

***TECHNO-ECONOMIC ANALYSIS OF SIMPLE PRODUCTION AND
CONSUMPTION SYSTEM FOR HYDRO POWER PLANTS: A CASE STUDY***

PhD student Andrea Paolacci:
andrea.paolacci@uniroma1.it

Prof.ssa Maria Carmen Falvo:
mariacarmen.falvo@uniroma1.it

Dott. Ing. Flavio Andreoli:
flavioandreoli@epico.green

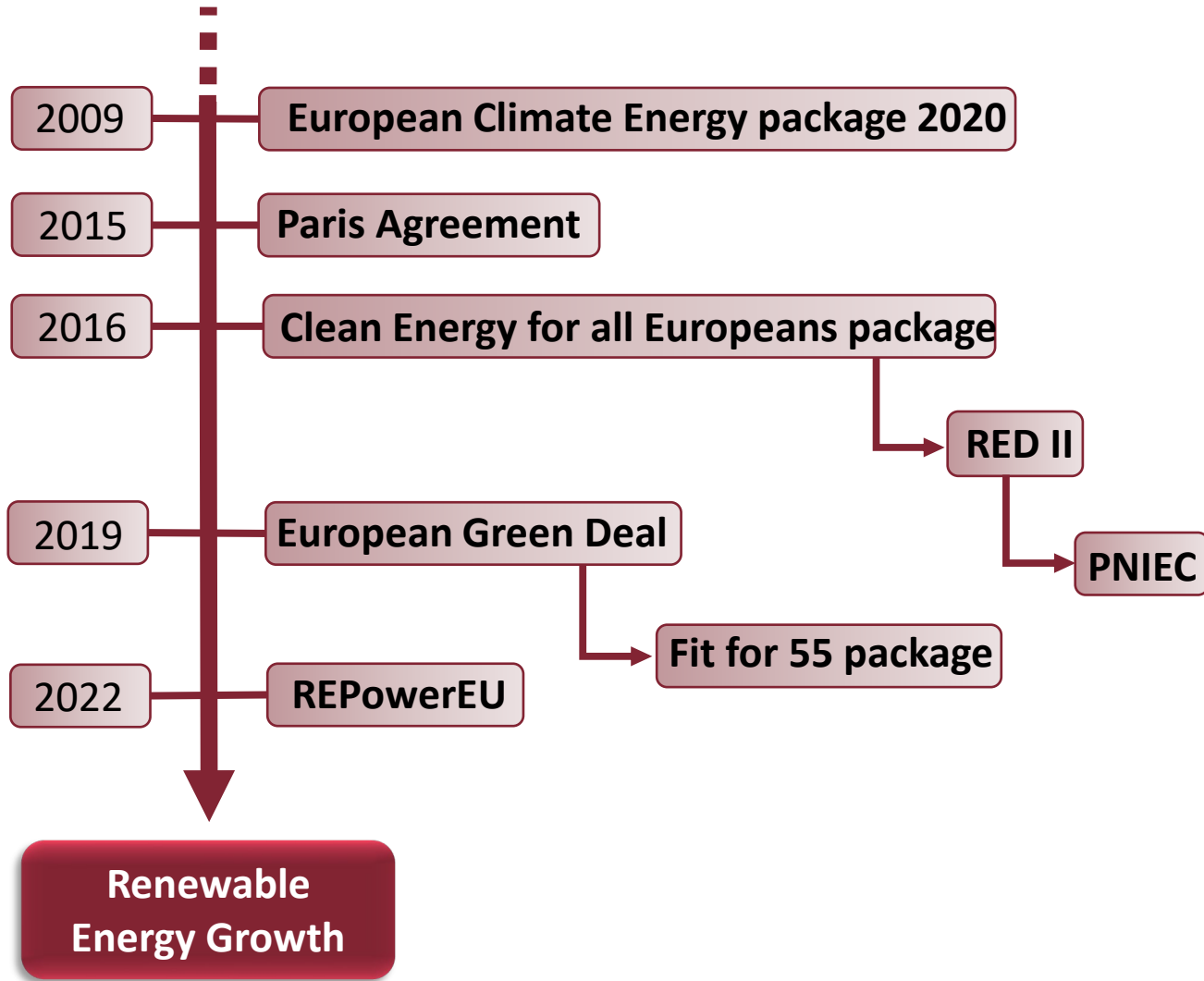


SAPIENZA
UNIVERSITÀ DI ROMA

