Economic incentives for energy efficiency measures and low-emissions technologies

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***Abstract*— For many years, the European Union has been designing and constantly reformulating various energy policies for the reduction of energy consumption and greenhouse gas (GHGs) emissions in order to contain the effects of climate change. These policies are transposed and expressed in the legislation of each Member State which establishes national objectives and specific intervention measures for the national context. In this work, incentive policies are compared according to the actual state of achievement of defined targets. Following the definition of the criteria for the classification of incentives, the SCORE investment calculator is presented. This online tool compares the economic convenience of different incentive policies and it represents a useful operational tool for the beneficiaries of the investment, but also to verify the effectiveness of the incentive policies themselves and, if necessary, redefine them.**

Keywords—energy and climate targets, economic incentives, energy policies, renewable energies, economic cash flow, payback time, investment calculator tool.

I. Introduction

In the scenario of energy policies, EU directives, national and regional resolutions have decreed over time a vast number of different types of incentives, aimed at supporting the objectives of energy transition. The goals of de-carbonization, reduction of energy consumption and energy security can be reached through the exploitation of renewable energy source (RES), and the implementation of energy efficiency measures in all sectors. The legislative act "Clean Energy for all Europeans Package" (CEP) adopted by the European Commission in 2016 aims to define the adequate regulatory framework to boost the transformation of the European energy market for the development of a "sustainable energy system, competitive, secure and decarbonized [1]". The new objectives set for 2030 by the CEP required the review and modification of some European directives, including the European Directive 2012/27/UE on energy efficiency (EED). To achieve the objectives set for the 2014-2020 period, the EED required member states (MS) to introduce an energy efficiency obligation scheme (EEO) in their national legislation. Together with this or as an alternative to it, MS could plan alternative measures (AM) defined as single energy policies. As can be seen from Fig. 1, 25 out of 28 member states relied on a combination of EEO and AM measures or exclusively on alternative measures. The AM measures are used by almost all MSs due to the flexibility and variety of existing energy policies on which they are based. In fact, 450 AMs were notified which contributed for the 60% to the achievement of the total European savings targets (compared to 40% of the EEOs) [2]. The alternative measures (AM) belong mainly to the following categories:

- Energy or carbon taxes
- Financial instruments or tax incentives
- Regulations or voluntary agreements
- Standards and norms
- Energy labels and certificates (Directive 2010/30/UE)
- Education and training.

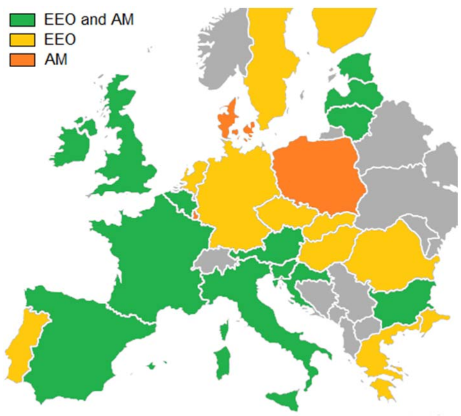

Fig. 1. Application of energy efficiency obligation schemes (EEO) and/or alternative measures (AM) to achieve the energy targets at 2020.

The measures that are mainly proposed by MSs are financial, especially in the form of grant schemes and low-cost loans interest; they represent over the 40% of the total AMs proposed. Funding programs and tax deductions are the most important in terms of energy saving: they contribute about 20% of energy savings planned. Energy and CO_2 taxes are less popular and were introduced only in few MSs [2].

TABLE I. Comparison of the three European countries according to selected SDG indicators 2010 (2018 in brackets).

