PHOTOVOLTAIC MICRO GENERATION INCENTIVE POLICIES

Joana Resende, Thereza Aquino

PORTO
FACULDADE DE ECONOMIA
UNIVERSIDADE DO PORTO

cef.up
Centro de Economia e Finanças da UP
Center for Economics and Finance at UP

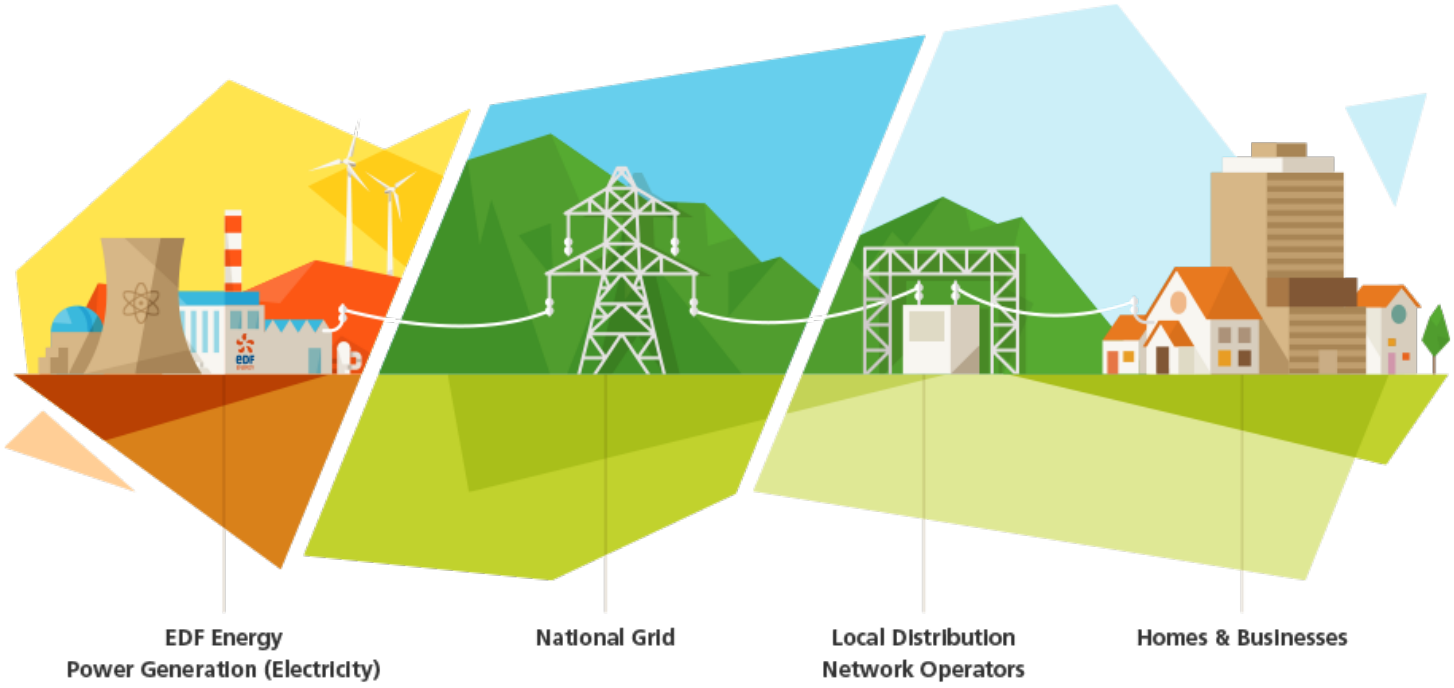
GESEL
Grupo de Estudos do Setor Elétrico
UFRJ

Outline of the Presentation

1. Introduction
2. Photovoltaic Micro Generation Incentive Policies
3. Regulatory Challenges
4. International Experiences
5. Conclusions

Introduction

Going from a unidirectional value chain....



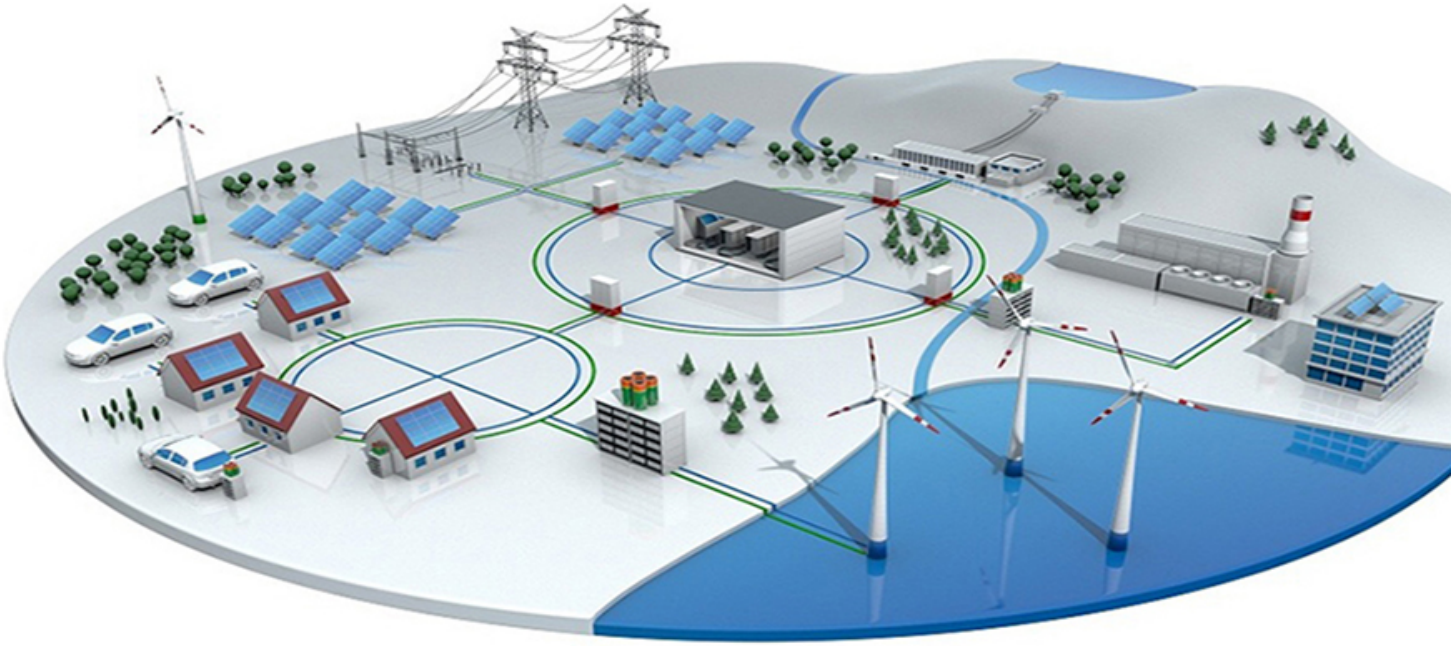
Source: EDF

Introduction

... to a smart grid based on Distributed Energy Resources

New Electricity Paradigm

- More Sustainable
- More efficient (e.g. DSM)
- Decentralized
- Storage
- Electric Mobility
- New business players



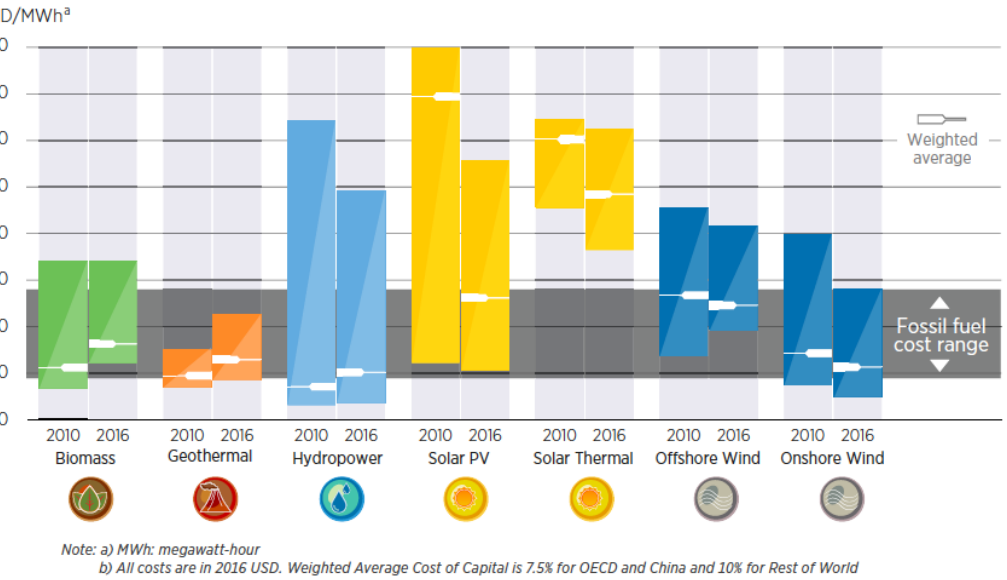
Introduction

PV Solar: recent developments and trends

Economic profitability of solar PV is growing considerably:

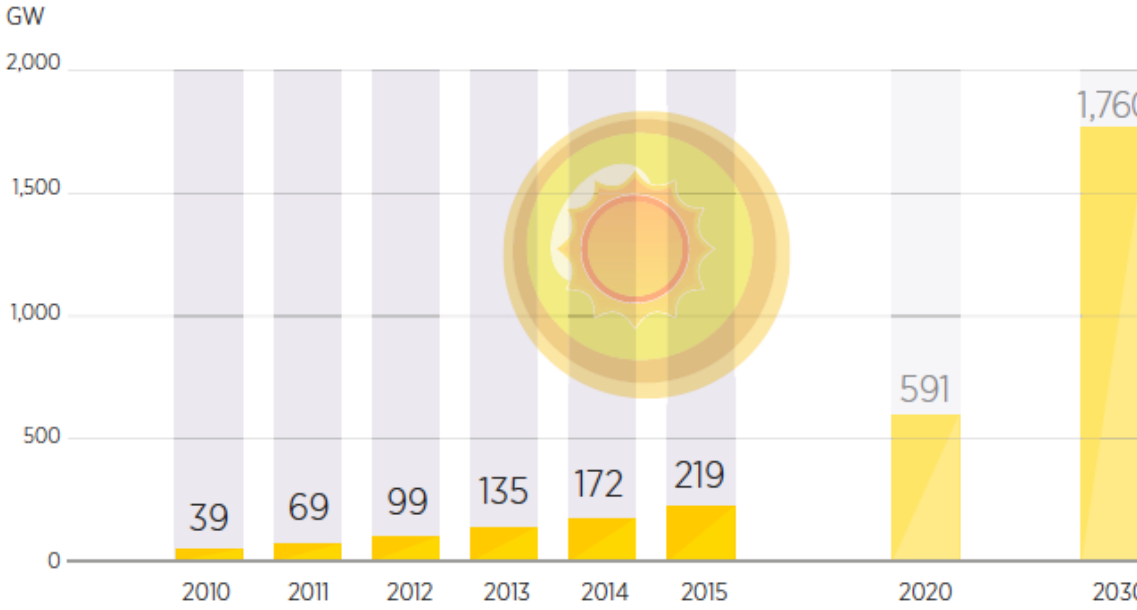
- LCOE are going down (and further reductions are expected – scale, scope and learning economies).