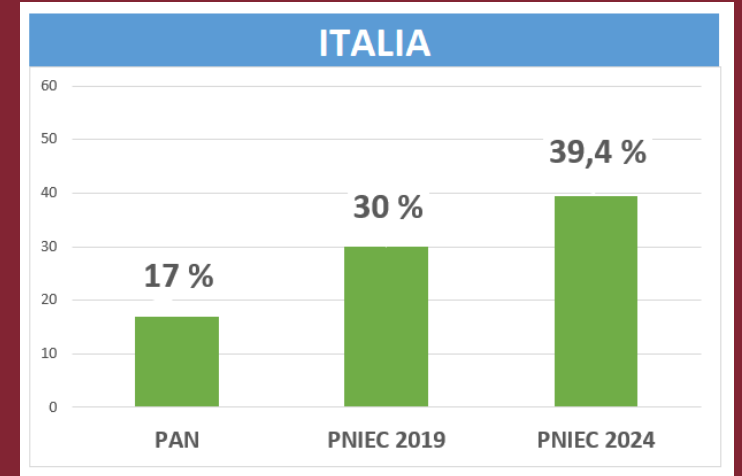
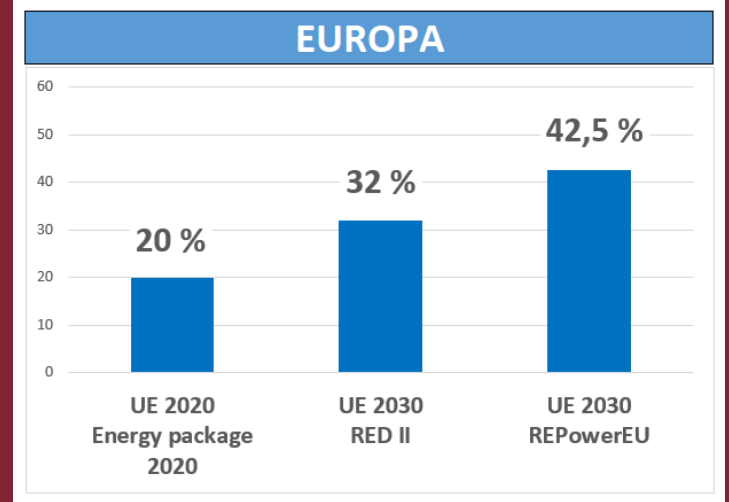


Facoltà di Ingegneria Civile e Industriale
Dipartimento di Ingegneria Astronautica, Elettrica ed Energetica

EUROPEAN FREAMWORK



RES Targets Evolution



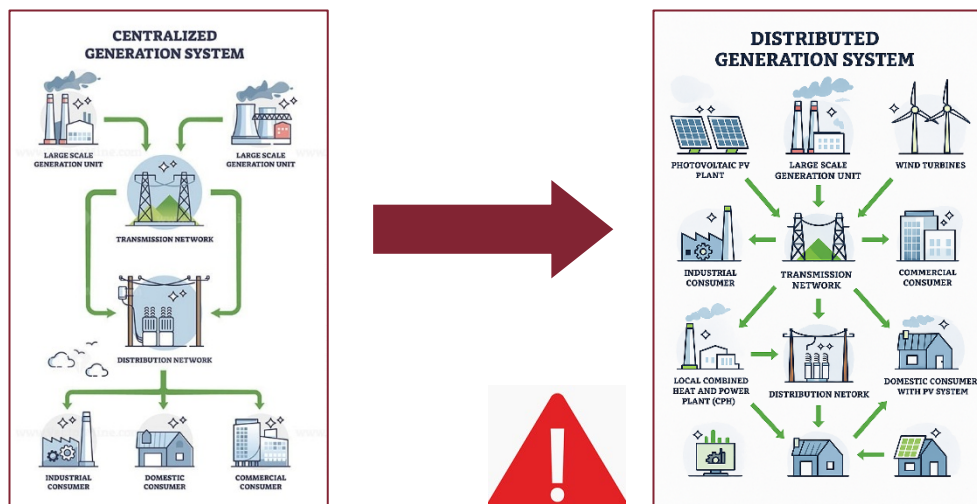
DEVELOPMENT OF RES IN ITALY

In Italy RES installed capacity has grown very fast !