SDG	Indicator	EU country			
		Czechia	**Germany**	**Italy**	**EU**
1. No poverty	People at risk of poverty or social exclusion [%]	14.4 (12.2)	19.7 (18.7)	25.0 (27.3)	23.8 (21.8)
4. Quality education	Tertiary educational attainment [%]	20.4 (33.7)	29.7 (34.9)	19.9 (27.8)	32.6 (39.4)
7. Affordable and clean energy	Primary consumption [Mtons Oil_{eq}]	42.7 (40.4)	315.2 (291.8)	167.3 (147.2)	1,458 (1,375)
	Energy productivity [€/kg Oil_{eq}]	3.44 (4.30)	7.52 (9.40)	8.96 (10.1)	6.84 (8.11)
	Share of RES in gross final consumption [%]	10.5 (15.1)	11.7 (16.5)	13.0 (17.8)	14.4 (18.9)
8. Economic growth	Real GDP per capita [k€/per capita]	15.0 (18.0)	33.2 (35.7)	26.9 (26.7)	24.9 (27.9)
13. Climate action	GHSs emissions intensity of consumption [%]	83.4 (75.2)	93.3 (90.2)	92.0 (83.7)	91.8 (85.2)

The purpose of this work is to critically analyse the scenario of alternative measures in Italy, comparing them to panorama of other countries: Germany and Czech Republic. These countries are member of H2020 SCORE project [3].

Table I briefly describes and compares the three Member States, according to the selected indicators of sustainable development goals (SDGs), as defined by the United Nation Agenda 2030 [4] and collected by the available online database Eurostat [5]. Starting with the energy indicators, it can be seen that primary energy has decreased in all countries, productivity has increased and so has the share of RES. Economic growth has decreased for Italy and this is one of the reasons that leads to an increase in energy poverty.

II. COMPARISON OF NATIONAL ENERGY POLICIES

Economic and financial incentives have a function of promoting and guiding investments in the energy sector. To achieve the objectives of energy and environmental sustainability, they can help to:

- create new opportunities of investments,
- allow the dissemination of good practices and innovative technological solutions,
- facilitate the initiative of different categories of end users (SMEs, public entities, private citizens) supporting their economic accessibility, including the most financially disadvantaged subjects.

However, although EU law has an important influence on the incentive system for RES and EE the corresponding national framework must be seen against the background of the general energy policy of each country.

In this work the renewable production of energy refers to Renewable Energy (RE). RE, in the narrower sense, is energy produced from sources not using fuels at all, that is, wind and solar power (PV and solar thermal), geothermal power and hydropower as well as "marine" tidal and wave power.

TABLE II. CHALLENGES, TARGETS, GOALS OF THE ENERGY TRANSITION IN THE CZECH REPUBLIC, GERMANY AND ITALY [8, 13].

	Main challenges	RE targets and climate policy	Policy goals
CZ	Coal-related air pollution; loop flows from neighbouring countries; shift from net exports (mostly coal and nuclear) to net imports foreseeable	_RES targets by 2030:_ 22% TFEC, 16.9% electricity, 22% heating and cooling; 14% transport _GHG reduction (ESR):_ 14% by 2030 (compared to 2005); _EC's assessment:_ unambitious as systematically below the formula calculation 13.5% of TFEC from RES by 2020 (14% heating and cooling, 14% electricity)	Energy independence; security of supply; nuclear and coal share reduction in gross production
DE	Exit from coal; high energy prices for households stemming from RES surcharge; cleaner natural gas-fired thermal power plants are unprofitable most of the time (operating reserve is affected)	_RES targets_: TFEC (30% by 2030, 60% by 2050), 65% electricity, 27% heating and cooling, 27% transport by 2030. _GHG reduction (ESR):_ 38% by 2030 (compared to 2005); 80% by 2050 (compared to 1990; separate target of 55% total reduction by 2030 to achieve climate neutrality by 2050; _EC's assessment_: mostly adequate, very ambitious for the transport target 60% of TFEC from RES by 2050; gross consumption targets by 2020: 35% electricity, 14% heat, 10% transport.	Foster greater market proximity; competitive determination of electricity prices; exit from nuclear power by 2022
IT	High dependence on fossil fuel and electricity imports (highest worldwide, mostly French nuclear energy); market concentration obstructing access for new players; coal related air pollution	_RES targets:_ 30% TFEC, 55% electricity (hydropower, geothermal and PV), 33.9% heating and cooling and 22% transport. _GHG reduction (ESR) by 2030:_ 33% (compared to 2005), 38% (since 1990); _EC's assessment:_ adequate although the consistency between targets and policy measures is questioned. RES by 2030: 30% TFEC and 55% electricity consumption (mostly from hydropower, geothermal, PV).	Reduction of TFEC; strengthen supply security; narrowing energy price gap (high industrial electricity prices); maintain 1990 nuclear exit; phase out coal

