
NPV, EUR	242156.70	291840.23	374646.11
PI	1.7114	1.8573	2.1005
DPP, years	5.72	5.63	5.48

Economic feasibility of the projects:

- Projects for constructing PV SPPs with a capacity of **300**, **500**, and **700 kW** are profitable at the current market electricity prices and feed-in tariffs
- Constructing a **100-kW** PV SPP is not competitive when selling **80%** and **50%** of the generated electricity at the feed-in tariff
- The most profitable option for all projects is **100/0** with **100%** of the generated electricity self-consumption

Economic feasibility of the projects:

- The profitability of different projects' options varies from **30.77%** (for **300** kW) to **71.14%** (for **700** kW) of the total amount of initial investments and decommissioning costs of PV SPPs for option **20/80**, from **42.13%** (for **300** kW) to **85.73%** (for **700** kW) for option **50/50**, and from **10.36%** (for **100** kW) to **110.05%** (for **700** kW) for option **100/0.**
- DPP for all projects with option **100/0** are the lowest compared to other options and range from **18.43** years (for **100** kW) to **5.48** years (for **700** kW).
- DPPs for PV SPPs with **300-700**-kW capacities do not exceed **10** years and decrease by almost half as the capacity of a PV SPP increases.

Reasons to become a prosumer:

- a small gap between the purchase price of electricity for an enterprise (**0.115** EUR/kWh) and the price of its sale to the grid at the feed-in tariff (**0.135** EUR/kWh);
- **18%**-tax on the company's income from selling green electricity that reduces the enterprise's net income from the energy sale.

Ukraine has already created conditions for forming a prosumer class among industrial enterprises owning small PV SPPs

Conclusions:

- By assessing the economic feasibility of **100-, 300-, 500-** and **700**-kW industrial photovoltaic solar power plants projects to implement in the Sumy region with three different energy-use options, we proved that ***Ukraine has sufficient conditions to develop a solar business prosumer class***.
- We confirmed that an increase in ***the self-consumption share improves the projects' profitability and motivates*** the industrial photovoltaic solar power plants' owners ***to become prosumers.***
- Therefore, with the preservation of current market conditions and state regulation of the sector, ***Ukraine has every opportunity to form a class of business prosumers*** in the photovoltaic solar energy segment.

Thank you for attention!

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