FOSTERING SMALL-SCALE PV DEPLOYMENT IN MOROCCO

RES4AFRICA FOUNDATION

AFRY ÅF PÖYRY

CLUSTER SOLAIRE







About

RES4Africa Foundation

RES4Africa Foundation is a European think tank that promotes the deployment of large-scale and decentralised renewable energy solutions in Africa. RES4Africa's mission is to create an enabling environment for scaling up investments to accelerate a just energy transition and transformation, while thoroughly meeting local energy needs. It gathers a network of public- and private-sector members from all over the clean energy value chain and relies on a solid network of high-level international partners, acting as a bridge between African and European stakeholders in the energy sector. Find out more at: www.res4africa.org

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SOLAR CLUSTER

The Solar Cluster is a non-profit organization, created in 2014, that aims to develop a competitive Moroccan green field able to answer the needs of the national renewable energy and energy efficiency strategies. The association has a membership of more than 200 stakeholders within the green economy field from the private sector, government, universities and research and development centers and supports more than 50 green innovative startups every year. The solar cluster contributes to the creation of the needed bridges between stakeholders, the maximization of synergies, the promotion of enabling policies, building capacity and stimulating innovation to achieve clear goals toward a smooth and sustainable green transition.

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List of Acronyms

ANRE	National Energy Regulatory Authority
CAGR	Compound Annual Growth Rate
CSP	Concentrated Solar Plant
FiT	Feed-in-Tariff
GDP	Gross Domestic Product
GoM	Government of Morocco
GW	Gigawatt
LCOE	Levelized Cost of Energy
LVLow	Voltage
MSME	Micro Small Medium Enterprises
MW	Megawatt
NES	National Energy Strategy
ONEE	Office National de l'Electricité et de l'Eau
PERG	Global Rural Electrification Programme
PV	Photovoltaic
RES	Renewable Energy Solutions
TSO	Transmission System Operator
TWh	Terawatt-hour

Foreword

Morocco aims to reduce the country's dependence on commodities imports and exploit national wind and solar potential. The New Energy Strategy approved by the Moroccan Government has set an ambitious target of 52% share of renewables on total installed capacity by 2030. Small-scale PV is expected to play a pivotal role in achieving the country's goals; nonetheless, is Morocco ready?

Thanks for the support of ENEL Green Power, RES4Arica Foundation, AFRY and Solar Cluster are glad to present the study results examining the barriers to unleashing the development of small-scale PV capacity in Morocco. The study identifies how Morocco can improve its policy and regulatory framework to reach the full potential of small-scale PV deployment and increase the attractiveness of self-consumption for Micro Small Medium Enterprises and local administrations.

Since its inception, RES4Africa Foundation has acted as a catalyser for dialogue between the European private sector and Morocco's decision-makers, providing support at policy and regulatory levels and fostering knowledge transfer and investments in the energy transition. AFRY offers strategic and operational guidance across the energy value chain, backed by extensive independent expertise and market insights, to help make informed decisions for a sustainable green transformation. Solar Cluster acts a bridge between the private sector and civil society in Morocco to encourage investment flows to achieve clear goals towards a smooth and sustaible green transition in Morocco.

RES4Africa Foundation, AFRY and Solar Cluster stand ready to collaborate with Moroccan partners in the public sector, private sector and civil society to make this objective a reality.

We wish to thank all stakeholders who contributed to this study and generously provided their knowledge and experience. Notably, we thank Enel X for their input. We consider this study another small step in the direction of greening Morocco's energy sector.

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Abstract

Morocco's stable economic development and rapid population growth have led to power sector demand more than doubling between 2000 and 2020. Projections indicate that these trends will continue in the future which means Morocco will need to invest in adequate power supply to meet the country's growing demand. As part of its long-term energy strategy, the Moroccan government plans to exploit the country's abundant solar and wind resources and reduce its reliance on commodities' imports. The 2015 update to the New Energy Strategy sets out an ambitious target for 52% of the total installed capacity to come from renewables by 2030, equivalent to 12 GW of renewable capacity.

Studies indicate that Morocco is one of the most attractive countries in the MENA region in terms of solar power potential which means small-scale PV could play a key role in meeting future energy needs and the 2030 target. However, the weak regulatory environment and specifically the lack of regulation for low-voltage connection is reducing attractiveness of the investment and slowing-down uptake of the PV self-consumption scheme.

The goal of this study is to identify the main policy and regulatory barriers which are delaying investment in small-scale PV in Morocco. The focus is on self-producers such as Micro Small Medium Enterprises (MSMEs) and on the public sector. The study proposes a number of remedies – based on learnings from international experience – which could be introduced to overcome the policy and regulatory barriers which are preventing investment in small-scale PV and delaying the country transition to a renewable-based electricity system.

I. Introduction

Morocco is undergoing a strong economic development, which is also impacting its power sector. Moroccan electricity demand has increased from 14 TWh in 2000 to 39 TWh in 2020 (average annual growth of 5.3%) and projections indicate that this trend will continue in the future.

Morocco will need to invest in adequate power supply to meet the country's growing demand. In achieving this goal, the Moroccan Government aims at avoiding the worsening of its dependence on commodities' import which, as declared by the Ministry of Energy Transition and Sustainable Development website[1], is higher than 90%.

Taking advantage of the fact that the Country is one of the most attractive in the MENA region in terms of renewable potential, the Government of Morocco (GoM) has set the ambitious target to reach 42% share of renewable capacity on the total installed capacity by 2020 and 52% share by 2030. At least in 2020, Morocco registered a consistent growth of installed capacity in RES, mainly driven by large centralized plants, reaching 70% of the selected 2020 target; however, as far as solar power development is concerned, despite Moroccan high potential, only 36% of the target has been installed.

International experiences have shown that small-scale PV development may accelerate the surge of RES capacity. ONEE estimated that such segment alone may be enough to respect the 2030 targets for solar capacity and hence represents a unique opportunity for Morocco. In this context, the Micro Small Medium Enterprise (MSME) and the public buildings represent the chance to increase the RES capacity rapidly and, at the same time, to raise awareness on small-scale PV among the population, pushing for residential deployment of rooftop small-scale PV at a later stage.

On one hand, the MSME sector is one of the key pillars of the Moroccan economy; MSMEs represent 95% of all companies in the Kingdom. The tertiary sector accounts for more than 10% of the Moroccan electricity consumption, with an estimated small-scale PV potential higher than 1 GW. Moreover, the MSME sector may access financing instruments more easily than residentials, opening small-scale PV deployment paths in all sectors.

On the other hand, public administration accounts for more than 5% of the electric consumption of the country, with an estimated small-scale PV potential higher than 500MW, more than double than the PV capacity currently installed in the country. Moreover, in 2019 Morocco released "Le Pacte de l'exemplarité de l'administration" to promote energy efficiency and renewable energy sources in public buildings and to reduce the energy cost. The government has seen the possibility of lowering the energy cost in the public sector, whose annual energy bill amounts to 3 billion DH, setting the example of clean energy access, and spreading the knowledge of small-scale PV as a great opportunity for the whole country.

Despite the chance this segment would represent for Moroccan power sector, the small-scale PV market is still almost absent in the country. The causes behind the lack of development of small-scale PV are to be found in the existence of several barriers of different nature: from the lack of the adequate regulatory framework, to the absence of incentive schemes, and the lack of awareness for this opportunity.