A comparative analysis of the energy policy of 18 countries worldwide [6] has found that motivations underlying the Energy Transition are diverse and manifold differing from country to country and sometimes even between regions of the same country. While these differences are mostly path dependent [7] rooting in geography, historical development of energy markets and cultural factors the underlying motivations often are heterogeneous including conflicting elements resulting in discrepancies between the declared goals regarding the deployment of RE and the actually implemented energy policies [8]. This discrepancy between declared goals and implemented energy policies observed is also true for the three countries under consideration.

Table II summarises the main challenges the Czech Republic, Germany and Italy, currently confront and contrasts them with both, officially announced RE targets and climate goals as well as general declared energy policy aims (with a focus on oil / coal / gas usage, greenhouse gas (GHG) emissions, electricity imports and exports and RE usage).

All three countries have extensive oil, coal, or gas usage (OCG) each for their own respective reasons; only the Czech Republic uses noteworthy amounts of nuclear power. Based on natural resources and dominant technology branches, countries may be electricity importers or exporters impacting the question of sustainability of the energy supply in a very different way. Germany is an exporter of RE while Italy imports electricity from French nuclear power plants a circumstance not evident when one only looks at domestic energy production. The role of RE is still most important in electricity, while only slowly increasing in transportation and heating. These sources are mostly used for electricity generation an issue concerning Germany and Italy while the Czech Republic is lagging behind.

The contradictions between actual status quo and ambitious aims become even more apparent when taking a closer look at the financing conditions for RES (and EE). In an environment of uncertain revenue predictions due to volatility of RES combined with low prices during seasonal or structural overcapacity [9] the countercyclical effect of this volatility – RES being fed into the grid with priority during overcapacity – causes average annual prices to drop (merit-order effect). The volatility of the most important RES, i.e., wind and solar power, destroys their market price, discouraging financial investment and jeopardizing the objective of increasing RE's share in the energy mix by closing the financing gap. Consequently, the Energy Transition is all but straightforward, and it is not surprising that as many countries worldwide the Czech Republic, Germany and Italy show a similar picture:

- the energy mix with regard to total energy production is still dominated by conventional fossil fuels and is sometimes driven by dirty imports accompanied by low levels of autarky;
- the share of RE in primary energy consumption which includes processing and transmission losses is also low;
- only the share of RE in total electricity consumption is usually higher.

Table III gives an overview of these three indicators with the columns organised as follows: Column B: Energy production presents the total energy production in 2018 and provides a rating of "conventional" or "clean" production according to the share of RE and waste on primary production (domestic production) and on gross available energy (primary production as well as net imports, recycling/recovery and change in stock) and "high", "medium", or "low" dependence from imports (fraction of net imports from gross available energy). Column C: Energy consumption shows "low", "medium", or "high" RES share in 2018 primary energy consumption (which, contrary to energy production, includes transformation losses). Column D: Electricity depicts the share of RE and waste in 2018 gross electricity consumption, showing unsustainable RES like biofuels, waste and large, potentially environmentally harmful hydro power plants ("mega hydro"), sustainable RES (up to three most important sources), and a marker for "low", "medium", or "high" total RE share in electricity.

TABLE III. RES IN THE ENERGY MIX IN THE CZECH REPUBLIC, GERMANY, AND ITALY [5, 8].

	B. Energy production	C. Energy Consumption	D. Electricity
CZ	Conventional: 11% RE and waste share on gross available production and17% on primary production Medium: 37%	Low: 11%	• Biofuels 5.6% • Hydro 3.6%, solar PV 2.6%, wind 0.8% Medium: 13%
DE	Conventional: 13% RE and waste share on total energy supply and 42% on primary production High: 64%	Medium: 15%	• Biofuels 7.2%, waste 2.0% • Wind 20.4%, solar PV 7.7%, hydro 4.2% High: 40%
IT	Conventional: RE and waste share 8% on total energy supply, 74% on primary production High: 76%	Medium: 18%	• Biofuels 5.8%, waste 1.7% • Hydro 16.3%, solar PV 8.1%, wind 6.9% High: 40%