This growth was driven by strong and different support schemes

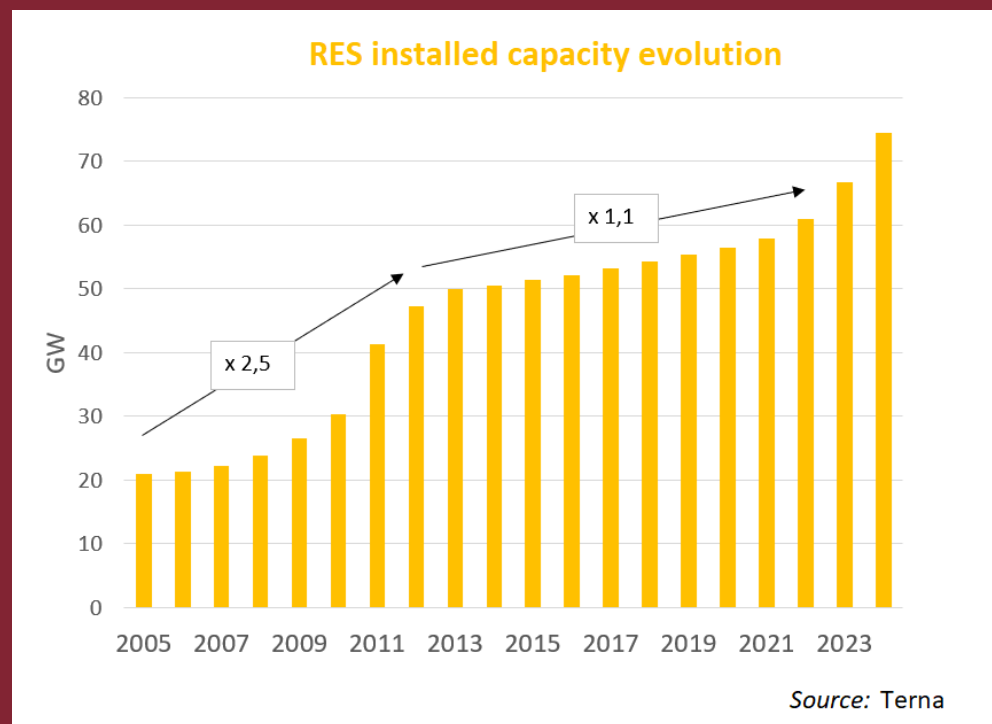
The growth in renewable capacity has led to the development of **DISTRIBUTED GENERATION**

From a **centralized** power system to a **decentralized** one



More complex operation of the power distribution grids

- «Conto energia»
- «Tariffa Omnicomprensiva»
- «Scambio sul posto»
- «Certificati verdi»
- «Aste e registri FER»



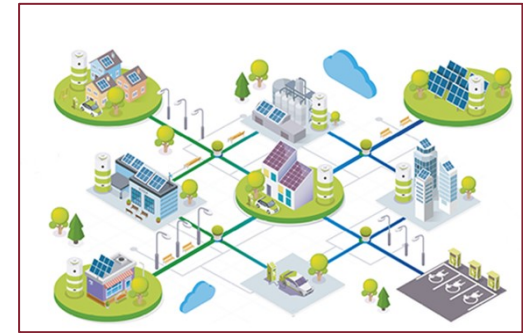
LOCAL SELF-CONSUMPTION (DECREE 199/21 & 210/21)

The local self-consumption of the energy generated by distributed power plants is one of the possible solutions to the challenges faced by the distribution grids.

In Italy, the RED II directive has been implemented through two major legislative decrees:

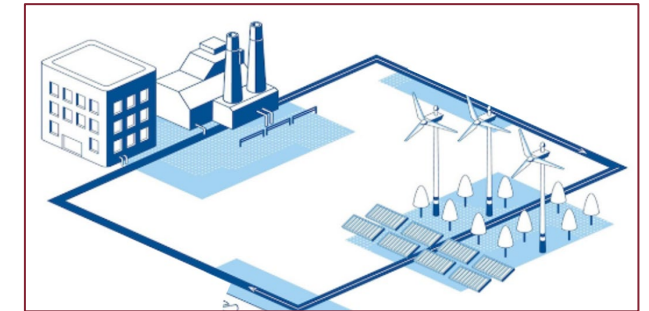
▪ Legislative Decree 199/21

- Introduces the concept of virtual self-consumption and Renewable Energy Community
- Provides new incentives for RES plants operating in virtual self-consumption configuration
- Defines limits and requirements for energy communities and other virtual self-consumption configuration