[1] https://www.mem.gov.ma/pages/index.aspx

II. Moroccan electric system

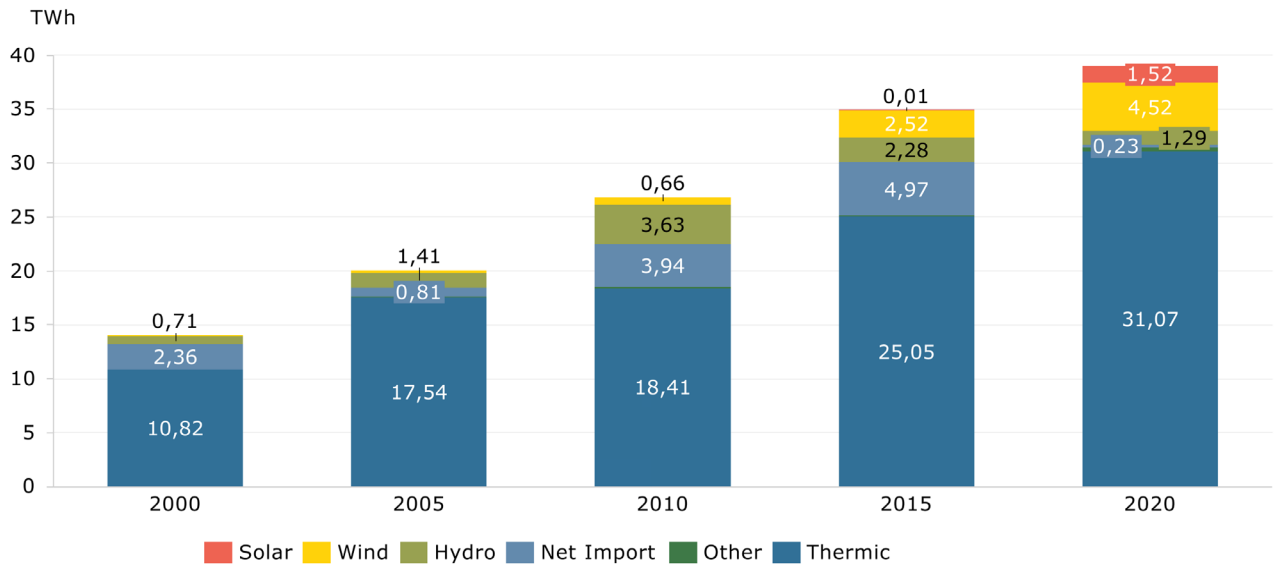
The electricity demand and production are rapidly growing, driven by sustained economic development and an increase in population. Moroccan GDP was higher than 110 billion USD in 2020, about three times the Moroccan GDP assessed in 2000 (World Bank). Morocco's population reached about 37 million people, growing by 30% in the last 20 years.

In this context, electricity demand grew from 14 TWh in 2000 to 39 TWh in 2020, with energy consumption per capita almost doubled[2].

National electricity net import consistently decreased in the last five years, from 5TWh to 0.23 TWh, with an export growth from 0.16 TWh in 2015 to 0.6 TWh in 2020. National electricity production increased over time, especially thanks to thermal power production, that in 2020 produced 80% of the national electricity demand.

Alongside national demand, Moroccan capacity grew from 4.4 GW in 2000 to more than 10 GW in 2020. However about two third of the installed capacity is thermal, and 40% derives from coal.

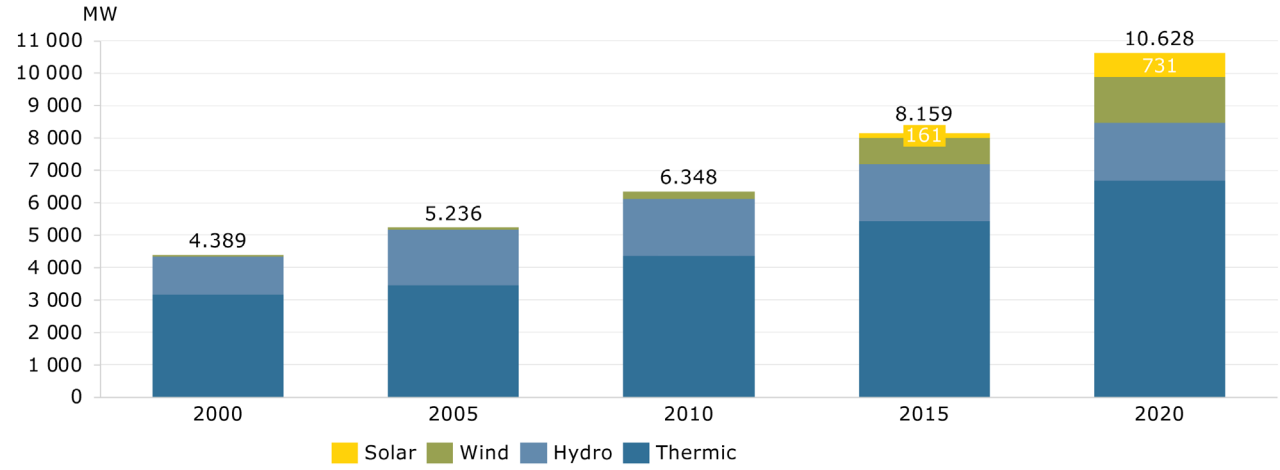
Moroccan growth is not limited to an increase in installed capacity, but also to a significant expansion of the grid and a growing off-grid capacity, achieved over the last few decades. In 1996, the government launched a 15-year rural electrification program (PERG) with the aim to increase rural electrification to 80% by 2010, starting from the 18% of 1995. The program performed better than expected, achieving 81% of rural electrification 5 years in advance and obtaining almost 97% of electrification in 2010. The programme included off-grid PV kits, micro grid and the extension of the regular national grid.



Source: AFRY Management Consulting

Figure 1: Electricity demand over the past decade

[2] Observatoir energie of Morocco



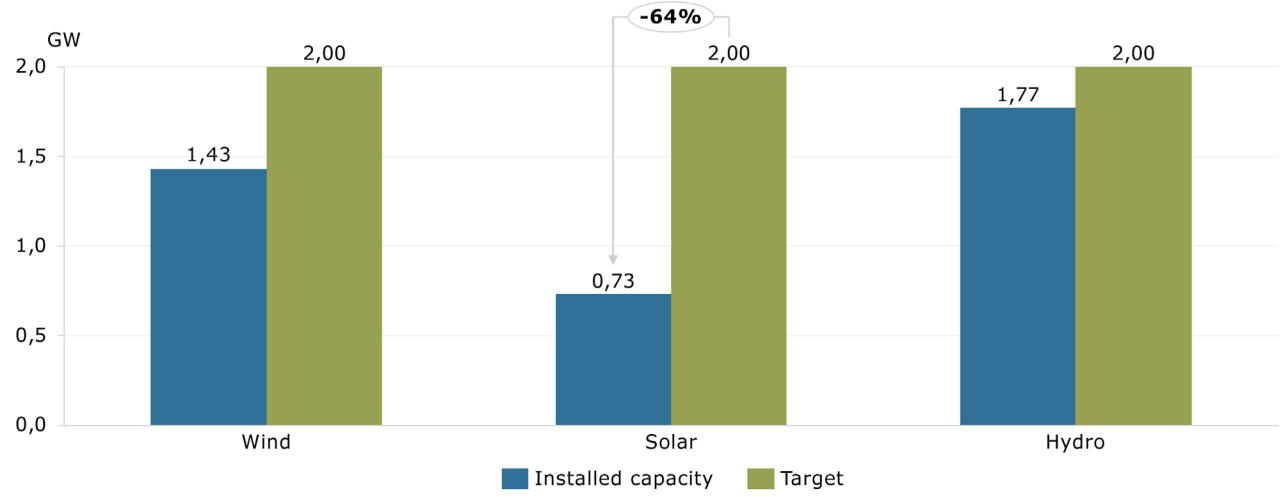
Source: AFRY Management Consulting

Figure 2: Installed capacity

Having accomplished this remarkable goal, the GoM set other ambitious target for clean energy production. In 2008 the National Energy Strategy (NES) defined the decarbonization roadmap in terms of RES capacity. The strategy set the goal of 42% of RES capacity at 2020, targeting 2 GW for each technology: wind, solar and hydro.

Moroccan commitment showed satisfying results in terms of renewable installed capacity where nearly 70% of the target capacity has been deployed, especially thanks to hydro and wind installation. Despite the high potential of Moroccan solar power development, however, only 36% of the target has been installed. In this context small-scale PV deployment may accelerate the installation of new solar capacity.

More recently, the Moroccan government imposed a target of 52% of total capacity by 2030 coming from renewable sources. In this framework, 20% of the installed capacity should derive from solar power, reaching around 5GW by 2030.