Against this background, energy policy in the Czech Republic, Germany and Italy can be characterized as follows:

- Unlike countries that are rather clean energy producers like Spain or Switzerland, all three countries are still considered to be on the conventional path. However, each of them has their own specific circumstances.
- The import dependence is particularly strong for Italy, but the Czech Republic is expected to become import dependent due to the pression of phasing-out coal.
- RE shares in electricity production and/or consumption may be low, as for the Czech Republic. But high shares must be separated by their origin: those high RES shares due to unsustainable RE sources like waste, biofuels, or "mega hydro" plants, or due to sustainable energy sources like wind, solar, geothermal and/or low-impact hydro plants. The latter is the case for Germany and Italy.
- Germany and Italy (unlike the Czech Republic) show political stability regarding the strategic decision to implement courses of action for green energy usage.
- The share of RE in electricity generation is in all countries greater than that in primary energy consumption. RE shares in total energy consumption are poor in comparison to those in electricity production (the latter are the figures countries are eager to present) and that "dirty" energy production, not surprisingly, is often linked to a strong import dependence.

Against this background the national incentive system and in particular the financing volumes deployed gain a different meaning. Although "rich" countries tend to have a differentiated incentive system with significant funding available it seems questionable whether they can compensate for the existing financing gap. If the ambitious policy goals are to be met and the discrepancy with the "dirty" status quo is to be bridged, we will need simple and effective incentives that are easily absorbed by the energy markets. In this light even countries previously considered pioneers like Germany or Italy may provide "too little too late" in the long run. However, a lot will depend on the design of the individual incentives (eligibility criteria, volume, funding conditions, etc.) as discussed in the following sections.

III. INCENTIVES CLASSIFICATION

This study aims to describe the state of the art of economic and financial incentives on energy related interventions currently in force in Italy, Germany, and Czech Republic, classifying them according to three main different criteria presented below. Fig. 2 describes the Italian incentive scenario as an example.

A. *Type of intervention*

As part of the energy transition process, three main areas of energy related intervention that already benefit from incentives, are individuated: energy efficiency interventions on building envelope and plants (**EE**), the use of specified technologies or ICT for optimizing energy management (**SMART**) and the implementation of renewable energy sources for distributed energy system (**RES**).

B. *Recipient of the incentive*

The beneficiaries are classified according to categories of end users in the energy market: domestic user (**DOM**), municipality user (**MUN**) and company user (**COM**). It considers not only differences in terms of quality and quantity of energy used, but also in terms of investment capacity. These categories correspond to the ones used to distinguish the possible members of Energy Communities [10]. In some cases, all categories access to the same incentive, in others the aggregation of different type of end users is encouraged.

C. *Methods of remuneration*

Firstly, incentives are classified in two groups (Monetary–Nonmonetary), for each the main existing cases are listed.

- **Monetary.** The recipient of the incentive benefits from a monetary refund. It can consist in the reimbursement of the initial expenditure for executed energy related interventions, or in the form of an operating account during the lifespan of the RES plant in which it has been invested. In the first case (*Reimbursment*), the invested capital is repaid in different periodic instalments, according to different percentages that correspond to the value of the incentive itself; it can be associated to subsidized interest rates and varies based on compliance with minimum requirements defined by law. In some few cases the incentive consists in the disbursement of a sum of money to be spent for the realization of a specific project previously approved (*Project*). As an operating account incentive, the energy produced and fed into the grid can be monetized in various ways: the beneficiary of the incentive ensures the sale at minimum guaranteed prices (*Warranty*); receives a discount on one (or more) tariff components that make up the bill (*Discount*); in addition to the revenue from the sale of energy, it receives a premium rate on each kWh produced (*Premium*).
- **Non-monetary.** The value of the incentive can be transformed into a *Bond issue* that can be spent on the energy market, or in the form of a tax deduction (*TD*) that corresponds to the value of the incentives itself. The TD can be expressed as a discounted investment loans (*TD-DL*) or tax breaks (*TD-TB*) to taxpayers of property taxes, personal taxes, or business taxes.