zed cost of electricity: utility-scale power (ranges & averages)



Source: IRENA (2017)

PV Solar global installed capacity (historical & projecti

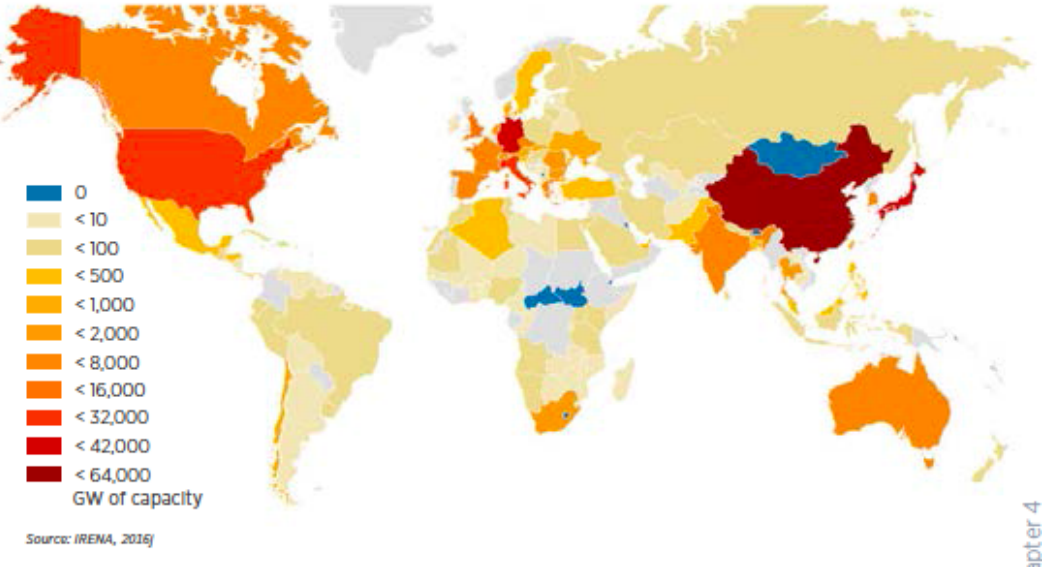


Source: IRENA (2017)

Introduction
PV Solar: recent developments and trends

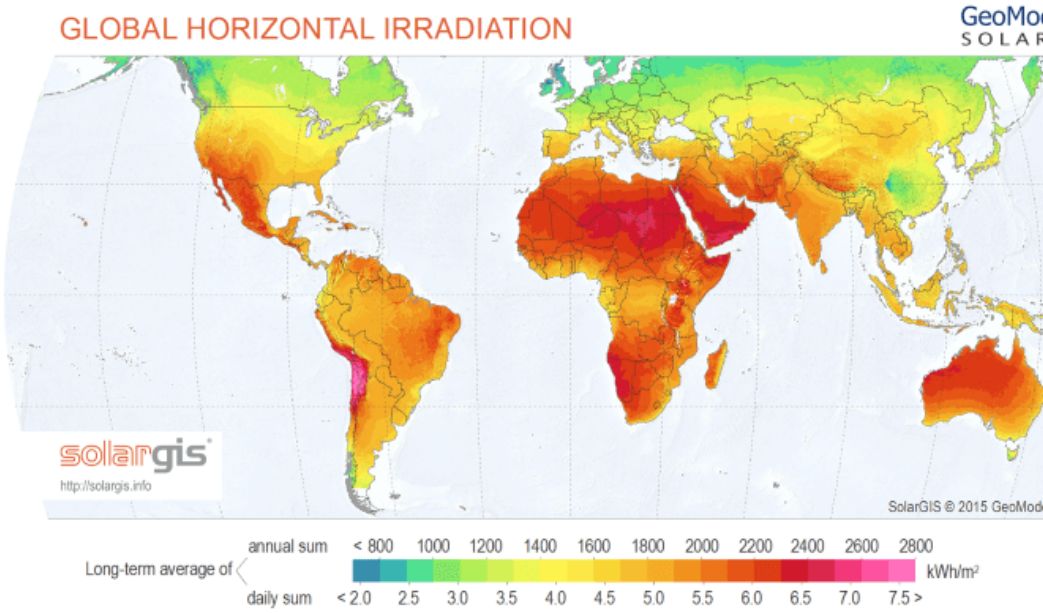
- Despite the PV solar considerable growth, there is a large **asymmetry** on the distribution of PV solar capacity, worldwide.
- **Economic efficiency** issues - Countries with greater PV solar capacity are not necessarily the ones with more potential (e.g. Brazil and Portugal).

Cumulative installed PV solar capacity by country (2015)



Source: IRENA (2017)

World Solar PV Energy Potential Maps

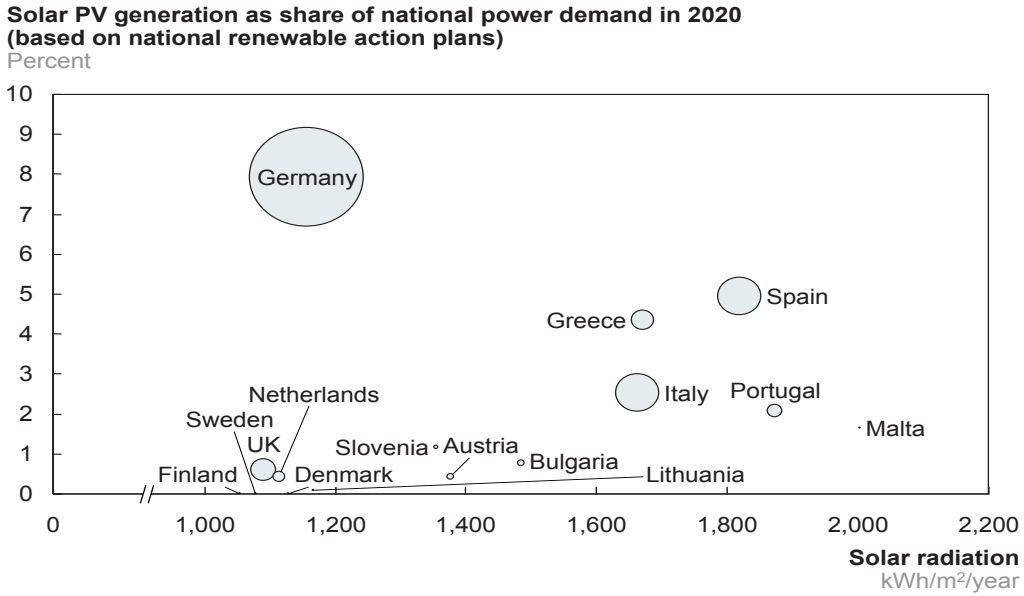


Source: British Business Energy (

Investment determinants
Solar PV

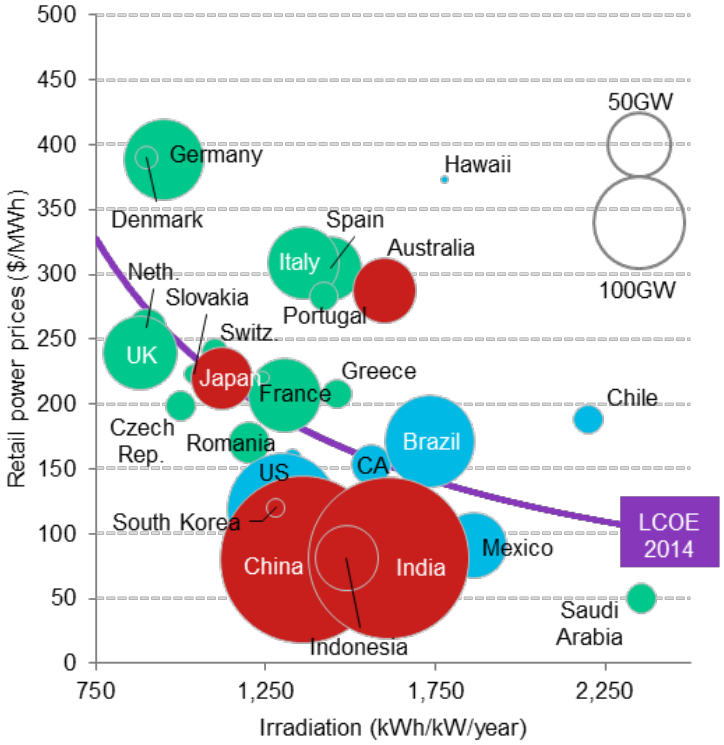
Current national renewable action plans neglect climate realities and lead to inefficient distribution of renewables, especially solar PV