Source: Ministry of Energy Transition and Sustainable Development

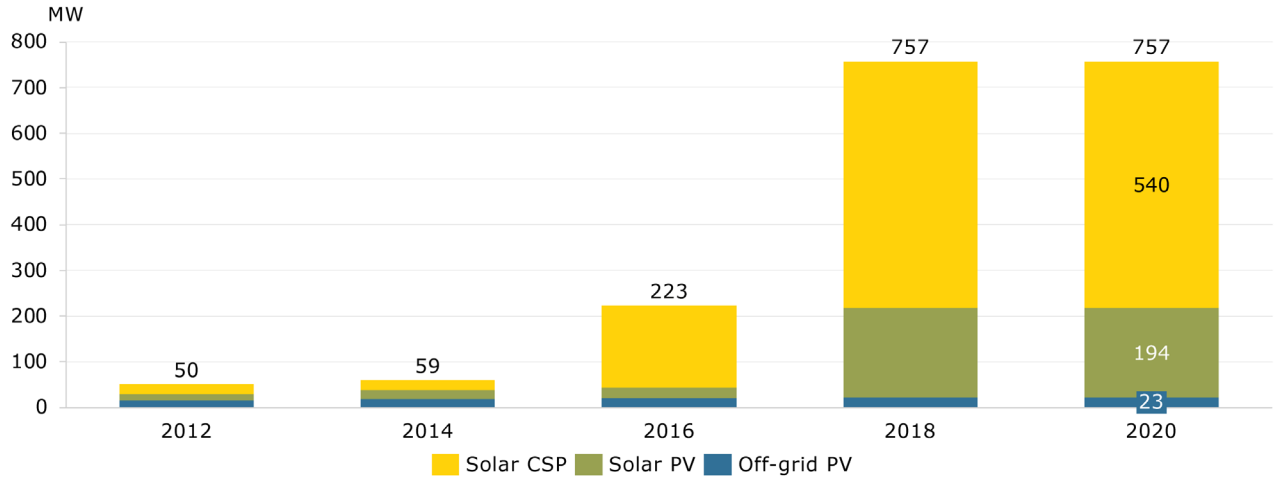
Figure 3: Res target and achievement by 2020

III. Solar Power development in Morocco

Currently, installed solar energy capacity in Morocco amounts to 760 MW approx., of which about 200 MW is photovoltaic. Solar power installed capacity mainly comes from the Noor-Ouarzazate plant in central Morocco, the world's largest concentrated solar power plant (CSP), which includes 72 MW of PV capacity.

Small-scale PV has first made its entry into the Moroccan market through the rural electrification programme PERG, which deployed solar home systems in the most isolated areas, where access to the grid was not possible to achieve. Solar kits consist of two solar panels of 290 watts and two batteries with a total capacity of 300Ah, providing up to three days of energy supply. More than 50 thousand off-grid PV systems, covering more than 100 thousand homes, were installed during the program, and IRENA[3] assessed a total off-grid PV capacity higher than 20 MW.

Moreover, in 2019 ONEE announced a solar program 2019-2023 in order to install 2015 MW of solar energy. Some other rooftop-PV complex has already been installed in few universities or public buildings.



Source: IRENA

Figure 4: Solar installed capacity in Morocco

[3] https://irena.org/publications/2021/Aug/Renewable-energy-statistics-2021

In 2015 the Ministry of Energy Transition and Sustainable Development launched the program Mosquee Vertes[4]. This program, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), and led by MEME, had the goal to develop the energy efficiency and the renewable energy production in the Moroccan mosques. In cooperation with the Ministry of Religious Affairs, the former state energy investment company (Société d'investissement énergétique, SIE) and the Moroccan Agency for Energy Efficiency (Agence Marocaine pour l'Efficacité Energétique, AMEE), the Moroccan government was able to increase energy efficiency, train solar installators and raise awareness among the population on this opportunity, especially thanks to Imams cooperation.

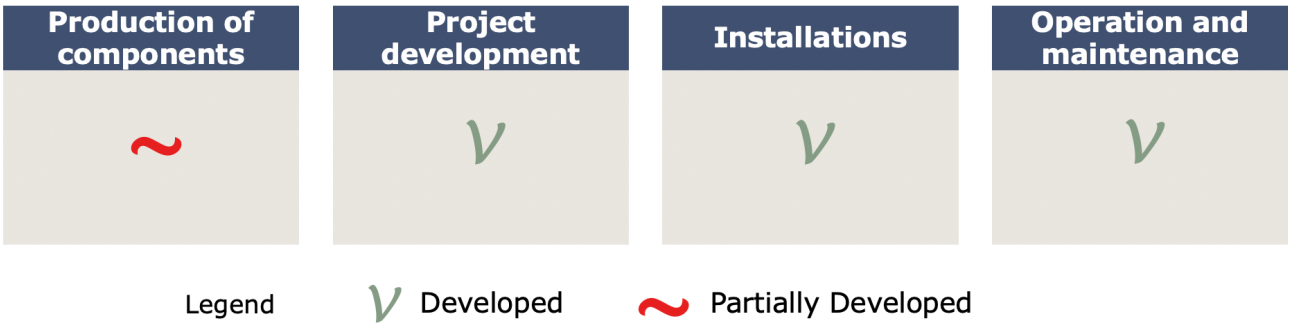
Moreover, this program was able to train and hire almost 300 employees that are now suitable for solar project installations and to upgrade almost 900 mosques in terms of energy efficiency and energy production via small-scale PV installations. In addition, thanks to the Ministry of Religious Affairs and AMEE, guidelines presenting arguments for energy efficiency and the increased use of renewable energies from a religious perspective have been defined. More than 800 imams and women preachers may use such guidelines to spread the knowledge they have acquired about energy efficiency to their communities. Finally, an official Website and a Facebook page with nearly 20,000 followers have been created to spread the knowledge of the information.

[4] https://www.giz.de/en/worldwide/32825.html

IV. Solar-PV industry in Morocco

The solar industry is already in place in Morocco ; many players are positioned at different stages of the value chain in the Moroccan market, as shown in figure 5. Indeed, several local companies assemble and mount solar collectors (PV INDUSTRY, ALMADEN, CLEANERGY) or produce complementary equipment to photovoltaic panels such as batteries and solar equipment. Operators such as Ifrikia, Casabloc, Imacables, Câbleries du Maroc and Nexans produce batteries, electric cables and switches. In addition to these local producers, there are actors who act as intermediaries for the marketing of imported products. In most cases for installation, importers deal directly with service providers. Design, maintenance, servicing and after-sales services, on the other hand, are in most cases subcontracted to local companies. Despite the presence of a handful of local companies able to produce PV panels, Cluster Solaire[5] reported that in 2018, 100% of the solar panels used were imported.

The large-scale development of small PV represents a growth opportunity for this already established market. The unexploited chance to develop a local PV panel producer market, however, could make Morocco dependent on imported PV panels, causing an increase in the upfront investment cost.



Source: AFRY Management Consulting

Figure 5: Moroccan PV market status

[5] Cluster Solaire - Etude sur le potentiel de marche des applicatifs solaires au Maroc

From the end-user point of view, the comparison between electric tariffs and LCOE of rooftop-PV in Morocco has been thoroughly investigated by a study performed by GIZ[6] in 2017. Taking into account the assumed LCOE evolution for consumption bands above 300 kWh per month, to which the tertiary sector currently belongs, and comparing them with current electricity tariffs for MSMEs connected to low voltage, LCOE is about 30% lower than electricity tariffs. A similar outcome emerges from the study performed in 2020 by the local stakeholder Cluster-Solaire[7] too. They observed that since 2014, the cost of the photovoltaic kWh has become competitive compared to the cost of the electric kWh, encouraging consumers to replace their source of electricity supply, especially for consumers whose need is predominantly during the day such as tertiary and industry (e.g. schools, universities, administrations, hospitals, factories, etc). In terms of small-scale PV development, it is thus expected that MSME and public sector could be the pioneers due to a more similar profile between power consumption and PV power generation.

Despite the economic attractiveness, the development of small-scale PV market has not yet taken place, not even among those segments where the consumption profile would be most profitable. This is due to a series of barriers, mainly resulting from the regulation in force, which will be explored more in detail below.

[6] Étude de l'effet sur l'emploi d'un régime d'autoproduction avec facturation nette d'électricité (Loi 13-09 et loi 58-15) issue d'installations photovoltaïques connectées au réseau de basse tension au Maroc
[7] Cluster solaire - Dimensionnement du marché des applicatifs solaires

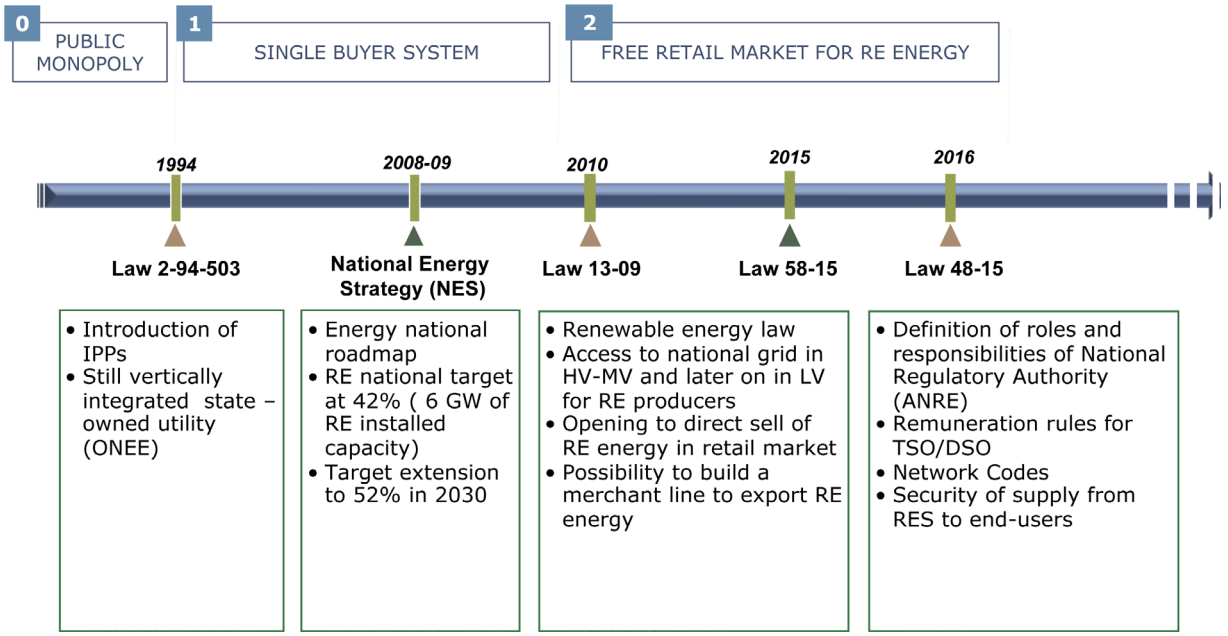
V. Electricity regulatory framework in Morocco