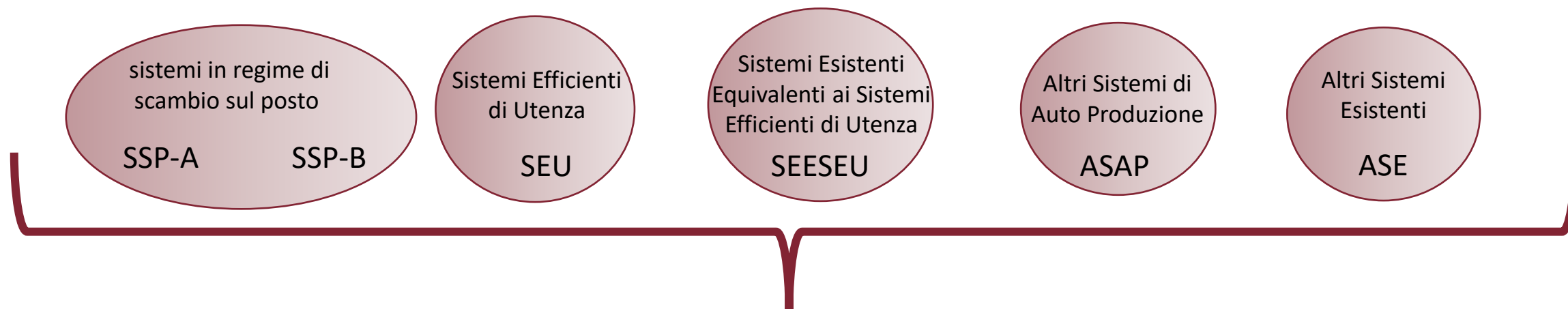


▪ Legislative Decree 210/21

- It simplifies physical self-consumption configurations
- Introduces **a new definition of Simple Production and Consumption System (SPCS)**



SIMPLE PRODUCTION AND CONSUMPTION SYSTEM (SSPC):



“The system in which **a private power line** connects, **one or more generation units**, operated by one or more producers, to **one or more consumption unit** operated by **a single end-user**. The various components that make up the system, excluding the electrical connections, have to be located on sites that are fully available to at least one of the parties belonging to the system itself.”

▪ SPCS main features:

private power line

one or more generation units

one or more producers

a single end-user

a private agreement for the purchase of self-consumed energy

BENEFITS OF A SIMPLE PRODUCTION AND CONSUMPTION SYSTEM

The **economic benefits** of an SPCS comes from the avoided cost on the bill

Additional charges applied to the energy withdrawn from the grid

Avoided cost generated by an SSPC

- regulated grid tariffs
- system charges
- retail energy tariffs

Bill charges	Set by	Time variation
Dispatching (PD)	ARERA	Quarterly
Distribution (DS)	ARERA	Annual
Transmission (TRAS)	ARERA	Annual
UC3/UC6	ARERA	Quarterly
System charge (Asos)	ARERA	Quarterly
System charge (Arim)	ARERA	Quarterly
Capacity Market Charge (CMC)	Retailer	Variable
Retailer's Spread	Retailer	Variable

Grid technical benefits

Maximizing local self-consumption
reduce energy flows towards
higher voltage grid levels

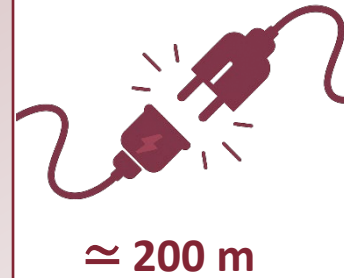
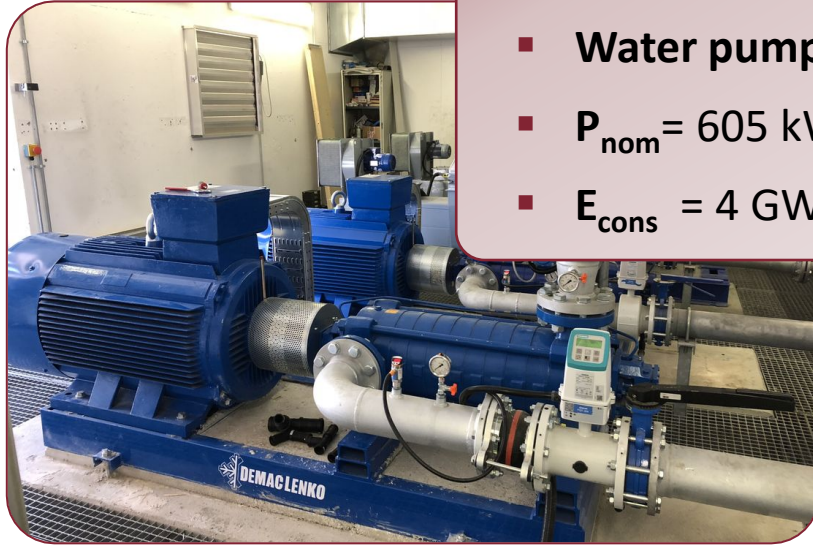
Minimizing investment costs in distribution grids expansion and upgrades