Planned solar PV generation vs. climate realities, 2020



SOURCE: National renewable action plans submitted to EU Commission; McKinsey

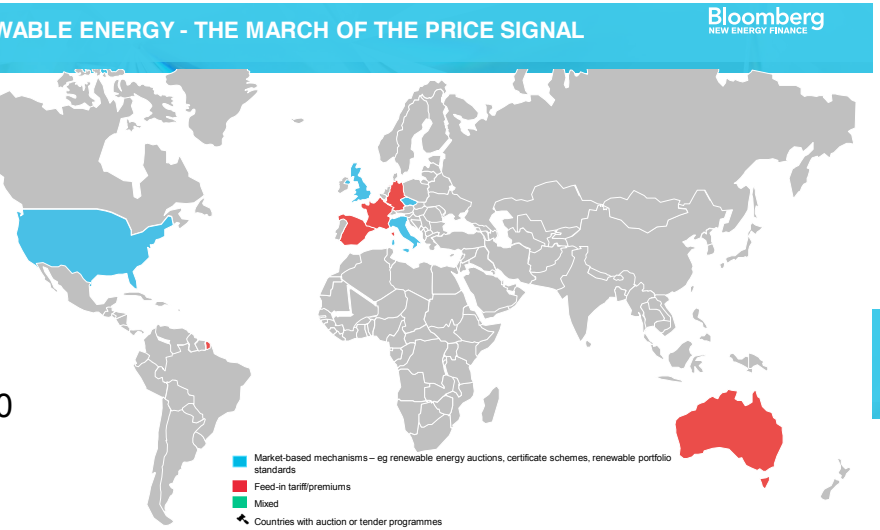
Source: McKinsey



Source: BNEF

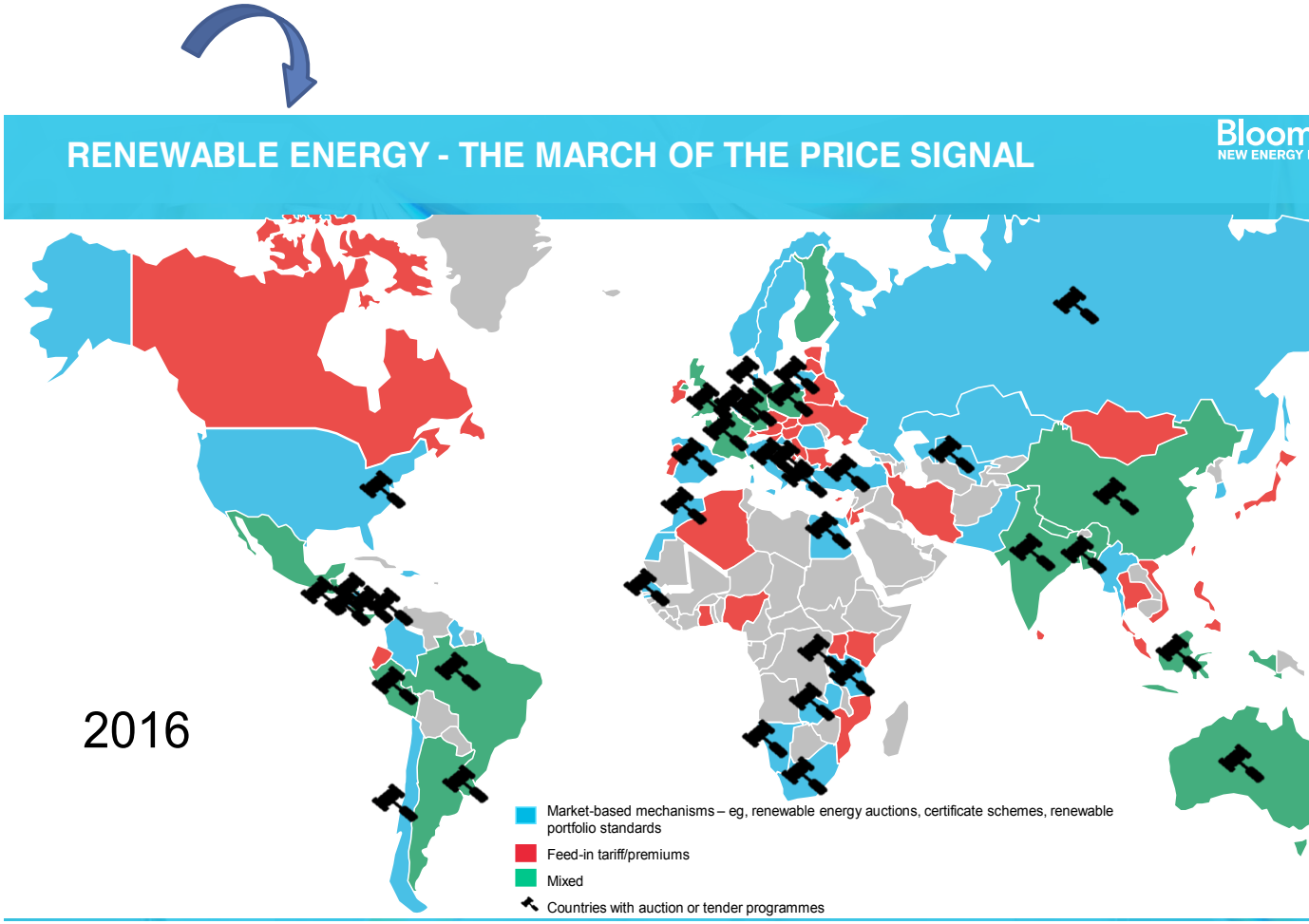
- Investment determinants: natural conditions, technical issues intermittency and DG integration), financial-economic considerations, environmental issues, **policy and regulatory framework…**

Photovoltaic Micro Generation Incentive Policies
A general overview



Source: BNEF

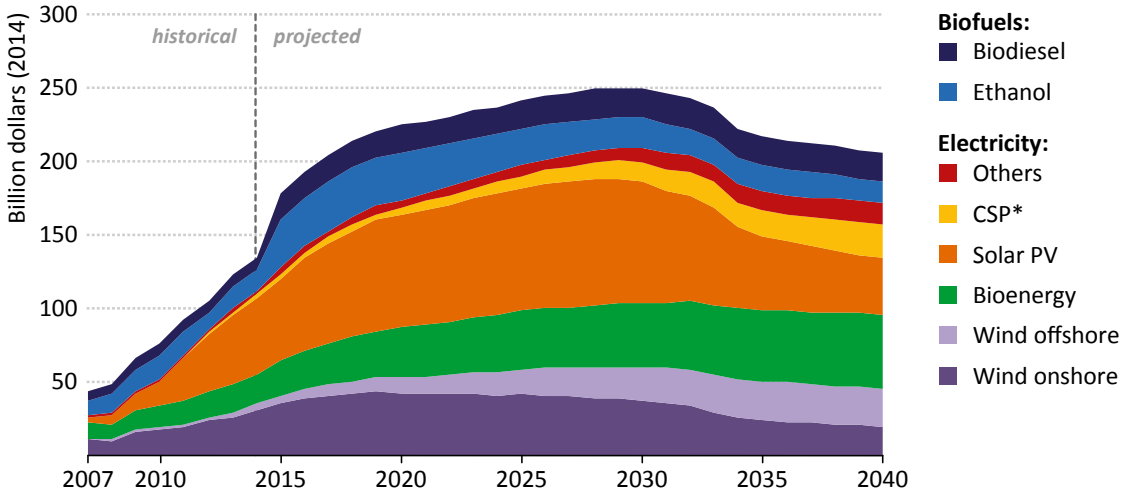
- RES at the core of energy policy (global scale)



Photovoltaic Micro Generation Incentive Policies
A general overview

- Solar PV at the heart of RES Incentive Policies
- Most prominent players: EU; US (?); China; India;

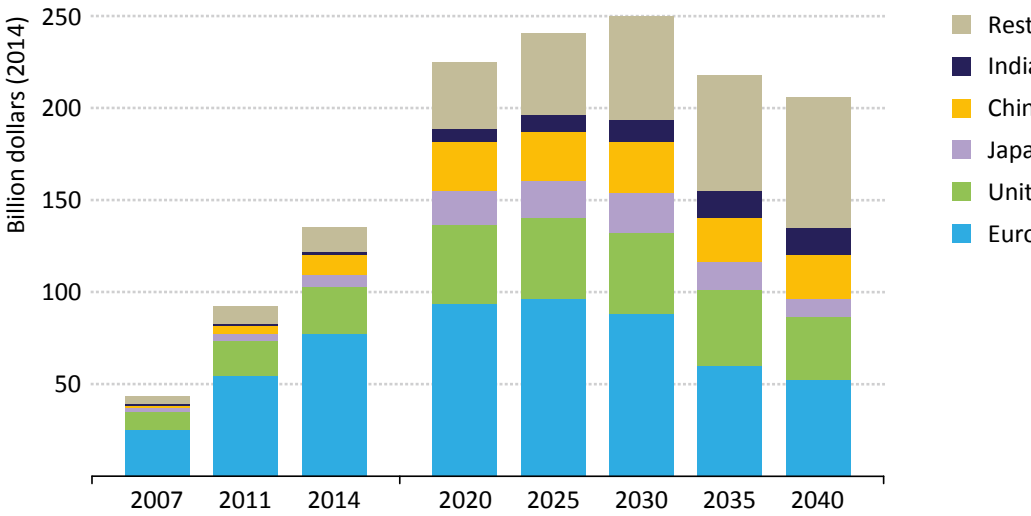
Subsidies by technology (New Policies Scenario)



*CSP = concentrating solar power.