The electricity sector is still vertically integrated, but significant steps towards the liberalisation have been done. In 2009 the GoM developed the National Energy Strategy (NES) and the laws containing provisions to liberalize the electricity market, renewable energy and energy efficiency.

The sector is dominated by the state-owned operator: Office National de l'Electricité et de l'Eau (ONEE), which acts as a producer, distributor and retailer of the water and electric power. ONEE can give concessions to private operators with purchase guarantees and has the status of single buyer of electricity produced. The Ministry of Energy Transition and Sustainable Development has a responsibility to set up the energetic strategy and the general framework while the Ministry of Interior is in charge of the supervision of the autonomous utilities of distribution.

Since 1994 Morocco has entered in a long period of energy market reform, aiming to progressively introduce competition at the different levels of the sector value chain as well as reform the sector governance framework. The reform, still undergoing, aims to establish a new industrial organization and new market functioning in order to achieve:

- A more competitive market, and most recently;
- Ambitious targets for renewable energy in 2020 and 2030.



Source: AFRY Management Consulting

Figure 6: Timeline of liberalization of Morocco power sector

In terms of energy transition, the Law 13-09, introduced in 2009, allows electricity to be produced, sold and exported by any private producer as long as they utilise renewable energy sources. Moreover, the establishment of a National Energy Regulatory Authority (ANRE) in June 2016 is a further step towards liberalization of the market, and aims to regulate both electricity and gas market, with clear responsibilities to the regulator:

- The definition of commercial and technical rules of the electricity market;
- The adoption of a grid code and grid access rules;
- Network and retail tariff methodologies.

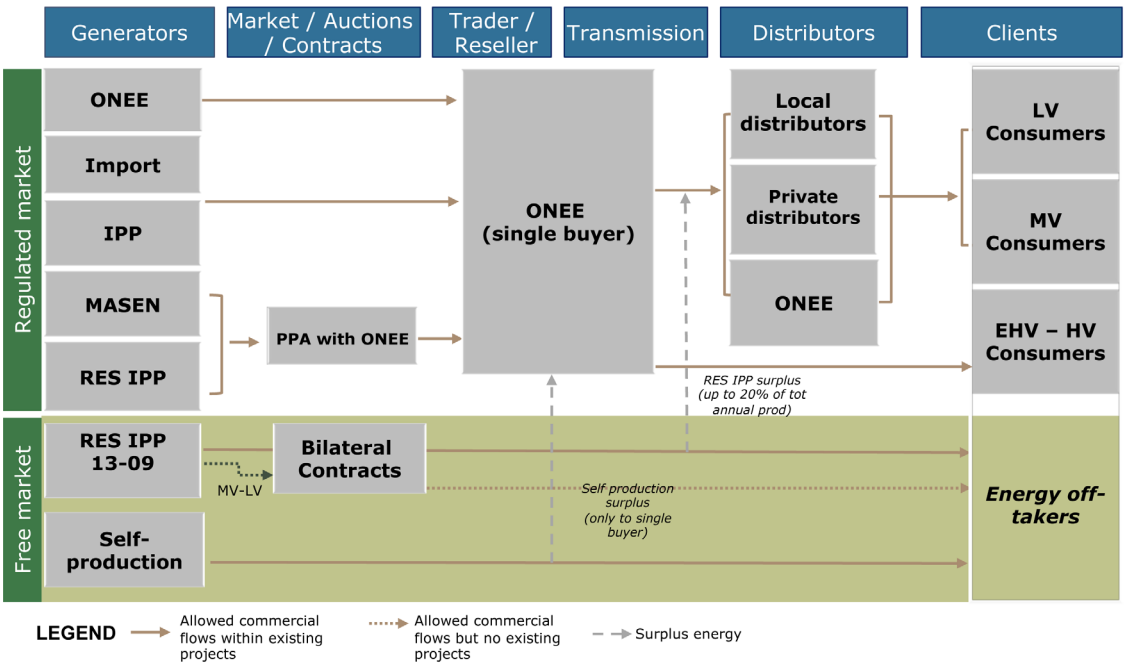
However, ANRE became formally operational with several years of delay (2021), still leaving ONEE acting as both a decision maker and regulator.

The result of the Moroccan energy reform is a hybrid market model where a regulated market, supplied by the single-buyer and distributors companies, coexists with a free retail market supplied by renewables producers and self-producers, as shown by figure 7.

Currently, three main routes-to-market are present for RES in Morocco, for both large installation and distributed generation:

- A TSO Procurement scheme where the IPP sells directly to the single buyer ONEE;
- A Retail Direct-Sales model, introduced by Law 13-09;
- A Self-production model, defined by Law 16-08.

In case of small-scale PV for both public sector and MSMEs the most suitable route-to-market is represented by the self-production model for a renewable plant, whose regulation is detailed below.



Source: AFRY Management Consulting

Figure 7: Moroccan electricity market structure

VI. Regulatory framework for renewable self-consumption

Any renewable plant is subject to the RE law 13-09 relative to the development of renewable energy, adopted and published in the official bulletin the 18th March 2010. Law 13-09 was promulgated in order to liberalize and develop the renewable energy sector.

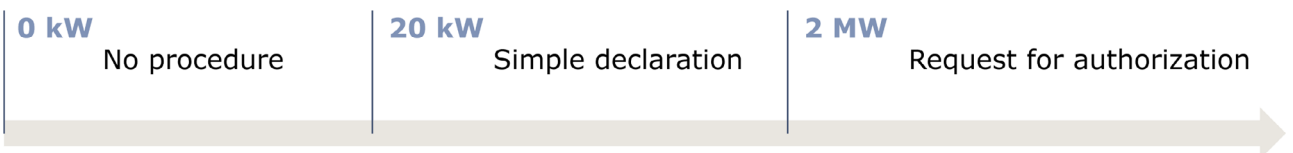
The 13-09 Law aimed to introduce several changes:

- The opening up of renewable electricity generation to competition;
- Access to the transmission of renewable electricity via the national grid;
- The possibility of exporting electricity via the national grid; and
- The possibility for a developer to build its own direct transmission line.

Moreover, Law 13-09 describes several permitting regimes for the construction, operation, capacity extension or modification of electricity production facilities from renewable energy sources, depending on the installed capacity. In case of renewable plants, permitting regimes are shown in figure 8. In case of a small-scale PV installation[8], with the exception of residential one, a simple declaration with the administration is required by Law 13-09. The declaration is accompanied by an identification dossier of the declarant and a technical dossier on the renewable energy source and its technical specifications.

Law 13-09 represented an obstacle for small-scale PV producers because it only opened for High and Medium voltage connections. For this reason, Law 58-15, an amendment to Law 13-09, defined the opening for renewable sources to the low voltage connection. Moreover, Law 58-15 introduces the net metering scheme for plants connected to high voltage and allows private investors in renewable power to sell their surplus output to the grid, up to 20% of their annual production.

However, the relative implementing decree 2-15-772 regulated the access to the national medium voltage network only, and no decree has been drafted for low voltage network. This issue is expected to be removed by ANRE and by the publication of the grid code, currently in preparation with the European Bank for Reconstruction and Development (EBRD) supervision. Moreover, to date, a net metering scheme is in place for High Voltage only.



Source: AFRY Management Consulting

Figure 8: Permitting processes: Law 13-09

[8] From 20 kW to 200 kW

In case of small-scale PV installed with the aim of self-production, the renewable plant is also subject to the self-production Law 16-08, later modified by 14-54 amendment.