Avoiding losses related to energy transmission

THE CASE STUDY AND THE METHODOLOGY OF ANALYSIS

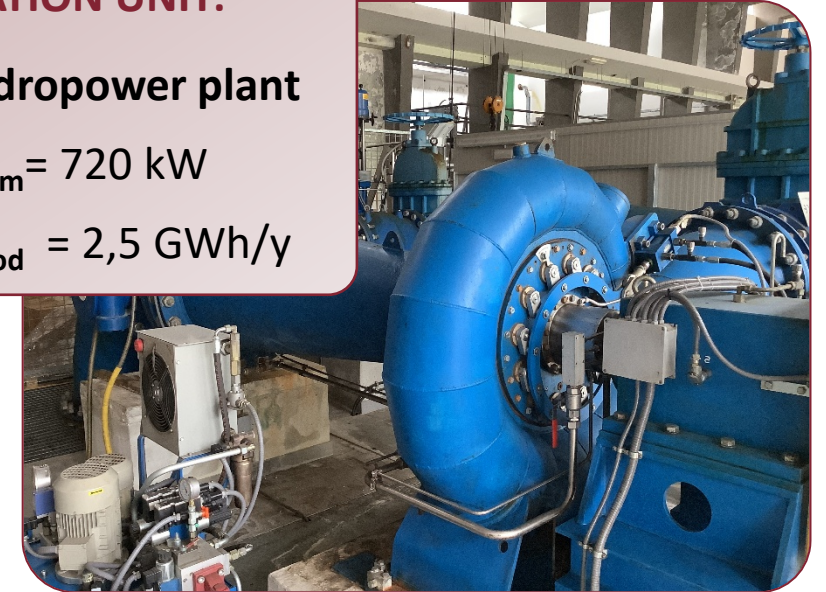
CONSUMPTION UNIT:

- Water pumping station
- $P_{\text{nom}} = 605 \text{ kW}$
- $E_{\text{cons}} = 4 \text{ GWh/y}$



GENERATION UNIT:

- Hydropower plant
- $P_{\text{nom}} = 720 \text{ kW}$
- $E_{\text{prod}} = 2,5 \text{ GWh/y}$



End-user \neq Producer

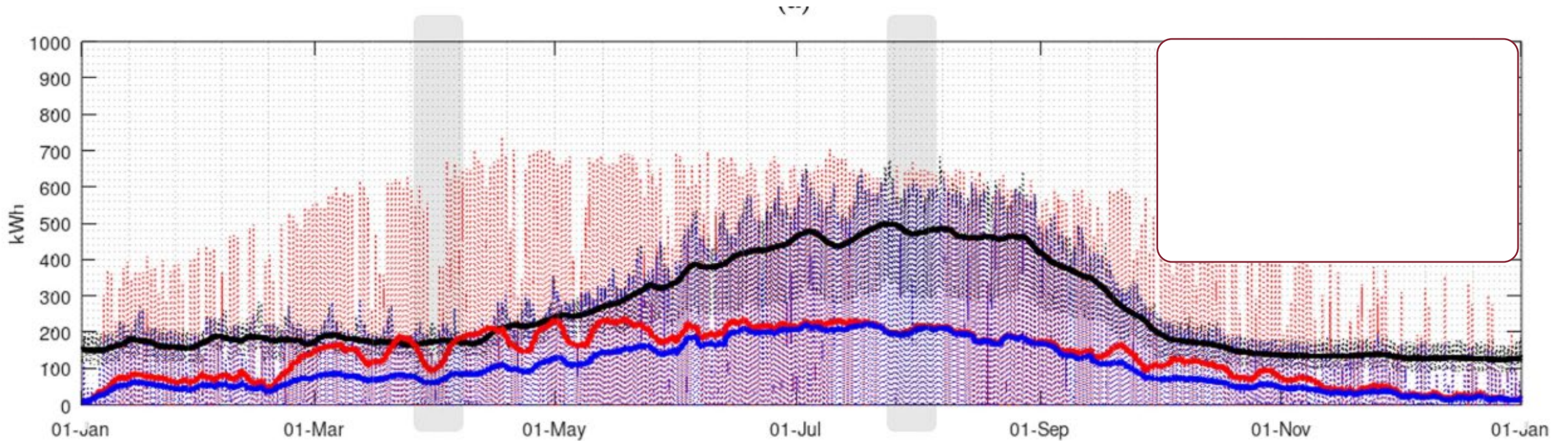


METHODOLOGY OF ANALYSIS :

To assess the SSPC feasibility, we have to check the compatibility between the two units, so we analysed:

- Units installed capacity
- Production and consumption curves
- Physical distance and connection costs
- End-user economic conditions

PRODUCTION AND CONSUMPTION CURVES



SSPC simulation - data_2024

	HYDROPOWER PLANT E_{prod} [MWh]	CONSUMPTION UNIT E_{cons} [MWh]	SELF-CONSUMPTION (ENERGY) SC [MWh]	INJECTED ENERGY E_{grid} [MWh]	WITHDRAWN ENERGY W_{grid} [MWh]	SELF-SUFFICIENCY SS_i %	SELF-CONSUMPTION SC_i [MWh]
ANNUAL AMOUNT	2.637	3.948	2.636	1	1.312	66,8%	99%