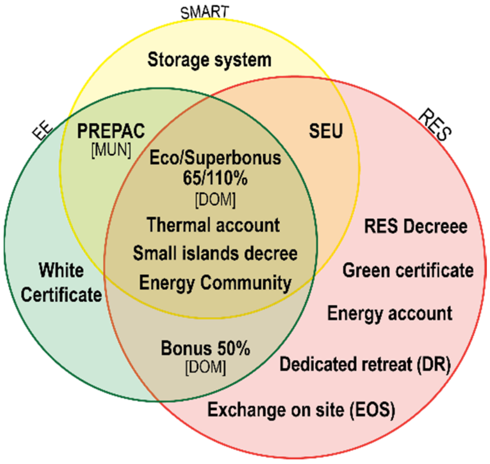

Fig. 2. Italian incentives according to type of intervention (coloured circle), and recipient (intended as "all users" where not specified).

IV. Material and Method

According to the classification presented in the previous paragraph, the existing incentives in Italy, Germany and Czech Republic are summarized in Table IV.

In Czech Republic, the incentives mainly concern the installation of PV and storage systems, increasing self-consumption, or the spread of low-carbon technologies.

In Germany, energy efficiency measures are mainly funded through the public Development Loan Corporation(s). Not only through low-interest loans and governmental monetary bonds, but also through significant grants maybe, which, unlike tax breaks, flow directly to investors. If energy efficiency measures are combined with the installation of selected renewable energy sources, the latter also will be subsidised by investment grants.

In Italy, the incentives, already numerous and differentiated in terms of methods and purposes, are part of the further complex framework of the free energy market; therefore, the result is a scenario that is not always clearly defined and sometimes difficult to access to uninformed beneficiaries. The residential sector is the one that is contributing the most to the achievement of the 2020 objectives, compared to industry and transport sectors [2]. This is also due to a continuous evolving regulatory framework on energy performance of buildings and implementation of RE plant system, particularly roof-integrated PV. For domestic residential users, the *Bonus 50%* and *Superbonus* (110%) allows them to benefit from tax deductions (TD-TB) on the total eligible expenditure for energy efficiency works on building envelope and/or plant system, such as the installation of PV systems for self-consumption. In the first case the 50% is repaid in 10 annual instalments, in the second case the invested capital is fully repaid in 5 annual instalments. The self-produced energy can be further enhanced by benefiting from incentives in the operating account during the lifespan of the PV plant. The energy produced and not self-consumed can be sold on the national grid, by accessing the Dedicated Retreat (DR), which offers a guaranteed minimum price for each kWh fed into the grid, as a greater protection of the sale than on the free market.

In the case of the Exchange on site (EOS), accounting for the energy withdrawn and fed into the grid is envisaged, net of the self-consumed energy which has null cost. In addition to the proceeds from the sale, a premium tariff is paid to the share of energy exchanged with the grid, it is related to the bill component of the system and transport charges.

Table V synthetizes the main AMs in the building sector individuated for the three countries and their contribution in the achievement of target 2020. For each one, is express the amount of energy saving (Mtep) that is already achieved (update at 2016) and the one estimated to reach in 2020, comparing them to the energy saving 2020 targets.

TABLE IV. The existing alternative measures in CZ, DE and IT according to the presented classification.