Self-production law 16-08 defines that:

Natural or legal persons may, on their own request, be authorised by the Administration to produce electrical energy by their own means, provided that:

- Such production capacity does not exceed 50 MW;
- It is intended for the exclusive use of the producer;
- It does not disrupt the electrical power supply plans of the area concerned;
- The surplus from production not used by the producer for its own needs is sold exclusively to ONEE.

Installations between 50 MW and 300MW are not authorised, while for production plants exceeding 300MW of installed capacity, on the other hand, self-producers are authorised to produce electrical energy by their own means, with the right of access to the national electricity grid to transport the electricity to the consumption site, provided that:

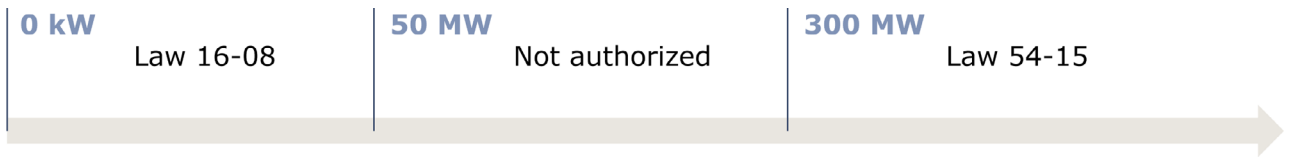
- The production is for the exclusive use of the producer;
- The production does not disturb the power supply plans of the national electricity network;
- The surplus of the production not used by the producer for its needs is sold exclusively to ONEE.

In both cases, agreements between the self-producers and the ONEE must be concluded concerning:

- The technical terms of connection to the national electricity grid;
- The commercial conditions for the supply of electricity by ONEE, if necessary and at his request the commercial conditions for the buy-back of the surplus energy produced;
- The technical terms of access to the national electricity grid as well as the commercial conditions relating to the transport of electrical energy.

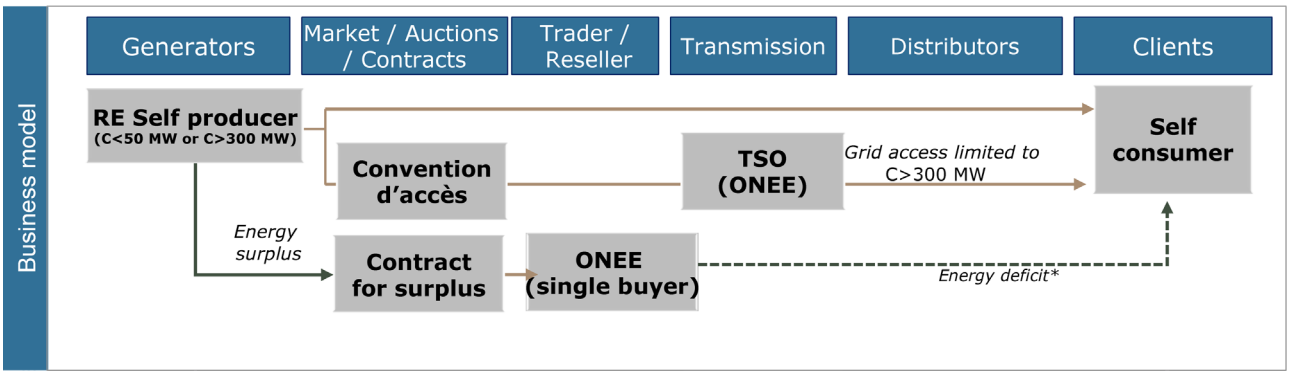
Figure 10 provides a schematic representation of the self-consumption model implemented in Morocco showing that, under the current regulation, the self-consumer must coincide with the electricity producer.

Stating IEA 2019, nearly 3% of the electricity production connected to the grid derives from self-production. However, due to the lack of implementing decree of law 15-58 on low voltage, the share of small-scale PV production is estimated to be negligible.



Source: AFRY Management Consulting

Figure 9: Self-production schemes



Source: AFRY Management Consulting

Figure 10: Self-consumption model

Factors slowing-down small-scale PV deployment in Morocco

The implemented regulation for renewable plant for self-consumption leaves open points and introduces barriers that might hinder the realisation of new projects. The main barrier concerning small-scale PV deployment in Morocco regards:

1. The **lack of grid connection in LV**: as of today, no renewable production plant can connect to low voltage grid, and this prevents the plant from selling energy when the power produced exceeds the power consumed. This barrier inhibits the economic attractiveness of the opportunity.

Barrier 1 may be considered a no-go condition, and hence needs to be addressed at first. Once removed this first obstacle, several other aspects slow-downs the small-scale PV deployment. In the following, the barriers are evaluated on the assumption that barrier 1 has already been removed, analysing what other aspects should be assessed to make small-scale PV market attractive, open and ready for the large scale-deployment:

2. At the time of writing, **net-metering scheme** is not present for low-voltage production plant. At the end of 2015, the Government of Morocco adopted Law n°58-15 amending renewable energy law and introducing net-metering scheme for solar PV and onshore wind plants. Only power plants connected to the high-voltage grid may benefit from net-metering. Those connected to the middle- and low-voltage level are expected to be eligible at a later date.

3. Law 16-08 and following amendments stated that self-producers must produce energy "par propre moyens", or "**by their own means**". The notion of production by one's own means, however, is subject to a restrictive interpretation by the administration, which may oppose contractual arrangements aiming to adapt this principle. This expression is in fact under discussion. A Draft Law that should update the self-consumption regulation, specifies that the self-producer must be the owner of the self-generation installation while it opens to the possibility of entrusting the construction and/or operation and maintenance of the said installation to third parties.

4. The **independent body (ANRE) delayed its entry into operation** still leaving a lack of clear and public regulation. **Grid connection rules** for self-producer are not clearly defined and still rely on private negotiation with ONEE. This barrier is expected to be removed once grid code is published ANRE. Moreover, both **tariffs** for **supply** of the required energy, if needed, and the tariff for **selling** the energy surplus still rely on private negotiation with ONEE, making the opportunity less attractive and more complex to assess during the feasibility phase of the project.

5. The high impact of the initial investment is not attenuated by any **incentive scheme** for small-scale PV in Morocco.

6. The PV market is already established, however Morocco historically relied on import instead of **local PV panel production**, as detected by local studies. In case of large-scale deployment of small-scale PV, this may represent a barrier in terms of Moroccan dependency on import, causing an increase of the upfront investment costs.

7. There is a **lack of knowledge** among the population about the opportunity represented by small-scale PV installations. In this context, several initiatives already in place, like the Green Mosque program, are extremely helpful in spreading the small-scale PV knowledge across the communities, making the society ready for the large-scale deployment of small-scale PV.

In addition to the above-mentioned list of barriers preventing small-scale PV spread, a further obstacle is going to be introduced by the new Bill 82.21, presented by the Minister of Energy Transition and Sustainable Development on 11th November 2021 and currently under discussion. Among the measures provided by the Bill, which aims to regulate the legislative and regulatory framework governing the self-production of electricity, the upper limit of 10% of the total electricity surplus that can be sold is going to be introduced. This would represent a disadvantage for prosumers since it would limit the possible gains achievable from the installation of a solar PV, further discouraging small-scale PV deployment.

In order to better understand how these barriers influence the market, the seven enlisted issues are further categorised in order to assess the openness readiness and attractiveness of the market. The identified barriers have been grouped according to a framework for regulatory review which have been already used in previous studies. Such framework focuses on the fundamental elements that create an enabling framework for the scale-up of investments in new renewable energy capacities:

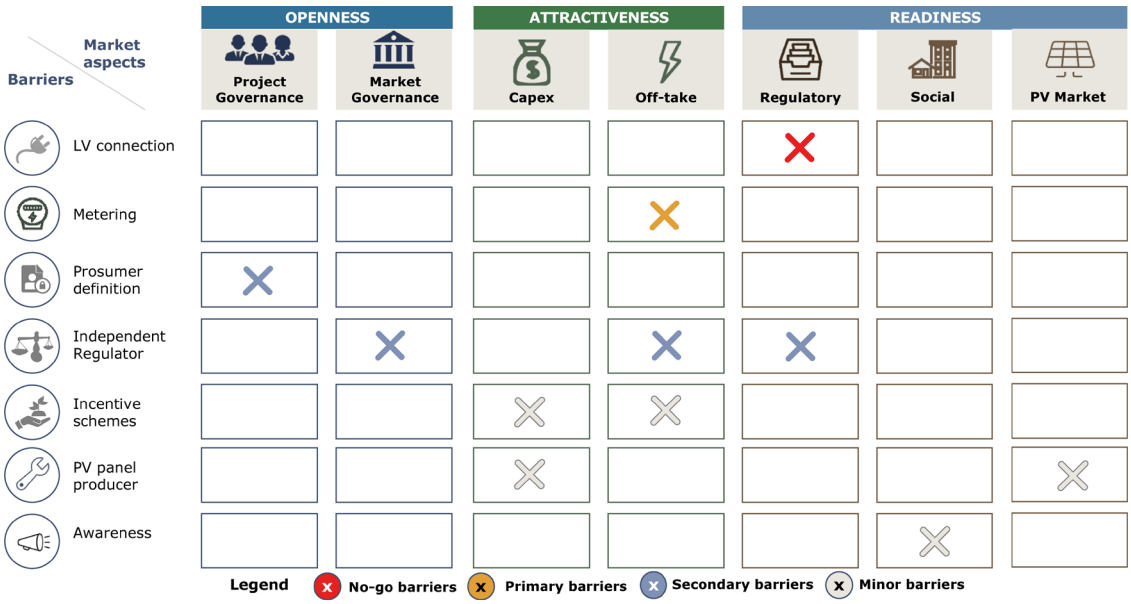
- Openness: legislation and regulation that ensure RES development planning and long-term visibility to investors;
- Attractiveness: legislation and regulations that ensure competitive development and implementation of RES projects as well as fair competition among power generation technologies;
- Readiness: regulation and conditions that ensure efficient integration and management of increasing RES capacities in national power systems.

OPENNESS		ATTRACTIVENESS		READINESS	
Project Governance	Project governance for self consumption is not clearly defined, due to unclear partnership and co-financing rules	Capex	Capex attractiveness is not supported by incentive scheme or other form of indirect subsidies. Upfront costs may reflect the import panel dependency of Morocco	Regulatory	Grid connection rules do not allow RES plants connected to low voltage, and grid connection rules are not clearly published by ANRE
Market Governance	ANRE has not yet published the required regulation, creating uncertainty and instability in the regulation	Off-take	Offtake attractiveness is hindered by the absence of defined metering scheme or other form of incentives. Moreover tariff are not yet published by the regulator	Social	Several studies assess a low awareness among the population of the opportunity represented by the small-PV market in Morocco
				PV Market	The scarcity of PV producer in Morocco may be a problem in case of rapid surge of small-PV installations

Source: AFRY Management Consulting

Figure 11: Barrier impact on openness, attractiveness and readiness

The matrix shown in figure 12 assesses the impact of each barrier, underlining which specific aspect of the market is affected. Moreover, the color-code specifies how the small-scale PV deployment is affected, splitting barriers in no-go barriers, primary, secondary and minor barriers, based on the above observations. The absence of regulatory readiness of the market, due to the lack of LV connection to the grid hinders the small-scale PV deployment.



Source: AFRY Management Consulting

Figure 12: Impact of current constraints on project lifecycle phases

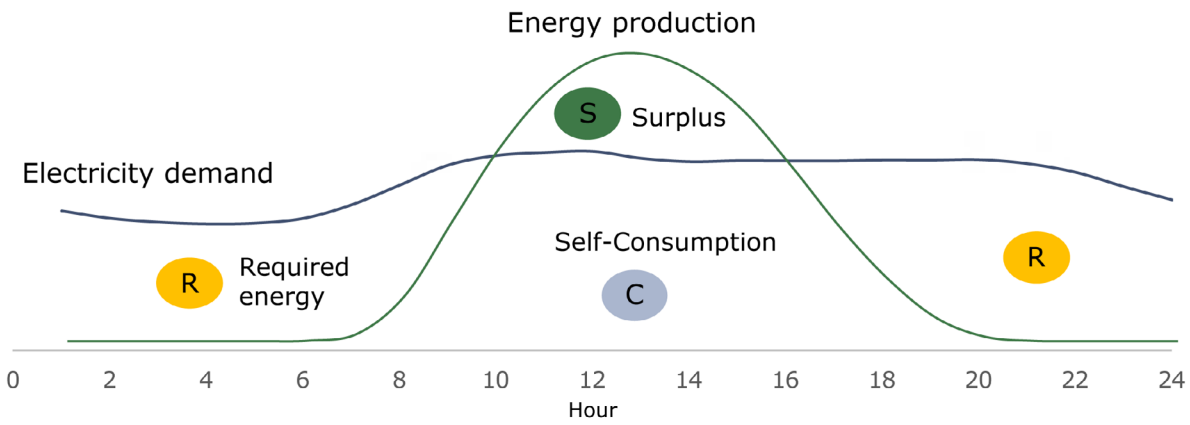
VII. Key enabling measures in successful countries

International best practices testify that even when RES plants can connect to low voltage grid, other measures are needed to speed-up deployment of small-scale PV for self-consumption. From a prosumer[9] perspective become fundamental the way surplus of energy produced is remunerated. This aspect is particularly important for PV installations since the production profile differs from the consumption one, with a usually high amount of energy surplus **S**, and energy required **R**, as illustrated in figure 13. The prosumer should be rewarded for the energy surplus and must pay for the energy required. The regulatory balance between these two cash-flows is a key enabler to make this opportunity attractive for investors. One of the key enabler from the metering perspective is the net-metering scheme.

Net-metering scheme

The net-metering scheme allows to completely recover the energy surplus. With a net-metering scheme the electricity bill paid by the prosumer is made by only the net amount of energy considered between energy surplus and energy required. In case of production surplus greater than the required energy surplus, the energy surplus is virtually stored for months. A sketch explaining the net metering scheme is shown in figure 14.

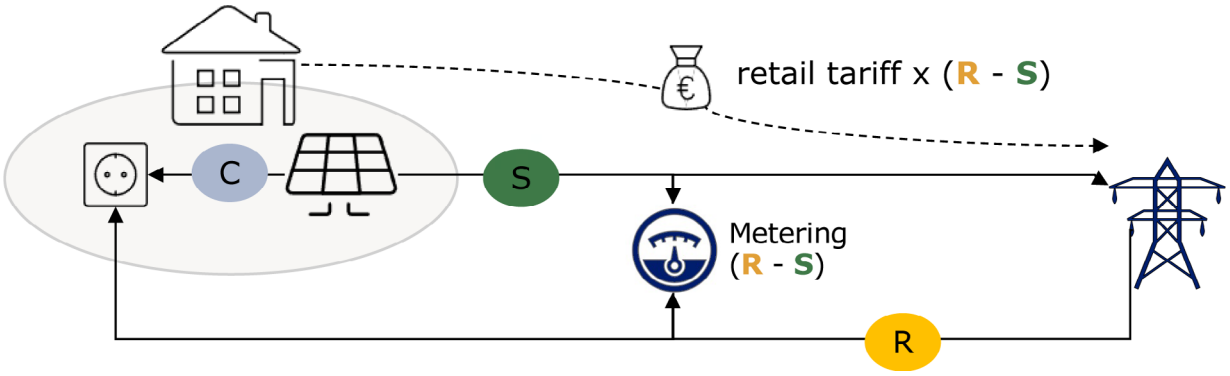
A good example of the effectiveness of small-scale PV is represented by Mexico where the net-metering scheme is in place for plants smaller than 500 kW. In Mexico net-metering is set on a monthly basis, while the excess of generation, with respect to surplus of energy required is stored up to 12 months in the virtual energy bank. After 12 months, is paid to the customer. Thanks to this mechanism Mexican distributed PV recently took-off reaching 1.8 GW of installed distributed PV in 2021, with a CAGR of 31% in the last five years, as shown in figure 15.



Source: AFRY Management Consulting

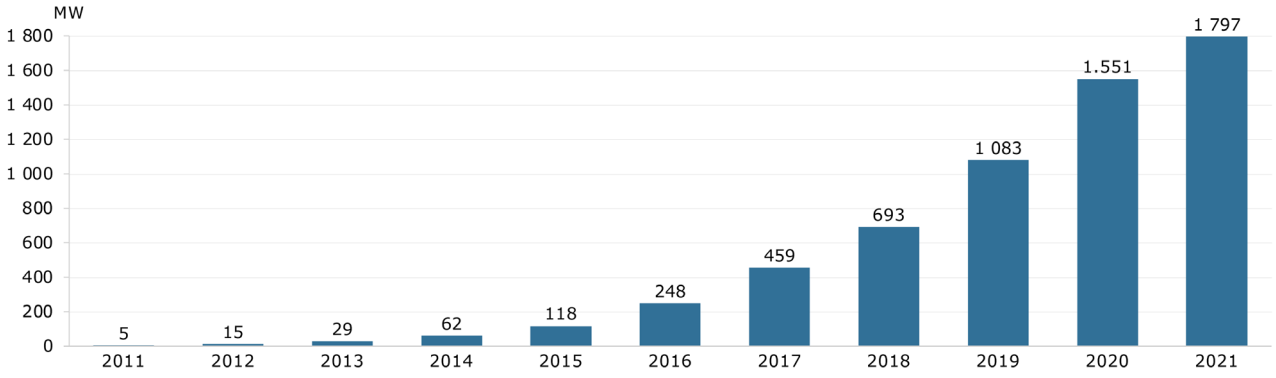
Figure 13: Sketch of the self-consumption energy balance

[9] An individual who both consumes and produces.