Source: WEO (2015), IEA

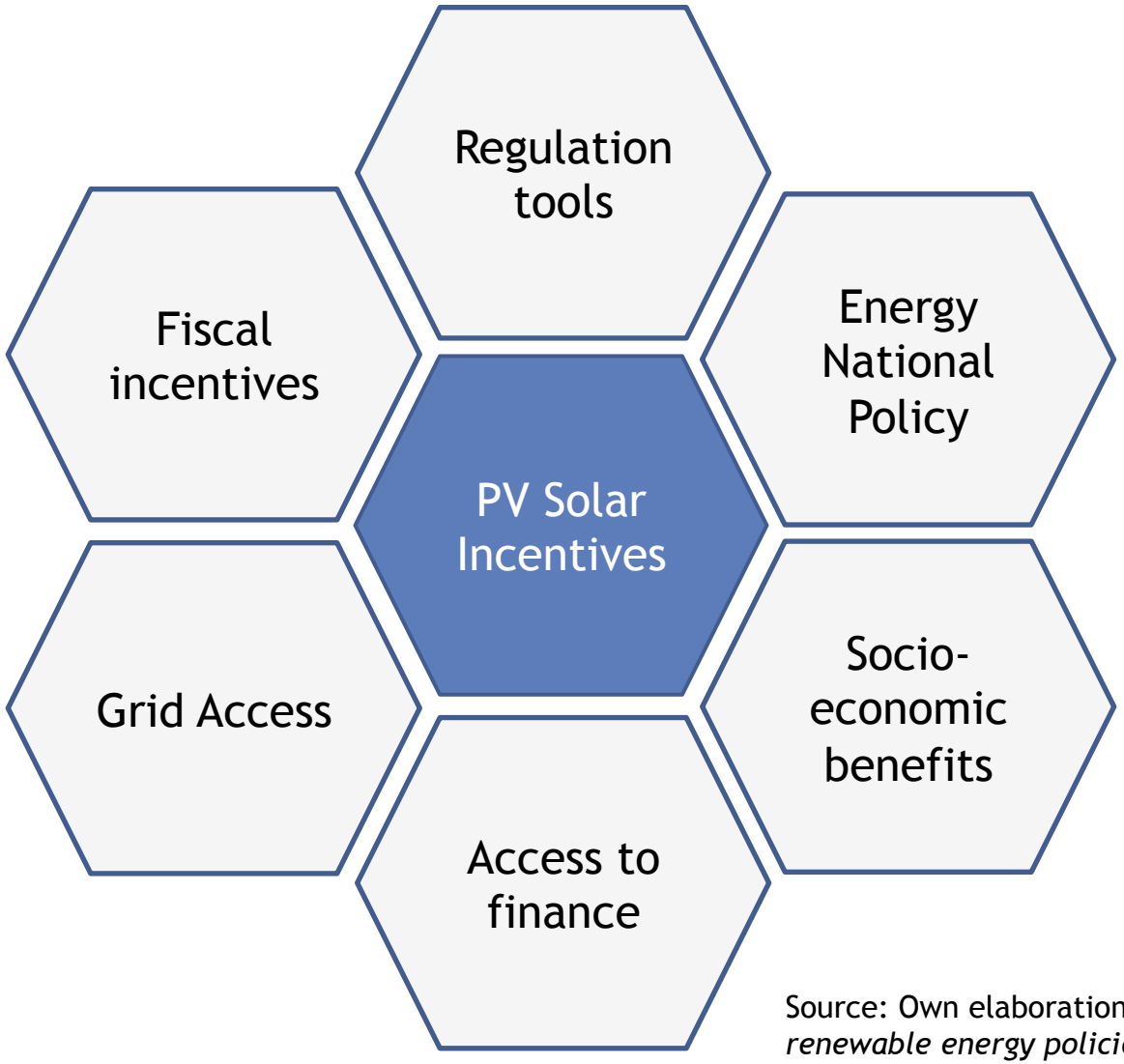
Subsidies by region (New Policies Scenario)



Source: WEO (2015), IEA

Photovoltaic Micro Generation Incentive Policies

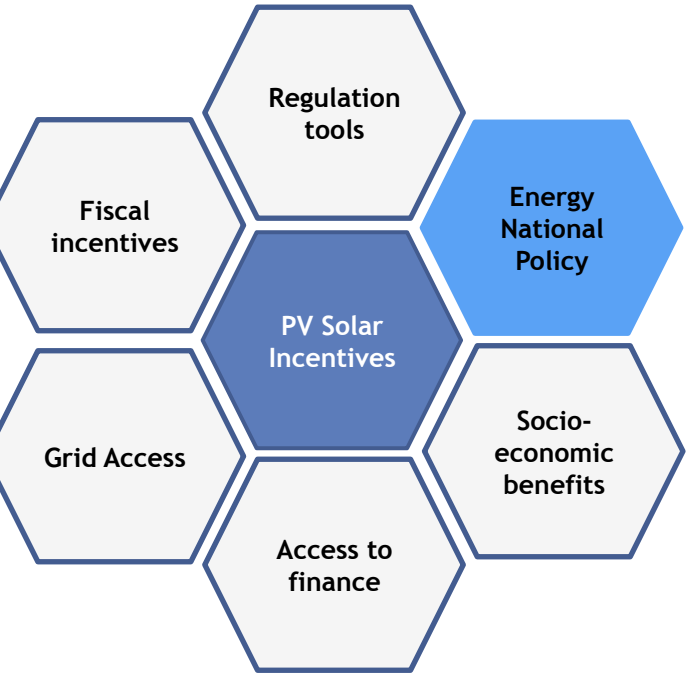
A general overview



Source: Own elaboration based on IRENA (2017), *Overview of the renewable energy policies and measures adopted*

Photovoltaic Micro Generation Incentive Policies

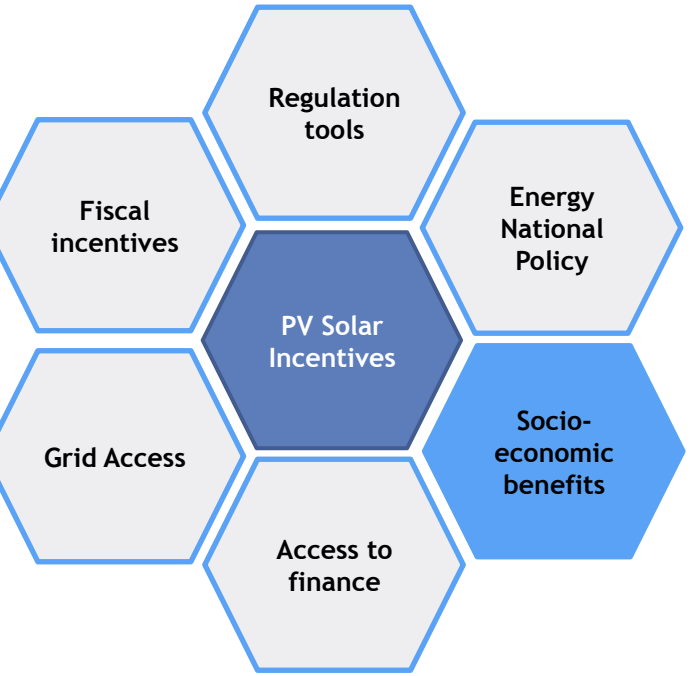
A general overview



- **National Policy**
  - Macro-level incentives (supply-side)
    - Ex. 1: RES national targets (Energy Policy)
    - Ex. 2: Solar PV national targets (Energy Policy)
    - Ex. 3 Technology specific Programs (Energy & Industrial Policy)

Photovoltaic Micro Generation Incentive Policies

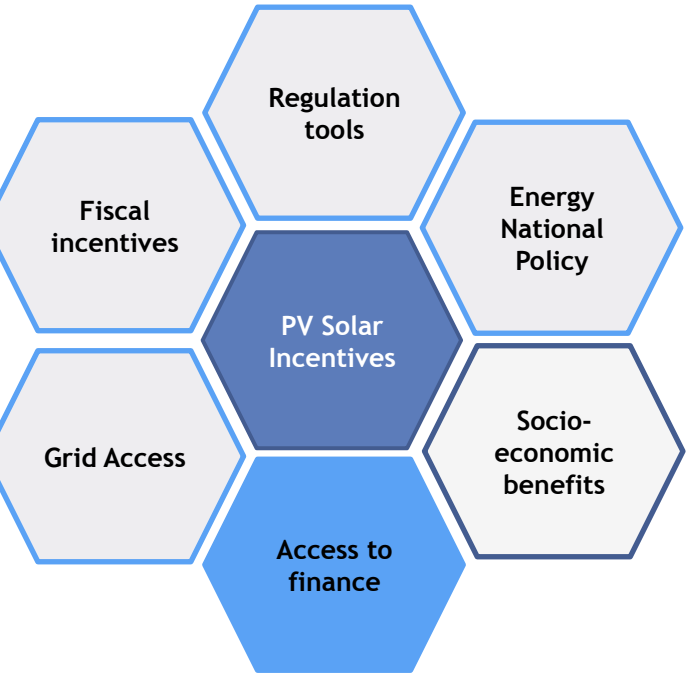
A general overview



- **Socio-economic benefits**
  - Local-content requirements
  - Human resources qualification programs
  - RES rural access programs/ energy poverty programs
  - Social requirements

Photovoltaic Micro Generation Incentive Policies

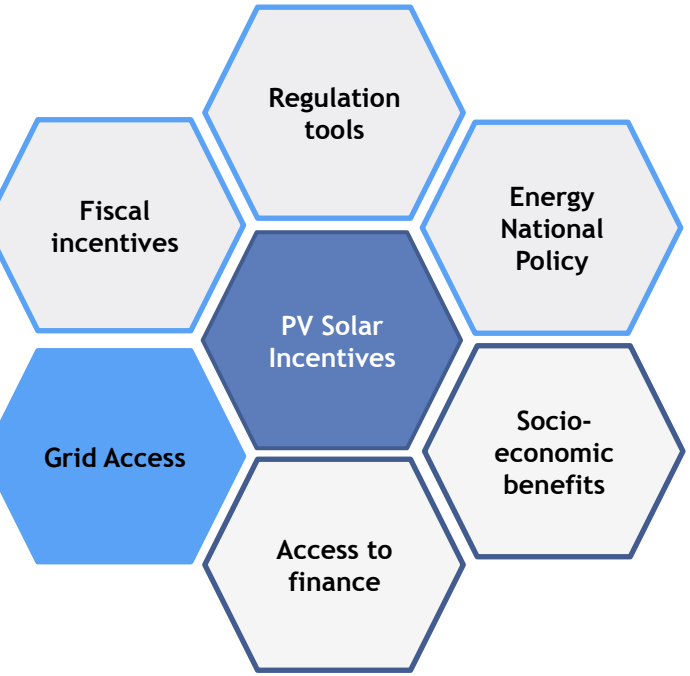
A general overview



- **Access to Finance**
  - Dedicated funds
  - Eligible funds
  - Guarantees
  - Pre-investment support
  - Direct funding
  - Currency hedging

Photovoltaic Micro Generation Incentive Policies

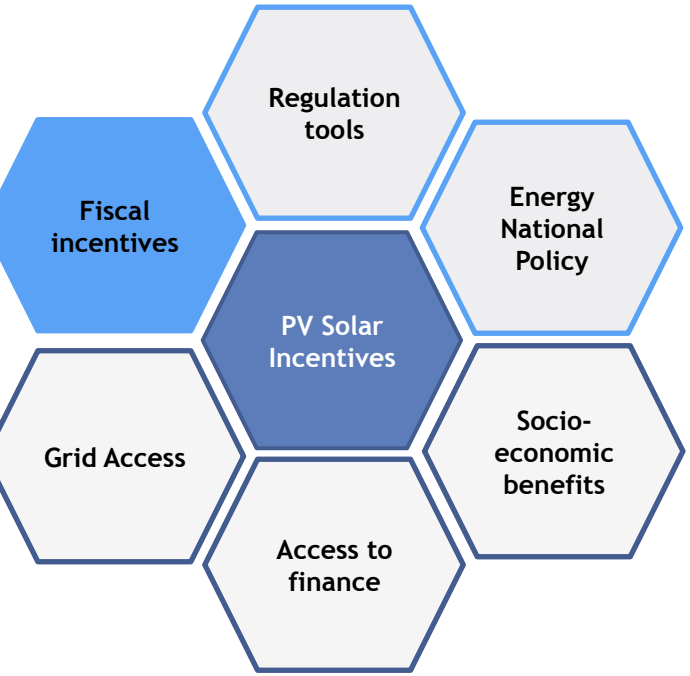
A general overview



- **Grid Access**
  - Transmission discount
  - Priority/ Dedicated transmission
  - Preferential dispatch...