Country	A. Type of intervention	B. Recipient of incentives	C. Method of remuneration	Name of the incentive	Energy vector
CZ	RES	COM	TD (DL)	PV-storage (30-50%)	El
		DOM	TD (DL)	PV (30-40%)	El
		DOM	TD (DL)	PV-storage system (50%)	El
		MUN	TD (DL)	PV (70%)	El
		MUN	TD (DL)	RES in public transport network (85-90%)	El
	SMART	COM	TD (DL)	Storage system (60-80%)	El
		COM	TD (DL)	Electromobility (20-30%)	El
	EE+RES	DOM	TD (DL)	PV (25% or 30% with insulation of buildings)	El, Th
DE	EE	DOM	TD (DL)	KfW (up to 40%)	El, Th
		COM	TD (DL)	KfW (up to 55 %)	El, Th
		MUN	TD (DL)	KfW (up to 27,5 %)	El, Th
	SMART	MUN	TD (DL)	Model project Smart Cities (up to 65%)	El, Th
		DOM	TD (DL)	KfW (up to 30%)	El, Th
		DOM, COM	TD (DL)	BAFA - SMART-home appliances	El, Th
	RES	All users	Premium and TD	RE Act; KfW – New RES plants	El
	EE+RES	DOM	Premium for organisational slacks and reimbursement	KfW; Renewable Energy Act - investments in PV or RE-Heating; up to 40% (up to 40%)	El, Th
		COM	TD	KfW RE-Heating; up to 55%	Th
IT	EE	All users	Bond issue	White Certificate	El,Th
	SMART	All users	Reimbursement	Storage system	El
	RES	All users	Premium	RES Decree	El,Th
		All users	Premium	Exchange on site (EOS)	El
		All users	Warranty	Dedicated retreat (DR)	El
		All users	Premium	Green certificate	El,Th
		All users	Premium	Energy account	El,Th
	EE+RES	DOM	TD (TB)	Bonus 50%	El,Th
		MUN	Project	PREPAC	El.Th
	RES+ SMART	Aggregated	Discount	SEU	El
	EE+ SMART+ RES	DOM	TD (TB)	Eco- Superbonus (65- 110%)	El,Th
		All users	Reimbursment	Thermal account	Th
		All users	Reimbursment/ Premium	Small italian islands decree	El,Th
		Aggregated	Project/Premium	Energy Community	El,Th

TABLE V. Alternative measures for the building sector and the targets of final energy savings at 2020.

Country	Principal AMs	Energy savings				
		Achieved 2016 (Mtep)	*Estimated 2020 (Mtep)*	*Total Estimated 2020 (Mtep)*	*Total Target 2020 (Mtep)*	*Total Target 2020 achieved (%)*
CZ	Requalification of concrete buildings	0.005	0.108	0.108	4.564	2.4
DE	Energy savings standards – new constructions	0.616	2.173	17.017	41.989	40.5
	Energy savings standards – existing buildings	1.619	6.771			
	EE – construction and retrofit	0.982	5.255			
	ER network	0.010	2.818			
IT	Thermal account	0.030	0.431	8.818	25.502	34.6
	TD "ecobonus"	1.176	8.387			

V. SCORE RE INVESTMENT CALCULATOR

The EU funded Horizon 2020 SCORE (Supporting Consumer Ownership in Renewable Energies) implements RE projects in the three countries analysed in this paper: Italy, Czech and Germany [3]. Thereby, the SCORE team uses a trustee-based financing technique to facilitate low-threshold consumer participation in RE projects. As a part of the project, the team developed an online tool for consumers to calculate the economic feasibility of RE installations based on different technologies and varying investment volumes.

The feasibility analysis in this tool is based on the different incentive structures of the respective countries, i.e., the cash flow calculation incorporates the national supporting schemes, such as feed-in-tariffs or tax benefits of Italy, Czech and Germany. Fig. 3 shows an example depiction of this online tool. It could be very useful for energy communities' users to understand which incentives they can access, and which are the most convenient for retrofit interventions. A similar tool had been developed for the Solar Portal of the Metropolitan City of Turin and, associated with a GIS model for the consumption of buildings, made it possible to evaluate the economic and environmental convenience of the installation solar technologies [11].

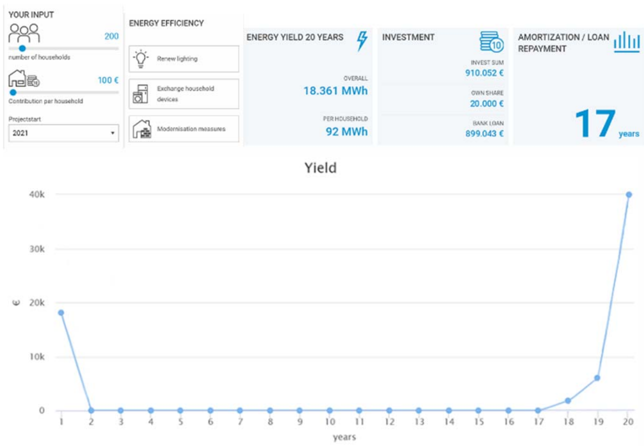

Fig. 3. Outputs example of SCORE RE investment calculator [3].