Source: AFRY Management Consulting

Figure 14: Sketch of the net-metering scheme



Source: AFRY Management Consulting

Figure 15: Mexican small-scale PV installation

Virtual Net-metering scheme

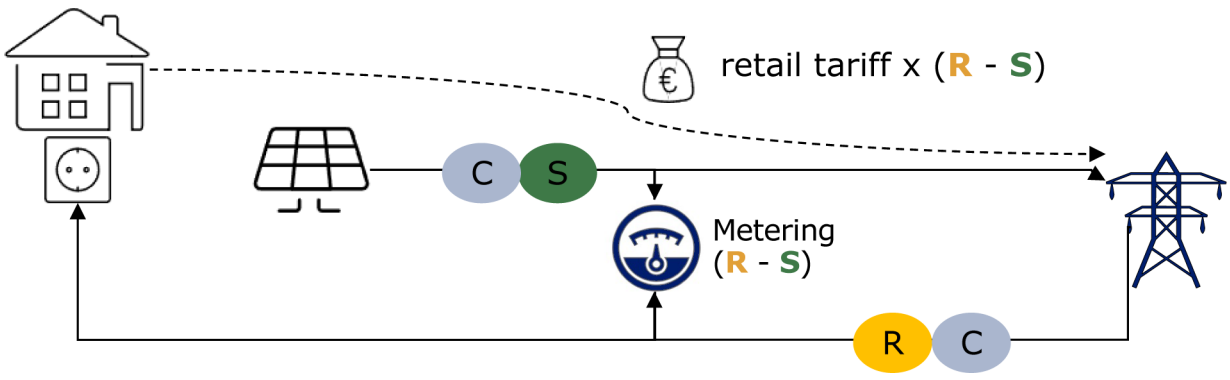
An interesting evolution of the net-metering scheme was successfully implemented in Brazil. Virtual net-metering has been introduced with the purpose of allowing the producer to self-consume energy far from the production site, or to allow more consumers to use the energy produced from one generation site. Brazilian virtual net-metering was introduced in 2015 allowing three different modalities in addition to the usual on-site consumption mode:

1. **Remote self-consumption** refers to a system in which the distributed generation unit is installed in a different location from the consumer unit, but in the same concession area. This idea allows the energy generated in one location to be compensated in another within the same concession area, which is the area served by the same electricity distribution utility company. A sketch of the remote self-consumption is illustrated in figure 16.

2. **Distributed generation condominiums**: Shared condominiums are characterized by vertical or horizontal condos with a distributed generation system installed. Generated electricity is compensated among all joint consumer units. This would involve dividing a major power source into smaller quantities that provide electricity to condominium units. This solution can be applied to residential or commercial condominiums, but all consumer units need to be located in the same property.

3. **Shared distributed generation** – consortia and cooperatives, according to which 2 or more companies agree (through a business contract) to take benefits from sharing a distributed generation system. The consortium, besides from registering at the National Registry of Legal Entities, must own the consumer unit where the distributed generation system will be installed. Through the net metering, the electricity produced is compensated at the cooperative members' consumer units.

Thanks to virtual net metering, Brazil saw an amazing increase of distributed PV installations, reaching more than 7 GW of distributed PV with a CAGR of 107% in the last five years.



Source: AFRY Management Consulting

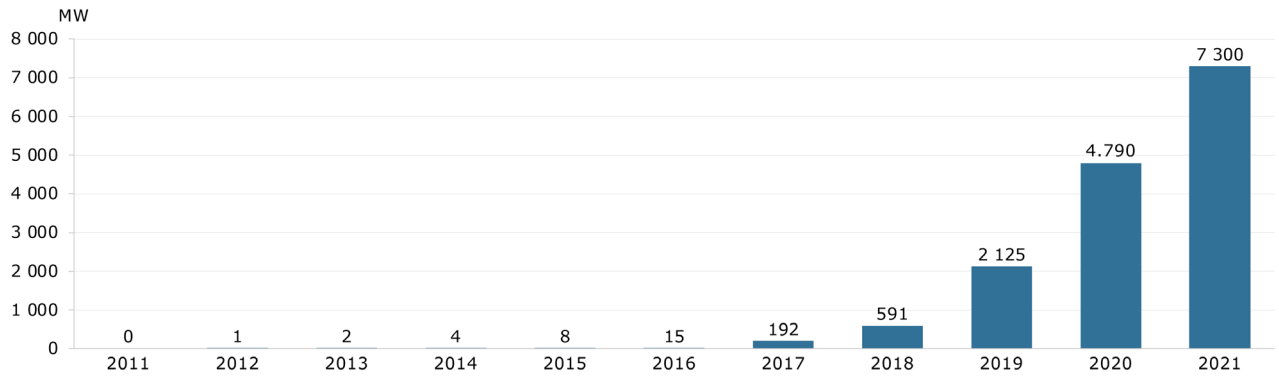
Figure 16: Scheme of remote self-consumption with virtual net-metering

In order to achieve the explosion of PV deployment, Brazilian government set other direct incentives like tax exemption for import PV equipment.

Feed-in-tariff scheme

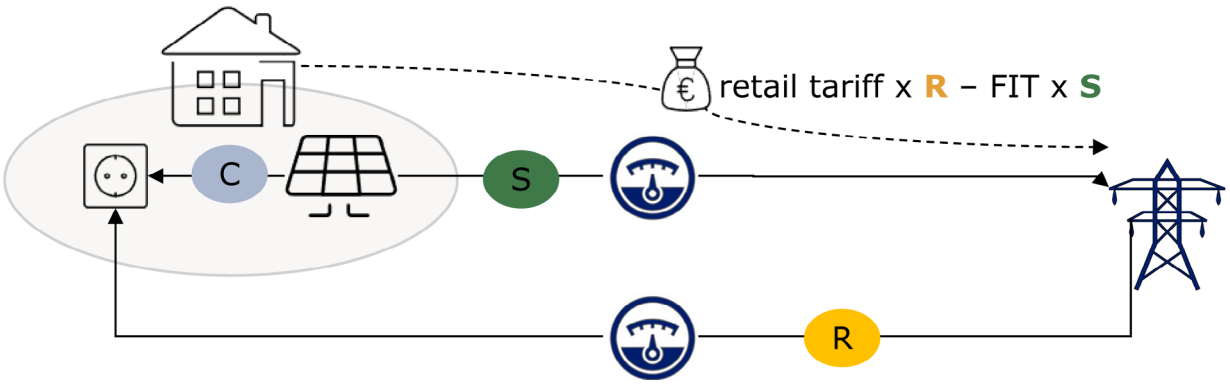
An even more impressive example is set by Vietnam, where an attractive Feed-in-Tariff (FiT) was introduced in 2019 in place of net-metering scheme. The vertically integrated Vietnamese utility claimed that it was very challenging for them to calculate and invoice the power based on net-metering scheme. Differently from the net-metering scheme, with a Feed-In-Tariff scheme, two different counters are necessary in order to separately consider the energy required and the surplus. Moreover, with a feed-in-tariff scheme, the surplus price is usually fixed and guaranteed by long-term contracts, drastically reducing the risks for the prosumers. FiTs can be higher than retail electricity tariffs so that they incentivise consumers to install distributed renewable generation capacity.

Vietnam saw an incredible deployment of rooftop-PV installation with this incentive scheme, with more almost 10 GW of rooftop capacity installed in 2020, as shown in figure 19. Vietnam government eased the PV deployment by introducing a series of indirect incentives as tax exemption for PV panel import and preferential loans for RES investments. However, the case of Vietnam shows the side effects of this incentive system. An out-of-control development of installations without an imposed upper limit can increase the costs for the system in an uncontrolled manner and require, as in the case of Vietnam, a review of the incentive scheme a few years after its implementation. Despite this, the feed-in tariff system can be useful as a transitional key enabler to kick-start the market.