Photovoltaic Micro Generation Incentive Policies

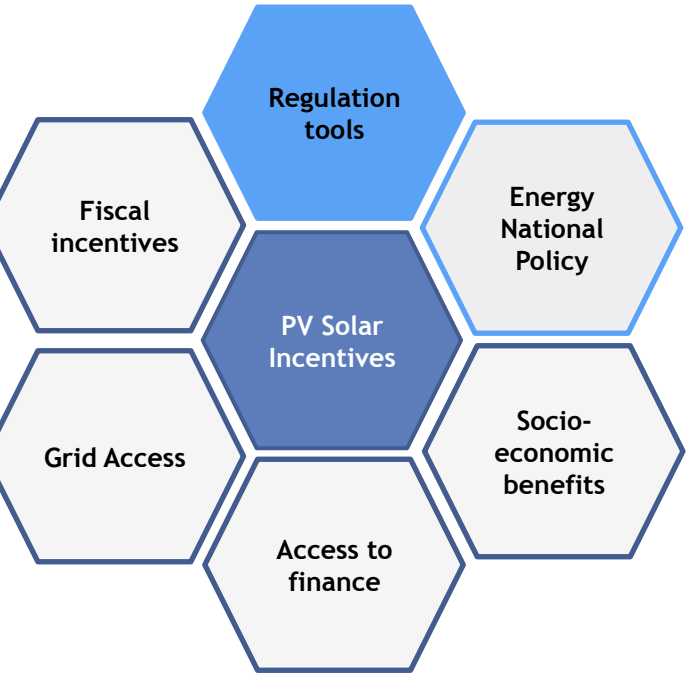
A general overview



- **Fiscal Incentives**
  - Tax exemption (E.g. VAT/ income tax; local taxes)
  - Carbon tax
  - Accelerated depreciation
  - Subsidies (e.g. Lump-sum subsidy or other tax benefits

Photovoltaic Micro Generation Incentive Policies

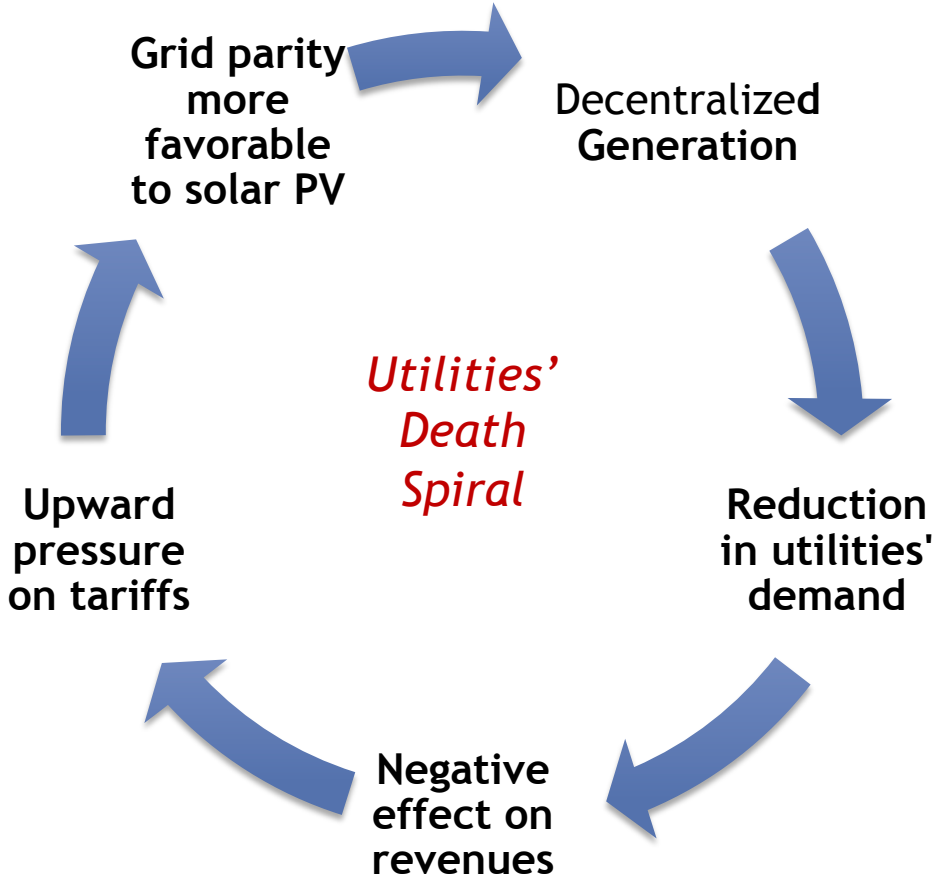
A general overview



- **Regulation Tools**
  - Supply & Demand-side mechanisms
  - Conventional and new tools (price mechanisms, mandat and licensing, certification systems)
    - Remuneration of energy surplus: Net metering; Net billing; Feed-in Tariffs; Feed-in Premium,...
    - Certificate system (QoS)
    - Licensing of new agents
    - Mandates to system operators...
  - **TRADE-OFF**
    - Utilities' financial stability versus solar PV incentive

Regulatory challenges
Balancing Solar PV incentives & Utilities financial viability

Decentralized PV Solar may threaten the utilities' conventional business model – "Death spira



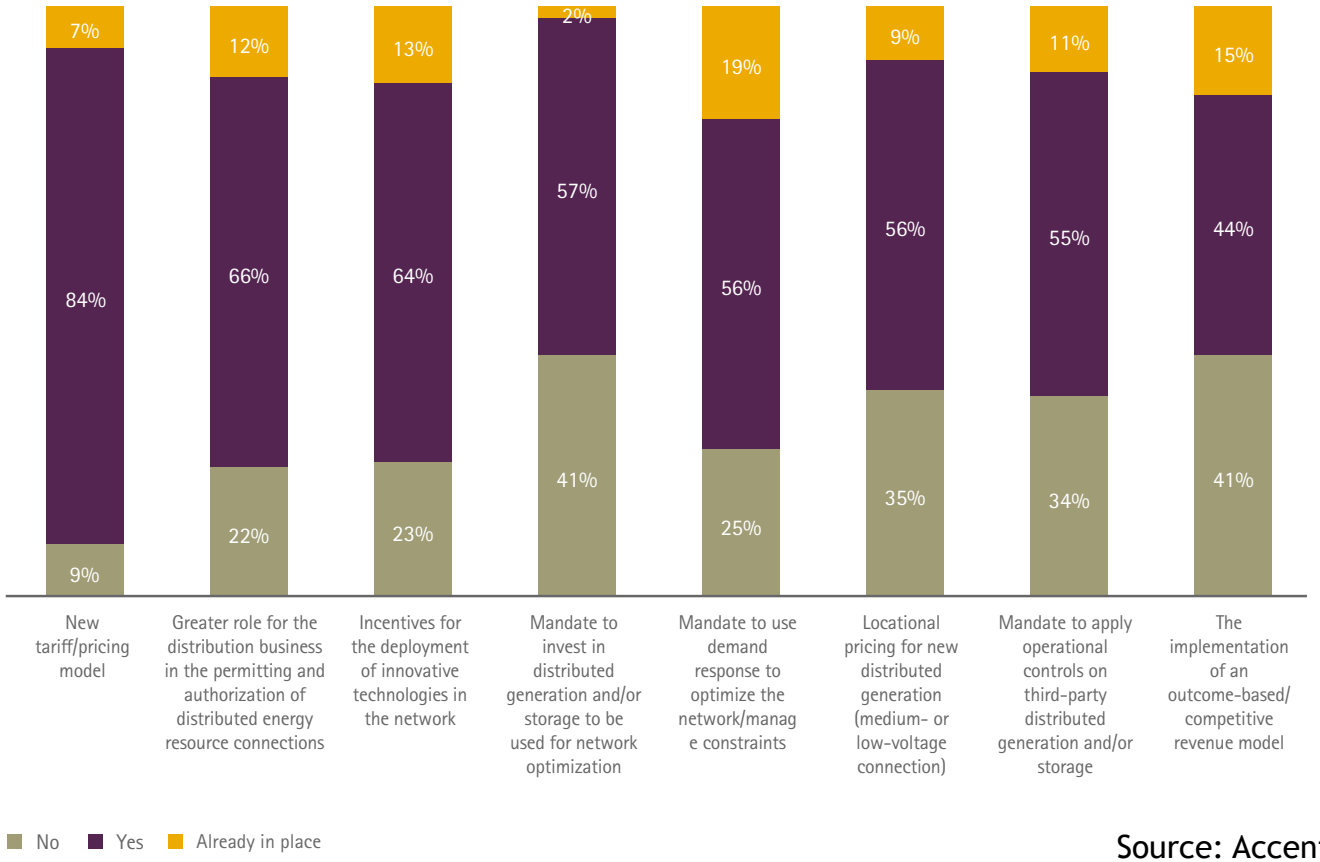
YET...

- Utilities' activity is increasingly challenging
  - Huge investment needs
  - Integration of DG production in the grid
  - Uncertain decentralized production & intermittent RES
  - Coordination among many heterogeneous ag
  - Grids' reliability & resilience
  - Facilitate coordination among many new heterogeneous problems

Regulatory challenges

Balancing Solar PV incentives & Utilities financial viability

Necessary regulatory challenges in the next 10 years according to utilities' managers:



Base: All respondents.

Source: Accenture's *Digitally Enabled Grid* research program, 2016 executive survey.