Firstly, the user of the calculator can switch between those countries. The tool can calculate RE installations based on photovoltaic, wind or CHP (combined heat and power). The candidate can indicate the number of participating households and their investment sum, then he can select different energy efficiency measures to accompany the RE installations. Advanced users can expand the calculator to an expert view, altering additional technical characteristics and financial figures. The calculator recommends own optimal project parameters to maximise the profit along the number of households and the overall investment.

After the user inputs, the calculator returns all important key performance indicators to properly evaluate a RE project: the energy yield for a project duration of 20 years, the cash flow, an overview of taxes and costs, and expected operational costs divided into different categories are displayed. Furthermore, the total necessary investment is calculated and divided into equity and leverage. Following this information, the pay-back period is shown. Additionally, simulations regarding the self-sufficiency of the RE project can be found when comparing yearly production and consumption for the indicated households.

For instance, assuming 200 German households are investing 100 € each in a PV installation with 8,000 m² in area, the calculator returns an overall investment sum of 910,052 € from which 20,000 € are carried through equity and 899,043€ (including payable interest until start of energy production) are financed through debt capital. After 20 years the PV installation produced 18,361 MWh electricity; 92 MWh per household. That corresponds to a yearly production of 918,057 kWh in total or 4,590 kWh per household. From an economic perspective the project generates a positive free Cash Flow and is profitable immediately, all debts are repaid after around 17 years approximately. EBIT (Earnings Before Interest and Taxes) are reaching a good middle 5-digit level immediately before falling down 29 % due to higher operating costs and reduced efficiency within the second decade. Until the very end of all two shown decades no taxes are payable for the project, first due to depreciation of the investment and secondly because of deductible spending's of interests. After 20 years we see an accumulated Free Cash Flow of 72,613 €, divided by 200 participants it's 363 € for household, a revenue of nearly 400% in total or nearly 18 % per annum.

Another example considers the typical residential user, comparing an Italian (IT) and a German (DE) family, located in Turin and Frankfurt, respectively. Assuming the average annual electricity consumption of the Italian family (2,700 kWh/yr) and the German family (3,400 kWh/yr), both are presumed to invest in a PV plant with the same technical characteristics: polycrystalline technology, installed power of 2.5kW, roof-integrated system (17.52 m² of gross area, orientation 0°, angle 30°) and a life span of 25 years. The *Polysun* software tool have been used to estimate the annual electricity production (IT: 2,942 kWh/yr, DE: 2,300 kWh/yr) and the amount of self-consumption (IT: 2,942 kWh/yr, DE: 2,300 kWh/yr), take into account climatic differences. The percentage of energy self-consumed on the total amount of PV production has been calculated (IT: 39%, DE: 51%), and it depends on the correspondence between the hourly profiles of solar radiation and the household electricity demand.

To compare the annual monetary savings related to some selected economic incentives that already exist in the two countries, a cash flow analysis has been conducted, considering the capital discounting and a different interest rate for the two countries. For the Italian family three scenarios were hypothesized, always associating a tax deduction (TD-TB) incentive to reimburse the PV investment and an operating account incentive. The *Bonus 50%* is associated to the *Dedicated Retreat* (DR) in the first case (IT: 50% DR), and to the *Exchange on Site* (EOS) in the second case (IT 50% EOS). In the third case (IT 110% DR), the *Superbonus 110%* is associated to the *Dedicated Retreat* (DR). The German incentives provides for reimbursement of the initial investment up to 40% and a premium tariff for the energy sold to the grid. Considering the unitary cost of PV installed power (IT: 2.0 €/Wp, DE: 2.25 €/Wp), the initial investment cost has been calculated. The purchase price was applied to the energy withdrawn from the grid, while the sales price, according to the incentive was applied to the share of energy fed into the grid. The premium rate corresponds to 0.08 €/kWh fed into the grid in the case of *DR*, to 0.13 €/kWh in the case of EOS and amounts to 0.1 €/kWh for the German incentive.

For each of the four selected incentives, the amount of annual monetary saving and the pay-back period have been calculated. All the energetic, economic, and financial parameters used are reported in Table VI. The comparison between the four different cash-flow calculated for each incentive scenario are described in Fig. 4.