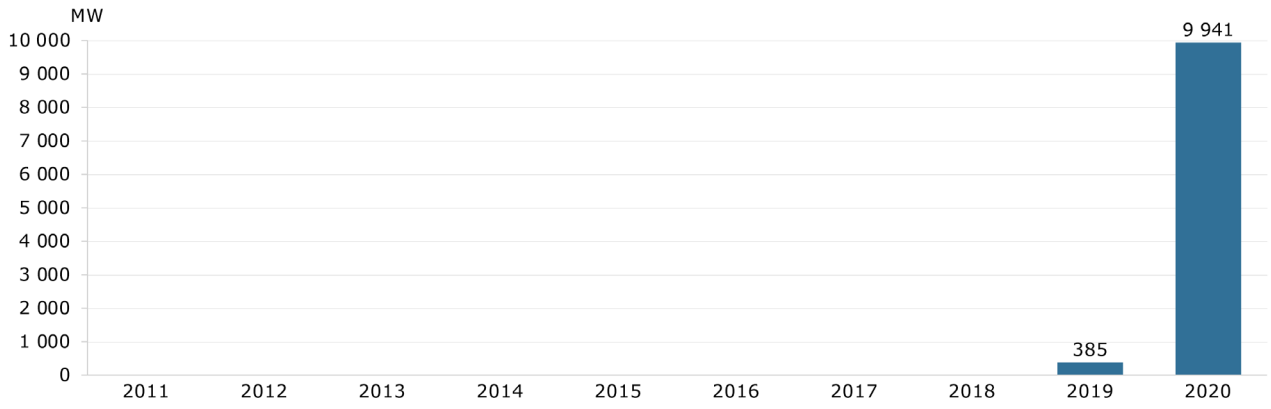
Source: AFRY Management Consulting

Figure 17: Brazilian small-scale PV installation



Source: AFRY Management Consulting

Figure 18: Scheme of the Feed-in-Tariff scheme for self-consumption



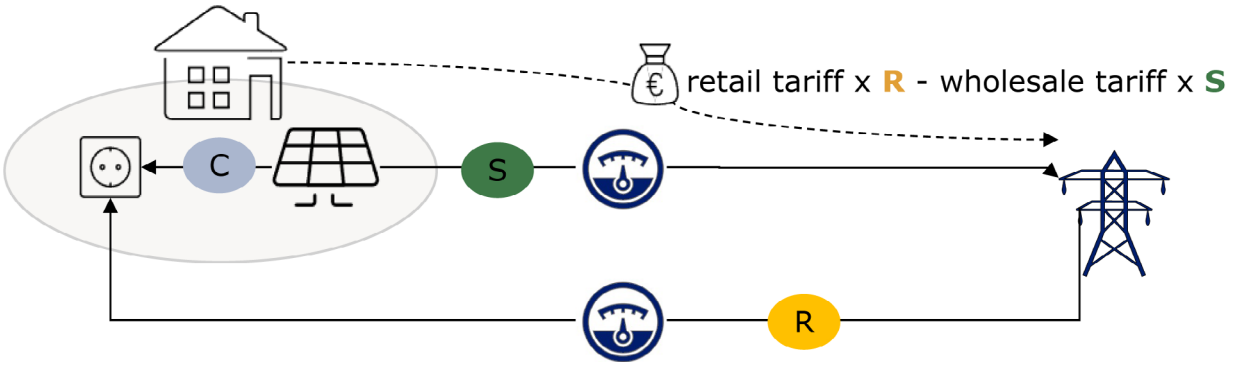
Source: AFRY Management Consulting

Figure 19: Vietnamese rooftop-PV installations

Net-billing scheme

While prosumers have widely appreciated net-metering and Feed-In-Tariff schemes, their compensation mechanisms are not reflective of the cost of electricity at the injection instant and can distort the system if the quantity injected is significant. For example, the injection of excess renewable electricity into the grid is more valuable for the system during peak load hours than during off-peak hours. Similarly, oversupply during hours of low demand could lead to curtailment of the power plant or reduce electricity prices. For these reasons, once the small-scale PV market is already established, several countries interrupted the above-mentioned schemes and adopted the net-billing scheme, illustrated in figure 20. Similarly to feed-in-tariff, two counters are required in order to differentiate the energy required from the surplus. The energy required is paid at retail price while the surplus is sold at wholesale price. Net billing is a market-based compensation mechanism, as prosumer compensation is based on the actual market value of the energy consumed or injected into the grid.

The whole amount of energy surplus required is bought at retail price by the consumer, while the surplus is sold directly to the utility at wholesale price. From an algebraical point-of-view, a net-metering scheme is equivalent to sell the surplus at a retail price, including network, transmission and distribution charges. With net-billing on the other hand, surplus is sold at wholesale price excluding network, transmission and distribution charges. For this reason net-billing is less attractive for the prosumers. Different version of the net-billing scheme is implemented in several countries, adopted especially after the successful deployment of the small-scale PV market. Net-billing represents in fact a cost-reflective mechanism, that assure a sustainable and more stable mechanism which avoids oversupply and distorted price-signal.



Source: AFRY Management Consulting

Figure 20: Sketch of the net-billing scheme

VIII. Unleashing Moroccan small-scale PV potential

The analysis of international key enablers has underlined that the metering scheme represents one of the main features of the self-consumption regulation. Once the RES plants can connect to Low Voltage, several aspects should be considered as well in order to pick the most suitable scheme, among which the increase of system costs. Moreover, in order to facilitate the correct evolution of the market, both project and market governance should be clearly defined allowing flexibility in the project management on one hand, and a transparent and independent regulation of the market on the other hand. Finally, in order to unleash the small-scale PV potential, other issues should be addressed, such as the introduction of incentive schemes to reduce the upfront costs of the investment, enabling the development of the market during the first stages. In this context, the impact of the absence of a well-established PV panel producer market should be monitored. To let small-scale PV become a key player in reaching the ambitious Moroccan RES targets, the awareness of this opportunity should be increased among the population.

All the above-mentioned barriers can be removed guaranteeing an open, attractive and ready small-scale PV market.



Regulatory

The first action required to unleash the small-scale PV Moroccan potential is the availability of connecting RES plants to the Low Voltage grid. In case the delay in Low Voltage connection is due to grid instability, an intermediate solution may be the implementation of zonal connection, allowing small-scale PV to connect the Low Voltage grid only in areas where the grid can sustain it.



Off-take

A key enabler for small-scale PV is represented by the metering scheme. Net-metering may represent the first option to promote small-scale PV deployment, followed by the most advanced virtual net-metering scheme. However, the cost for the system and the technical feasibility of the scheme may represent an issue. Similarly, a feed-in-tariff, characterized by a simpler implementation, can only be considered as a transitional measure to launch the market during the initial stages. Finally, net-billing may represent both a long-term solution, and a short-term key enabler. Thanks to the high solar potential, small-scale PV may be already attractive in some region even without other form of incentives. Moreover, even with net-billing scheme, virtual schemes that allow remote self-consumption or shared generation may be a key factor, especially in a country where MSMEs and public building represent a significant share of the small-scale PV potential.

Project Governance

A clear project-governance is a key element for a successful small-scale PV deployment. Moreover, partnerships and shared generation may allow to sustain the initial investment costs.

Market Governance

The entering in operation of ANRE guarantees clarity and transparency in the whole market. The publication of clear rules and tariff may help the jump-start of the small-scale PV market.

Capex

Thanks to the high solar potential present in Morocco, the most effective incentive may be related to the upfront cost. A possible option is the introduction of a direct incentive in order to refund part of the initial investment cost. Another solution is represented by preferential loan, already implemented in other countries.

PV Market

The partially developed market of PV panels producers in Morocco may cause an import dependency followed by possible logistic issues and increase in the upfront costs in case of surge of small-scale PV installations. As already implemented in Brazil and Vietnam, an import tax exemption may help in limit the upfront cost, increasing the small-scale PV attractiveness.

Social

Social awareness may be enhanced by spreading knowledge via public projects. In line with the Mosquees Vertes program, a first step may regard public buildings. In Kuwait, for example, according to the Ministerial decree 126/2018, all governmental buildings are required to have at least 10% of their building's peak demand deriving from rooftop solar. This kind of initiatives may represent a fruitful first step to increase the share of RES power and, in the meantime, consistently advertise the small-scale PV opportunity among the population.

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- Comisión Reguladora de Energía https://www.gob.mx/cre
- Institut de Recherche en Energie Solaire et Energies Nouvelles (IRESEN) https://iresen.org/
- Ministry of Energy Transition and Sustainable Development https://www.mem.gov.ma/pages/index.aspx
- Ministry of Energy Transition and Sustainable Development https://www.observatoirenergie.ma/data/electricite/ventes_electricite
- Moroccan Agency for Solar Energy (Masen) https://www.masen.ma/
- Office national de l'electricité et de l'eau potable (ONEE) http://www.one.org.ma/





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