Utilities' major concern in the short-run - Tariff & pricing tools

1. *Re-designing conventional tools*
2. *New PV solar specific remuneration mechanisms*

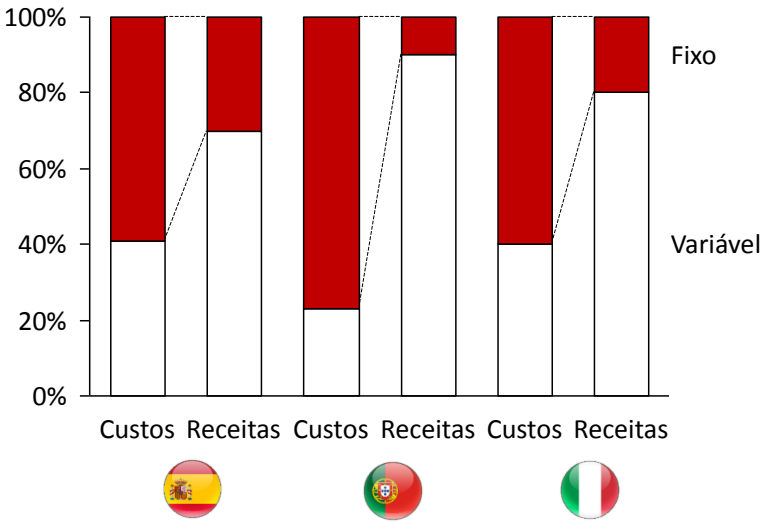
Source: Accenture (2016)

Regulatory challenges
Redesigning conventional tools: tariff structure

1. Tariff structure

- Towards non-linear **pricing schemes**:
  - Change the current (mostly) volumetric system
  - **Cost-reflective system** (that accounts for the different costs imposed on the network by different profiles of users)

Cost and Revenue structure in the Power Sector



1. Dados de Espanha referem-se a 2015 e são provenientes da BCG; Receitas para Portugal referem-se a todos os níveis de tensão; Dados de custos e receitas em Portugal referem-se a 2016; em Itália, a estrutura de receitas considera apenas clientes domésticos

Fonte: BCG, Eurelectric, Comissão Europeia, análise EDP

DPE - Direção de Planeamento Energético

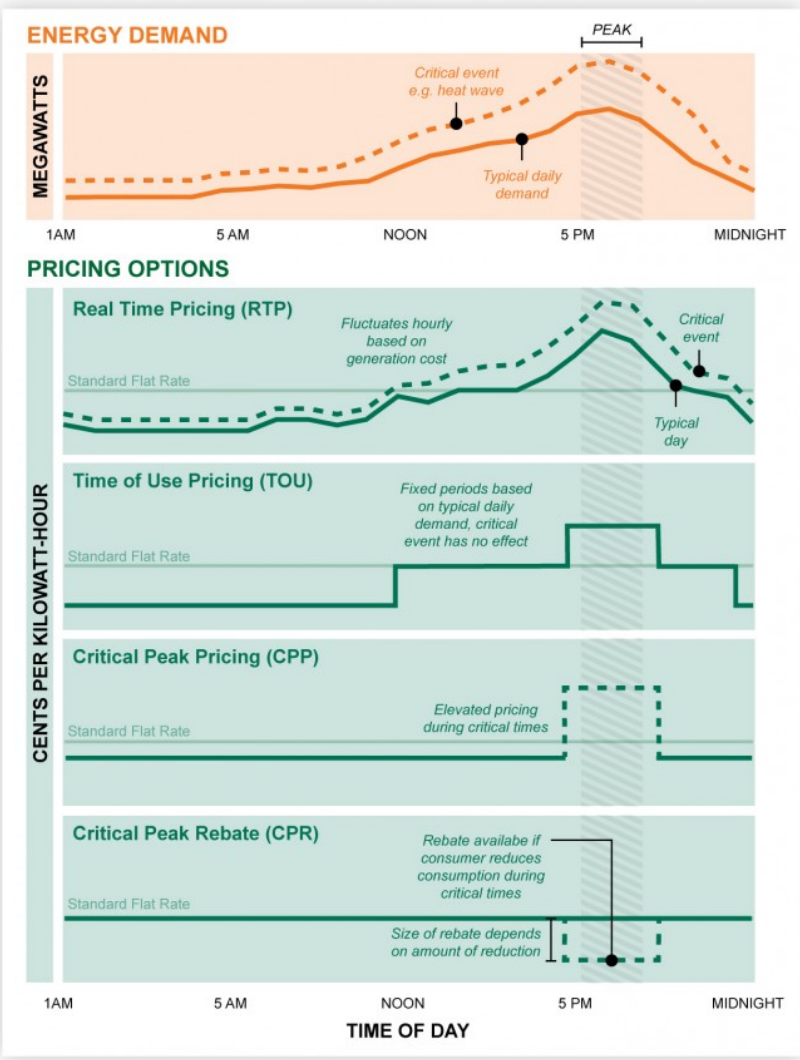
Source: EDP (2017)

Regulatory challenges

Redesigning conventional tools: tariff structure

1. Tariff structure
   - **Dynamic tariffs**
     - Critical peak pricing
     - Critical peak rebate
     - Real time pricing….

   - Cost-effectiveness
   - Complexity of the tariff design process
   - Sophisticated metering/ communication systems
   - Sophisticated and Tech-savvy consumers
   - Social impact



Source: Environmental Defense Fund (blog)

Regulatory challenges
Solar PV remuneration mechanisms

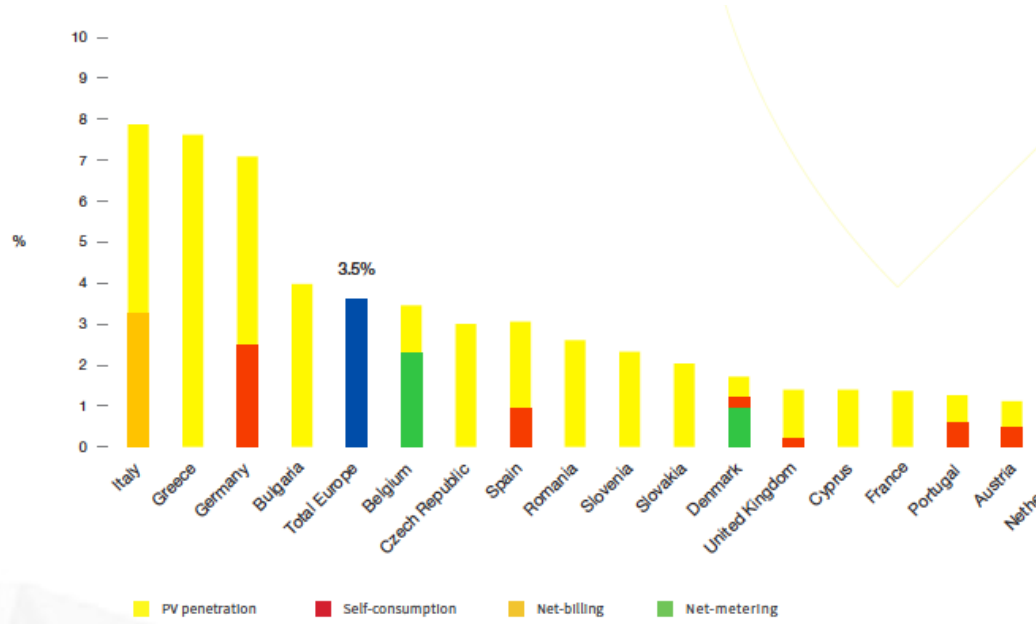
2. Alternative mechanisms to incentivize PV solar investment

- Feed-in tariffs/ Feed-in-Premium
  - High-remuneration scheme
  - No uncertainty – low risk
  - Market signals? Investment rationale? Cost-effectiveness

- Net metering (Brazilian & USA systems)
  - Grid acts as a cheap battery (very important for non-dispatchable energy sources)
  - Investment incentives coupled with consumption needs
  - No effective signals to reflect the grid congestion

- Net-billing
  - Market –price – coordination issues?
  - Administrative price – Avoid cost price? How to compute?

European PV Solar production and self-consumption in 20



Source: Solar Power Europe

ternational Experiences
comparative analysis

Main support mechanisms for RES in the power sector

Support method	Support mechanism	China	India	European Union	United States	Japan	Brazil	South Africa	Middle East
Providing additional revenue	Price premiums	●	●	⬤	●	●			
	Cash grants		●	●	⬤	●	●		⬤
	Green certificates		●	●	●				
	Net metering		●	⬤	⬤	●	●		●
Providing a guaranteed price	Feed-in tariffs	⬤	⬤	⬤	●	⬤			●
	Power purchase agreements		●	●	⬤		⬤	⬤	⬤
	Auction tenders		●	●	●		⬤	⬤	⬤
	Required share or amount*	⬤	●	●	⬤				
Reducing total costs	Tax credits or exemptions	⬤	●	●	⬤	●	●	●	●
	Preferential financing rates		⬤	●	●		●	●	●
	Accelerated depreciation**		⬤		●				

* Policies may specify a required share (e.g. renewables in total generation) or minimum amount of installed capacity or generation. **Accelerated depreciation lowers total discounted costs by delaying the tax burden.

Note: ⬤ = primary driver of renewables deployment; ● = secondary driver of renewables deployment.

Sources: IEA/IRENA Joint Policies and Measures database; IEA analysis.