TABLE VI. COMPARISON BETWEEN ANNUAL ECONOMIC SAVINGS FOR A TYPICAL RESIDENTIAL USER WITH A INVESTMENT IN PV PLANT AND BENEFITS FROM INCENTIVES.

	IT 50% DR	IT 50% EOS	IT 110%	DE 40%
Total Consumption [kWh/yr]	2,700	2,700	2,700	3,400
PV production [kWh/yr]	2,942	2,942	2,942	2,300
Self-consumption [kWh/yr]	1,147	1,147	1,147	1,173
Energy withdrawn [kWh/yr]	1,552	1,552	1,552	2,227
Energy sale [kWh/yr]	1,795	1,795	1,795	1,127
Energy price (purchase) [€/kWh]	0.23	0.23	0.23	0.3
Energy price (sale) [€/kWh]	0.08	0.13	0.08	0.1
Investment cost [€]	5,000	5,000	5,000	5,637
Number of instalments	10	10	5	10
Interest rate [%]	2	2	2	-0.5
Economic saving [€/yr]	412	486	412	459
Pay-back period [years]	7	6	4	7

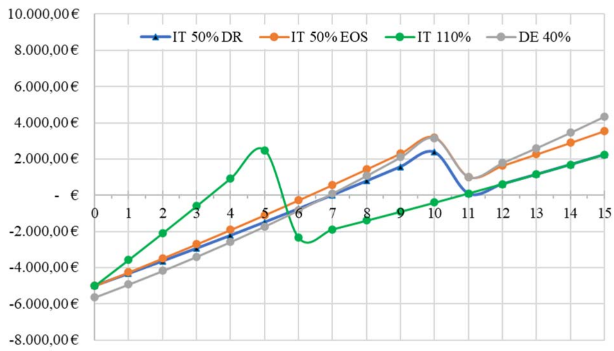

Fig. 4. Cash flow of the four incentives analysed.

Although the economic and financial conditions are different between the two countries, the IT 50% DR and IT 50% EOS cases provide for similar payback periods to those allowed by the DE 40%. The IT 110% DR allows extremely short pay-back period, increasing the access to incentives to possible beneficiaries that do not have economic or financial availability, implementing the use of RE among the population and contributing in overcome the energy poverty.

VI. CONCLUSION

From the presented scenario of the existing incentives emerges the importance of defining a single direction for all countries of the European Union. For developed countries, the main energy policies pursue two macro objectives: the reduction of energy consumption and the transition to renewable energy production systems. Furthermore, considering the number of incentive measures envisaged to a greater or lesser extent by the various countries analysed, the complexity of the incentive scenario affects its activation and implementation. The more complex the incentive system with its specific requirements, the more difficult is access for beneficiaries, and the lower the probability of achieving the targeted objectives. Finally, the often confusing or fragmented communication of the panorama of incentives accessible to the different energy users limits the take up by those directly involved. In this regard, tools such as the RE investment calculator are valuable with regard to a double use: a) an operational use by comparing the payback times of the different types of investment, facilitating beneficiaries in accessing the more suitable incentive; and b) a strategical use for policy makers to evaluate which policy is most effective, to achieve energy and climate targets. These decision-making tools can also provide a service to energy communities members to facilitate access to existing incentives.

Further developments of this work will involve the cost-optimal analysis [12] to consider also the energy and environmental performance of the energy efficiency and low GHG emissions interventions and future climate changes.

NOMENCLATURE

AM	Alternative measures	MUN	Municipal user
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle - Federal Office of Economics and Export	MS	Member State
CHP	Combined heat and power	OCG	Oil, coal, gas usage
COM	Company user	RE	Renewable energy
DL	Discounted loans	RES	Renewable energy source
DOM	Domestic-residential user	SDG	Sustainable development goal
EE	Energy Efficiency		
EEO	Energy efficiency obligation	SMART	Optimization of energy Management and ICT
El	Electrical	SME	Small-medium enterpr.
GDP	Gross domestic product	TD	Tax deduction
GHG	Greenhouse gas emission	Th	Thermal
KfW	Kreditanstalt für Wiederaufbau – Reconstruction Credit Institute	SEU	Efficient user system

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