AVOIDED COSTS IN THE SPCS CONFIGURATION

To assign an economic value to the self-consumed energy, we have to estimate the avoided-costs

Quarter (2024)	Dispatching (PD)	Distribution (DS)	Transmission (TRAS)	UC3	System charge (Asos)	System charge (Arim)	Capacity Market Charge (CMC)	Retailer's Spread
	[€/MWh]	[€/MWh]	[€/MWh]	[€/MWh]	[€/MWh]	[€/MWh]	[€/MWh]	[€/MWh]
Q1	7,5	0,48	9,89	6,3	35,34	4,086	2,5	4,54
Q2	6,87	0,48	9,89	6,3	41,13	4,77	2,5	4,54
Q3	6,38	0,48	9,89	6,3	41,13	4,77	2,5	4,54
Q4	8,22	0,48	9,89	6,3	41,13	4,77	2,5	4,54
AVERAGE	7,2	0,48	9,89	6,3	39,68	4,6	2,5	4,54

$$BF = PD + DS + TRAS + UC3 + CMC + A_{SOS} + A_{RIM}$$

BF is the economic benefit (p.u.) generated from the SSPC configuration

BF ≈ 75 €/MWh

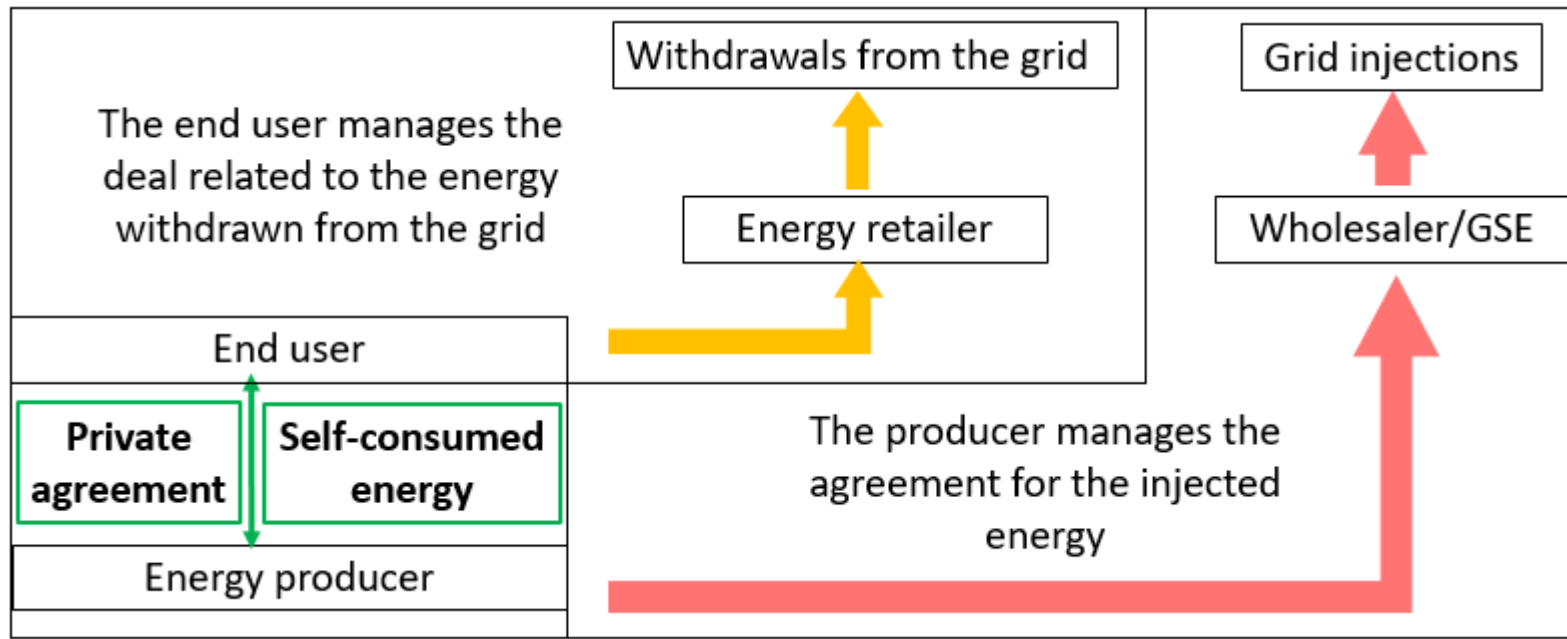
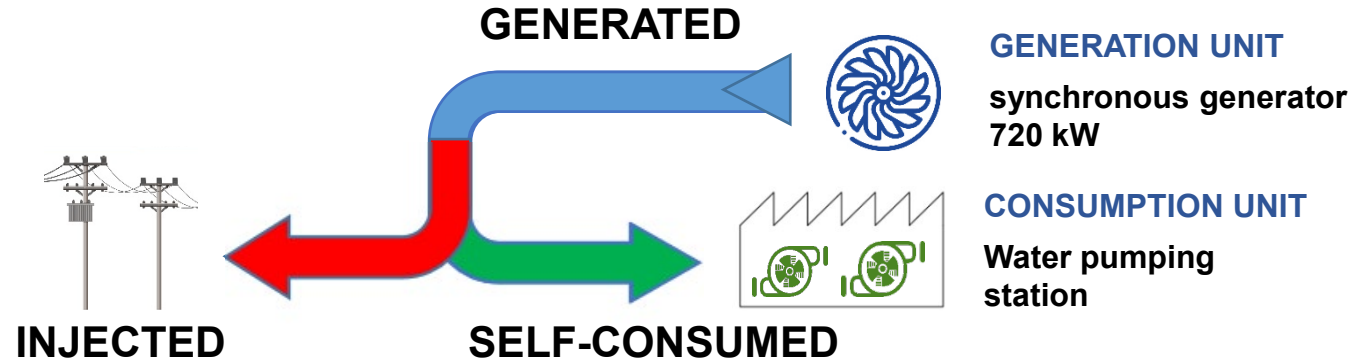
It represents a direct saving for the end-user