Solar PV:

- FIT
- Net metering

Source: WEO (2015), IEA

International Experiences
A comparative analysis

Country	Policy / Regulatory Target	Supply Side Drivers	Demand Side Drivers	Fiscal Incentives	Remarks
Germany	Yes	Feed-in tariff; Competitive bidding	Mandatory interconnection	Capital subsidy	Grid parity achieved, capital subsidy now provided for energy storage.
China	Yes	Feed-in tariff; Competitive bidding		Capital subsidy	
Japan	Yes	Feed-in tariff	Net metering	Capital subsidy	Shifted from net to gross metering in 2009.
Italy	Yes	Feed-in tariff			
United States	Yes	Investment tax credit (ITC)	Renewable Portfolio Standards (RPS); Net metering	Capital subsidy; Tax credits	A few states have gross metering in place
France	Yes	Feed-in tariff			
Spain	Yes	Feed-in tariff		Capital subsidy	New projects not eligible for FiT from 2012,

Country	Policy / Regulatory Target	Supply Side Drivers	Demand Side Drivers	Fiscal Incentives	R
United Kingdom	Yes	Feed-in tariff	Net metering; Renewable Obligation (RO)	Capital subsidy	
Australia	Yes	Feed-in tariff	Net metering	Capital subsidy	
India	Yes	Feed-in tariff; Competitive bidding	Renewable Portfolio Obligation (RPO); Renewable Energy Credits (REC)	Capital subsidy; Viability gap funding; Accelerated depreciation; Tax holidays; Priority Sector Lending; Concessional Duties	C bi ta pr in ra F

Source: World Energy Council (2016)

International Experiences
A comparative analysis

- Self-consumption schemes

Member State	Remuneration for self-consumed or surplus electricity sold to the grid	Grid and system cost contribution
Germany	**< 90% production: applicable FIT or FIP rate** **> 90% production, either**: a) average **spot market price for solar energy** (4-5 €ct/kWh) b) **income from electricity sale** (market or PPA) plus management premium of 1.2 €ct/kWh (decreasing to 0.7 €ct /kWh by 2015) PV system > 100 kWp (from 2016): market price	Before 01/08/2014 : exemptedAfter 01/08/2014 : exempted if < 10 kWp and < 10 MWh/year If >10 kWp or > 10 MWh/y : subject to reduced RES-surcharge: 30% by end 2015 35% by end 2016: 40% by end 2017
Italy	**<20 MWe: private purchase agreement (PPA)**	**< 20kW, exempted from grid and system costs** **20-200kW partially exempted >200kW exempted only from system costs**
Portugal	Average Iberian electricity market price minus 10%	If SC systems capacity <1% of total power capacity (TPC): SC exempted >1% and <3%, SC pays 30% grid fees, >3%, SC pays 50% grid fees
Spain	Up to 100 kWp, regulation still to be adopted	
United Kingdom	PV and wind systems < 50 kWp: generation tariff + export premium of 4.77p £/kWh for up to 50% of excess power fed into the grid > 50 kWp and < 5 MWp : Feed-in-tariff	Exempted

Source: European Commission (2015), Best practices on Renewable Energy Self-consumptio

Regulatory challenges
Redesigning *old* tools and creating *new* ones

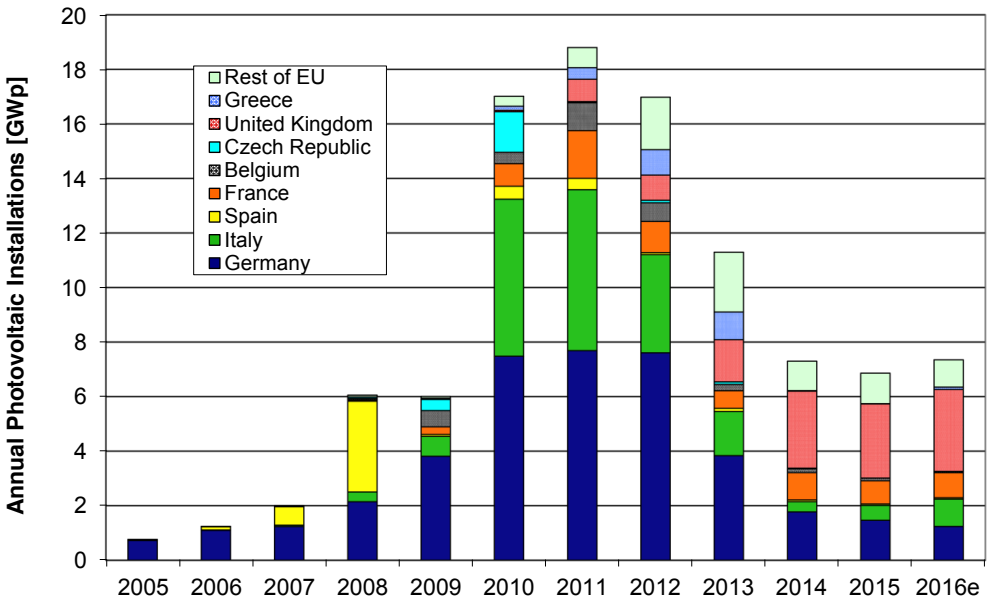
- Net Metering Systems

Member State	Eligibility requirements	Netting period	Electricity compensation	Capacity cap
Cyprus	Household and municipal PV systems < 3 kW	Yearly	- Retail price - Subsidy of 900 Euro/kW for vulnerable consumers	10 MW per yea
Denmark	Non-commercial RES systems <6 kW	Hourly	Retail price	N/A
Greece	PV systems <20 kWp	Yearly	Retail price	N/A
Italy	RES systems: <200kW (after 31/12/2007) <500kW (after 1/01/2015)	Yearly	Net-billing system: remuneration based on time-of-use price	N/A
Poland	RES systems <40kW	Half- yearly	< 10 kW : Feed-in tariffs (15 years): ~ €0.18 per kWh per below 3 kW; €0.11 per kWh for below 10 kW projects. > 10 kW and < 40 kW: 100% of the average sales price of electric energy on the competitive market in the preceding quarter	300 MW for systems <3kW 500 MW for systems <10 k
Sweden	RES systems connection size <100A	Yearly	Tax reduction: 0,60 SEK (~6 €cent) per kWh of RES reduction, but at least an equal amount of electricity should be bought from the grid. Tax reduction for delivery up to 30 MWh/y	For up to 3000 kWh, or 18000 SEK per year

Source: European Commission (2015), Best practices on Renewable Energy Self-consumptio

International Experiences
A comparative analysis: the European Case

Annual installations in EU and candidate countries



Source: European Commission (2016)

- In 2011, there is a peak in new installations
- Support schemes not always appropriate:

"Some Member States had introduced support schemes wh
were not designed to ***react fast enough to the very rapi***
growing market *and this led to unsustainable local marke*
growth rates. To counteract this, ***unpredictable and freq***
changes in the support schemes*, as well as* ***legal***
requirements*, led to installation peaks before the annou*
deadlines and ***high uncertainty for potential investors****.*
number of retroactive changes have further decreased
investment confidence*."*

Source: European Commission (2016)

International Experiences

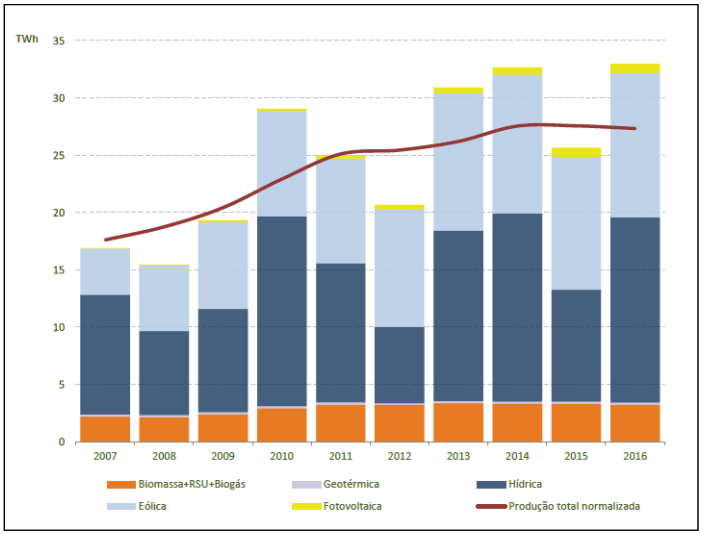
A comparative analysis: the European Case

- European Commission (2015) Recommendations:
  - Preference for self-consumption schemes over net-metering mechanisms
  - Limit net-metering to phase-in periods, allowing for regular revisions
  - Avoidance of retrospective changes in project's return and risks
  - Phasing in of short-term market exposure by valuing surplus at wholesale electricity price
  - Monitor market developments in order to assure cost-effectiveness and avoid over-compensation (and cross subsidization)

International Experiences

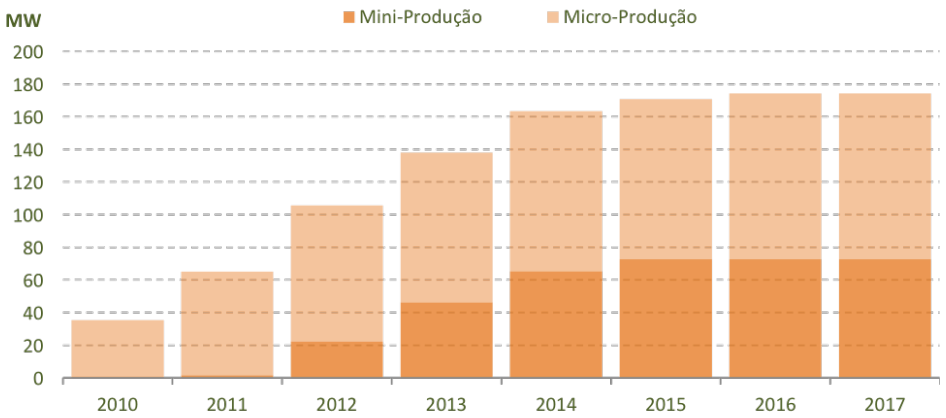
A comparative analysis: the Portuguese Case

Renewable Energy Production in Portugal



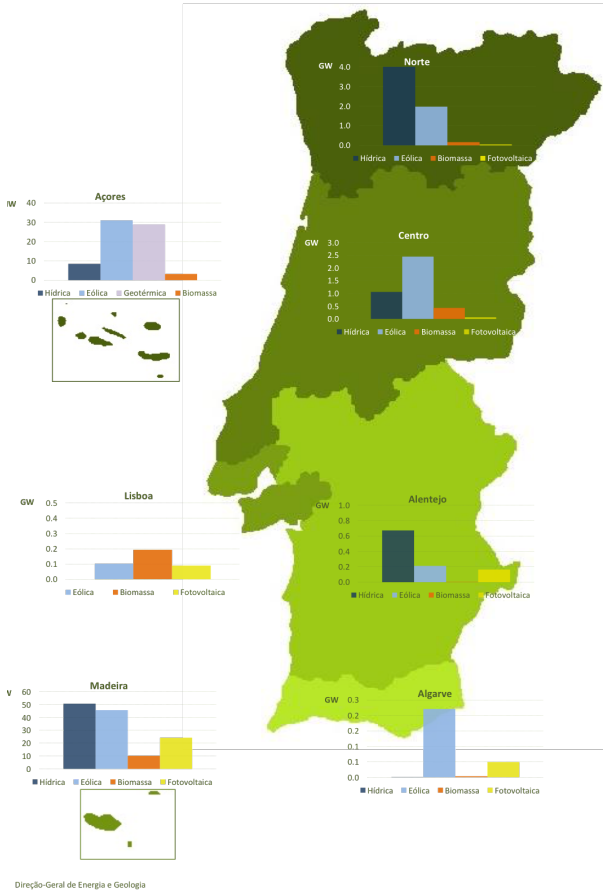
Source: DGEG (2016)

Mini and Micro generation



Source: DGEG (2016)

Installed capacity (per RES)



Source: DGEG (2016)

International Experiences

A comparative analysis: the Portuguese Case

- **Utility-scale projects (e.g Amareleja plant)**

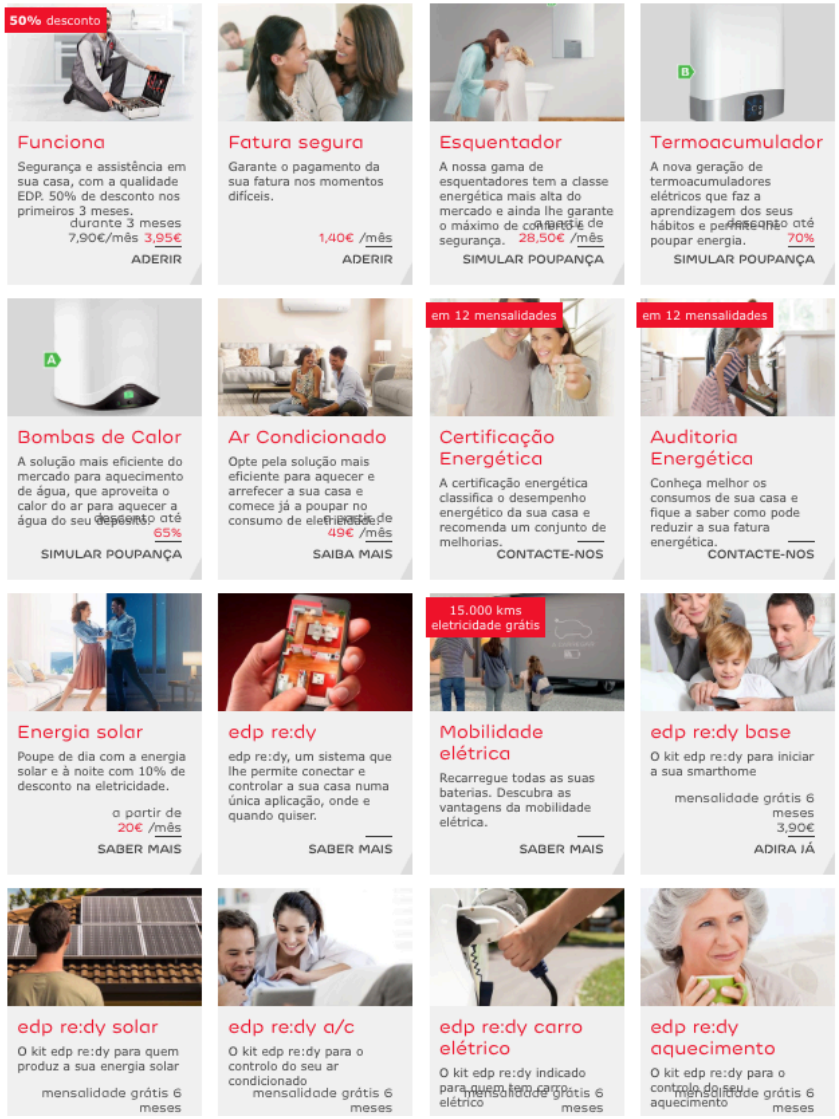
- **2015** – Installation of approx. 3500 self-consumption generation units
- **2016** – Installation of 6.067 self-consumption generation units
- Cumulative capacity **50.393 kW**

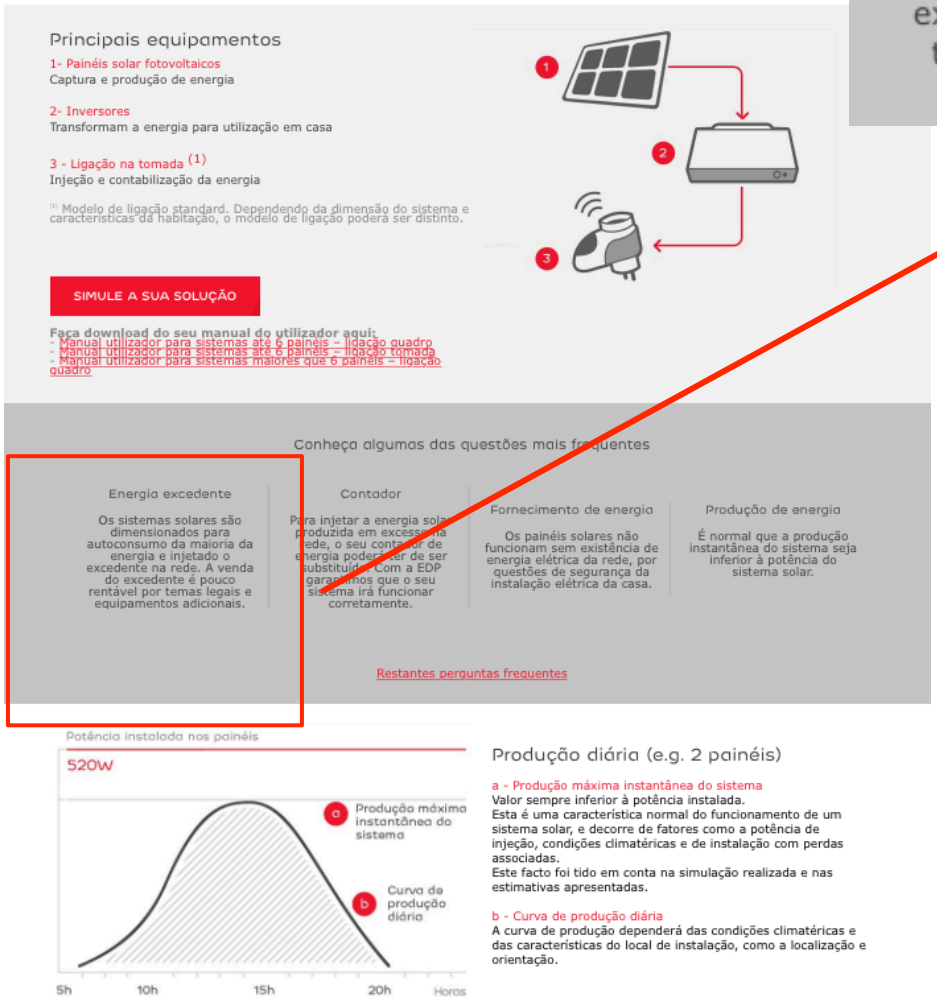
"Portugal vai ter a maior central solar da Europa sem tarifa subsidiada
A nova central solar vai ficar localizada em Alcoutim, no Algarve."

in Jornal de Negócios, Feb. 2017 (200 million Euros investment (Chinese investment) – Installed capacity 221 MW

International Experiences

A comparative analysis: the Portuguese Case





Produção diária (e.g. 2 painéis)

a - Produção máxima instantânea do sistema
Valor sempre inferior à potência instalada.
Esta é uma característica normal do funcionamento de um sistema solar, e decorre de fatores como a potência de injeção, condições climatéricas e de instalação com perdas associadas.
Este facto foi tido em conta na simulação realizada e nas estimativas apresentadas.

b - Curva de produção diária
A curva de produção dependerá das condições climatéricas e das características do local de instalação, como a localização e orientação.

Energia excedente

Os sistemas solares são dimensionados para autoconsum
maioria da energia e injetado
excedente na rede. A venda
excedente é pouco rentável p
temas legais e equipamento
adicionais.

International Experiences

A comparative analysis: the Portuguese Case

	UPAC (Self consumption)	UPP (Small decentralized producers)
Production activity	Production unit designed for self-consumption. Energy instantaneous surplus may be injected to the grid and sold to last resource retailer (CUR) if power <1MW (otherwise bilateral agreements)	All the energy is injected in the grid but productio indexed to the electricity consumption of the associated consumption installation (annual production <2x installation consumption)
Remuneration scheme & System Compensation	Market price-10% (injection costs) Fórmula de remuneração do excedente injetado na RESP: $R_{UPAC,m} = E_{fornecida,\ m} \times OMIE_m \times 0,9$ If UPAC installed acumulated power> 1% and <3% of installe power of the SEN=>30% "Custos de Interesse Económico Geral, if >3%=>50% CIEG	Auction system (bidders offer discounts wrt the reference tariffs, administratively defined)- 15 yea contracts E.g. - catgory I the reference tariff is 95 Euros/MW (100 Euros for category II and 105 Euros for Cargor
Registration & Power limits	Power<200W – no register; 200<power<1,5kW – communication only (simplified registration); >1MW (licensing requirements); Mandatory metering (except power < 1,5 kW)	Power<min [contracted power of the consumption installation, 250 kW] - quota 20 MW; Registration & Certification); Mandatory metering

Conclusions

Solar PV has extensively grown in recent years and it is expected to continue to grow in the future

- New electricity paradigm: more sustainable, more decentralized, storage, demand-side response, electric mobility, …
- Utility-scale projects & Mini and Micro-generation projects growing side-by-side

Solar PV Micro-generation incentives are key to phase in DG

- In some countries (e.g. Portugal), investment incentives have slowed down in recent years, despite the natural potential…
- Business model innovation is needed in order improve the expected returns of investments in this field (both for new players and conventional utilities)
  - Multi-disciplinary approach to build new service-based products
  - Attractive financing schemes
  - Solar Community models
- Regulatory innovation is key to allow a smooth transition to the new electricity paradigm.

PHOTOVOLTAIC MICRO GENERATION INCENTIVE POLICIES

THANK YOU!!!

OBRIGADA!!!!

jresende@fep.up.pt

U.PORTO
FEP FACULDADE DE ECONOMIA UNIVERSIDADE DO PORTO

cef.up
Centro de Economia e Finanças da UP
Center for Economics and Finance at UP

GESEL
Grupo de Estudos do Setor Elétrico
UFRJ