It can be seen as the configuration implicit incentive

CONTRACTUAL PROFILES

Simple Production and Consumption System Configuration (SPCS)

The producer and consumer remain fully independent entities, they can manage the withdrawal and the injection of energy separately.



The two parties can define a private agreement for valuing the self-consumed energy, or—if they prefer—one party may manage both injection and withdrawal contracts.

This flexibility is one of the strengths of the SPCS model.

SELF – CONSUMING TARIFF PRICE:

The private agreement, between end-user and producer, provides the development of a tariff applied to direct self-consumed energy within the SPCS

$$TP = \left[\frac{Q_{F1} * PUN_{F1} + Q_{F2} * PUN_{F2} + Q_{F3} * PUN_{F3}}{Q} * (1 + F_{LOSS}) \right] + [(BF * S(\%))]$$

Tariff Price:

The price paid to the producer for the energy supplied within the SPCS

Spot market energy price
weighted by consumption
across time bands (F1, F2, F3)

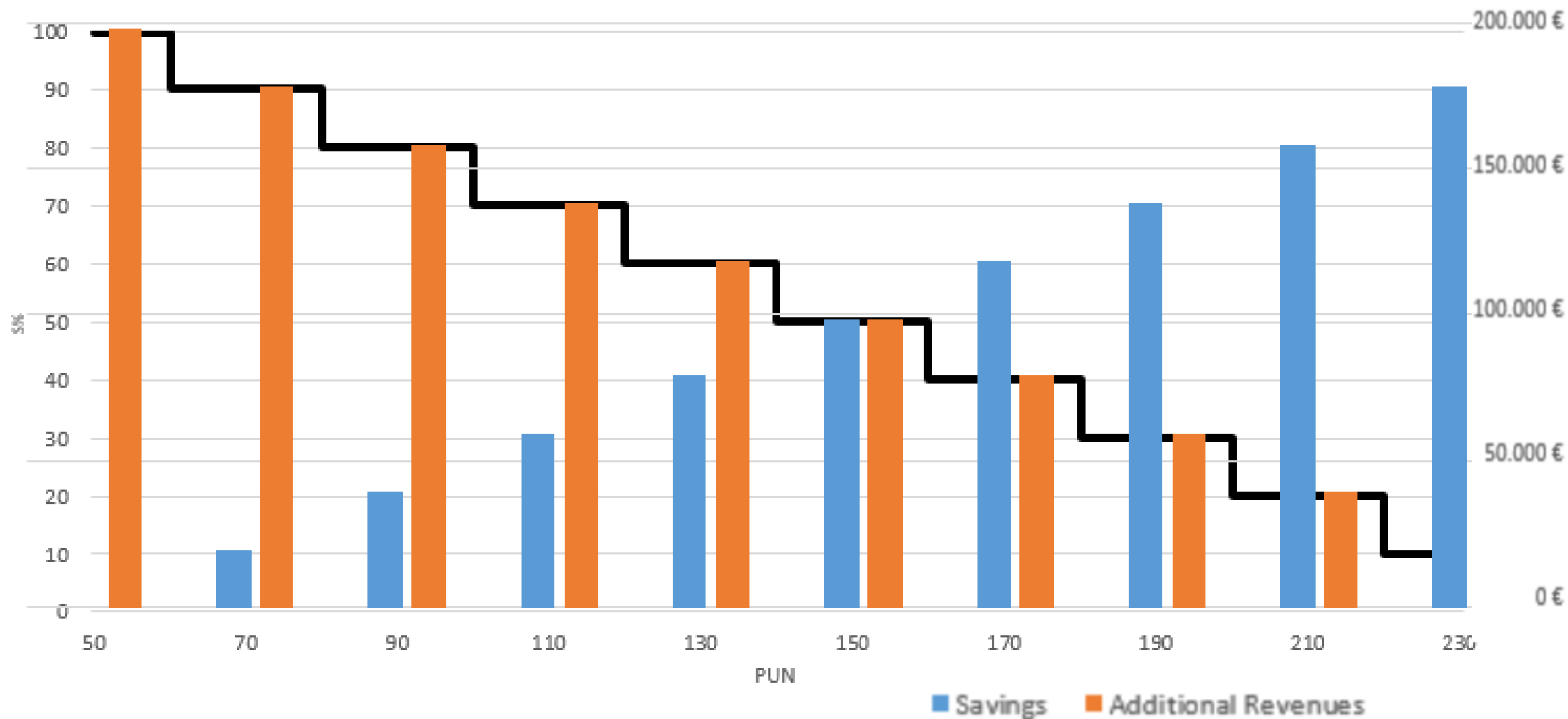
Percentage loss factor:

It is a constant, the end-user
pays it also for the energy
withdrawn from the grid

Producer's benefit share:

It is the share of savings
generated by the SPCS
that is paid to the
producer

INSURANCE SCHEME:



ECONOMIC REVENUE :

Assumption:

- Annual average PUN = **110 €/MWh**
- S (%) variation each $\Delta_{PUN} = 20 \text{ €/MWh}$
- BF is calculated with the **2024 grid and system charges**

PUN annual average	S (%)	Producer's benefit share (BF * S (%))	End-user's benefit share (BF * (1- S (%)))	Tariff Price (TP)	Retailer's tariff	Δ price	ANNUAL SAVINGS	PRODUCER ADDITIONAL REVENUE
$PUN_m < 50$	100 %	75,0 €	0 €	< 127 €	< 127 €	0 €	0 €	< 197.700€
$50,01 < PUN_m < 70$	90 %	67,5 €	7,5 €	≈ 130 €	≈ 137 €	7,5 €	19.770 €	≈ 177.930 €
$70,01 < PUN_m < 90$	80 %	60,0 €	15,0 €	≈ 143 €	≈ 158 €	$\approx 15,0$ €	≈ 39.540 €	≈ 158.160 €
$90,01 < PUN_m < 110$	70 %	52,5 €	22,5 €	≈ 156 €	≈ 179 €	$\approx 22,5$ €	≈ 59.310 €	≈ 138.390 €
$110,01 < PUN_m < 140$	60 %	45,0 €	30,0 €	≈ 170 €	≈ 200 €	$\approx 30,0$ €	≈ 79.080 €	≈ 118.620 €
$140,01 < PUN_m < 150$	50 %	37,5 €	37,5 €	≈ 183 €	≈ 220 €	$\approx 37,5$ €	≈ 98.850 €	≈ 98.850 €
$150,01 < PUN_m < 170$	40 %	30,0 €	45,0 €	≈ 196 €	≈ 241 €	$\approx 45,0$ €	≈ 118.620 €	≈ 79.080 €
$170,01 < PUN_m < 190$	30 %	22,5 €	52,5 €	≈ 209 €	≈ 262 €	$\approx 52,5$ €	≈ 138.390 €	≈ 59.310 €
$190,01 < PUN_m < 210$	20 %	15,0 €	60,0 €	≈ 223 €	≈ 283 €	$\approx 60,0$ €	≈ 158.160 €	≈ 39.540 €
$210,01 < PUN_m < 220$	10 %	7,5 €	67,5 €	≈ 236 €	≈ 303 €	$\approx 67,5$ €	≈ 177.930 €	≈ 19.770 €
$PUN_m > 220,01$	0 %	0 €	75 €	≈ 239 €	≈ 314 €	$\approx 75,0$ €	≈ 197.700 €	= 0 €

Under these assumption →

EXPECTED PRODUCER REVENUE ≈ 138.390 €

ANNUAL SAVINGS ≈ 59.310 €



CONCLUSIONS:



highly valuable **opportunity for producers, prosumers, and large consumers.**



maximize the local energy self consumption, reduce investment costs, and support a **more stable and efficient operation of the electrical grid.**



SPCS configurations can ensure strong economic performance and become an effective tool in supporting the energy transition of the power system.



However, a detailed preliminary analysis is essential.



Not all production–consumption pairs are compatible, and when the energy profiles do not align well, it is more appropriate to **consider alternatives, such as virtual self-consumption schemes.**

Thank you for your attention!