Development of Rooftop PV programmes using the EU experience:

A case study from the EaP region and the applicability in GCC region

Renewables: A Key Driver for Clean Energy Transition Solar PV Roof Top Workshop & Training

Muscat, Oman, 13-14 December 2017

Kantor Management Consultants

In partnership with:

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HiQSTEP

High Quality Studies for the Eastern Partnership

An EU-funded Project

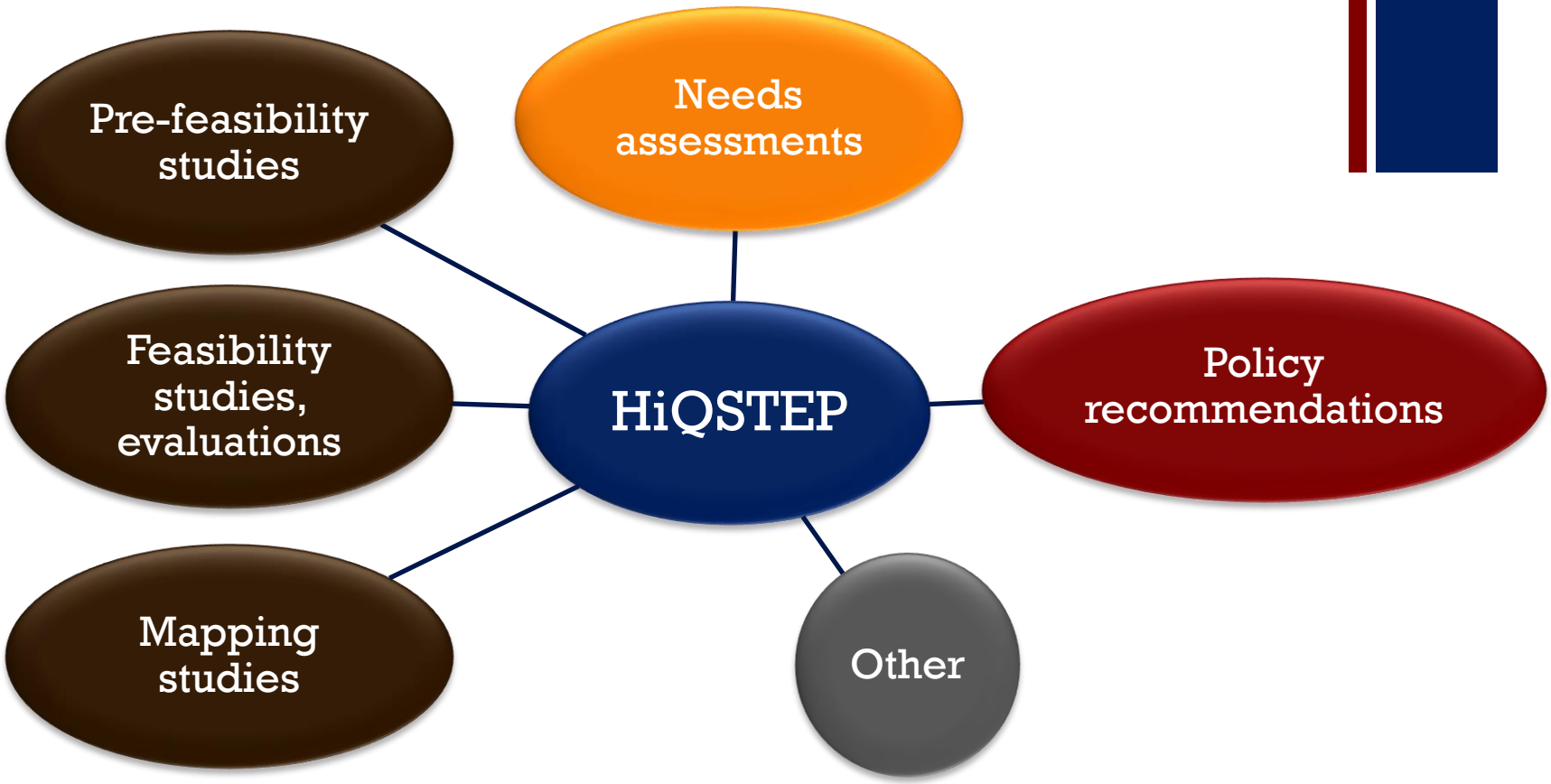
Out topic as a riddle:

- What is:
  - Renewable & abundant
  - Technologically mature
  - Closely situated to demand
  - Easily integrated to the built environment
  - Silent
  - Almost maintenance free

Agenda

- Background on energy cooperation and the HiQSTEP project
- The results of our EU practices review
- Benchmarking the status in third countries
- A city-level technical potential assessment
- CBA and scenario building
- Can this work out in GCC region?
- Questions and feedback

EU HiQSTEP Project Objective



- The objective of the Project is to provide **short-term expertise** which can be mobilised at short notice in order to carry out different types of studies
- The Project started on 13 January **2014**. It runs for 4 years (January **2018**).
- The **Budget is 5M EUR** and it is funded by the EU (DG NEAR)

The EaP Countries Question(s)

- **Does it make sense for a country to go forward with rooftop PV?**
  - How much should we develop?
  - How we may possibly develop a "programme"
  - What are the costs?
  - What are the benefits?

http://www.consilium.europa.eu/en/meetings/international-summit/2017/11/24/

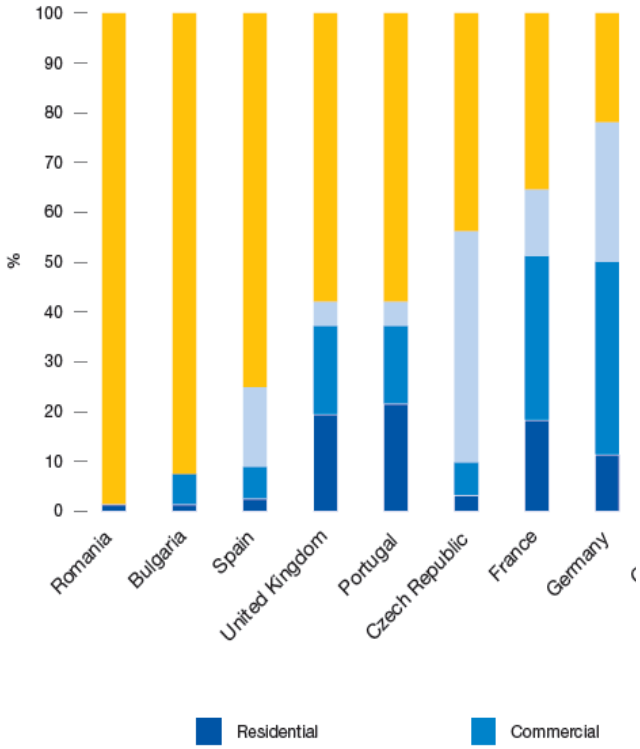
The answer: A Building PV regional study

HiQSTEP Building Solar Power Study

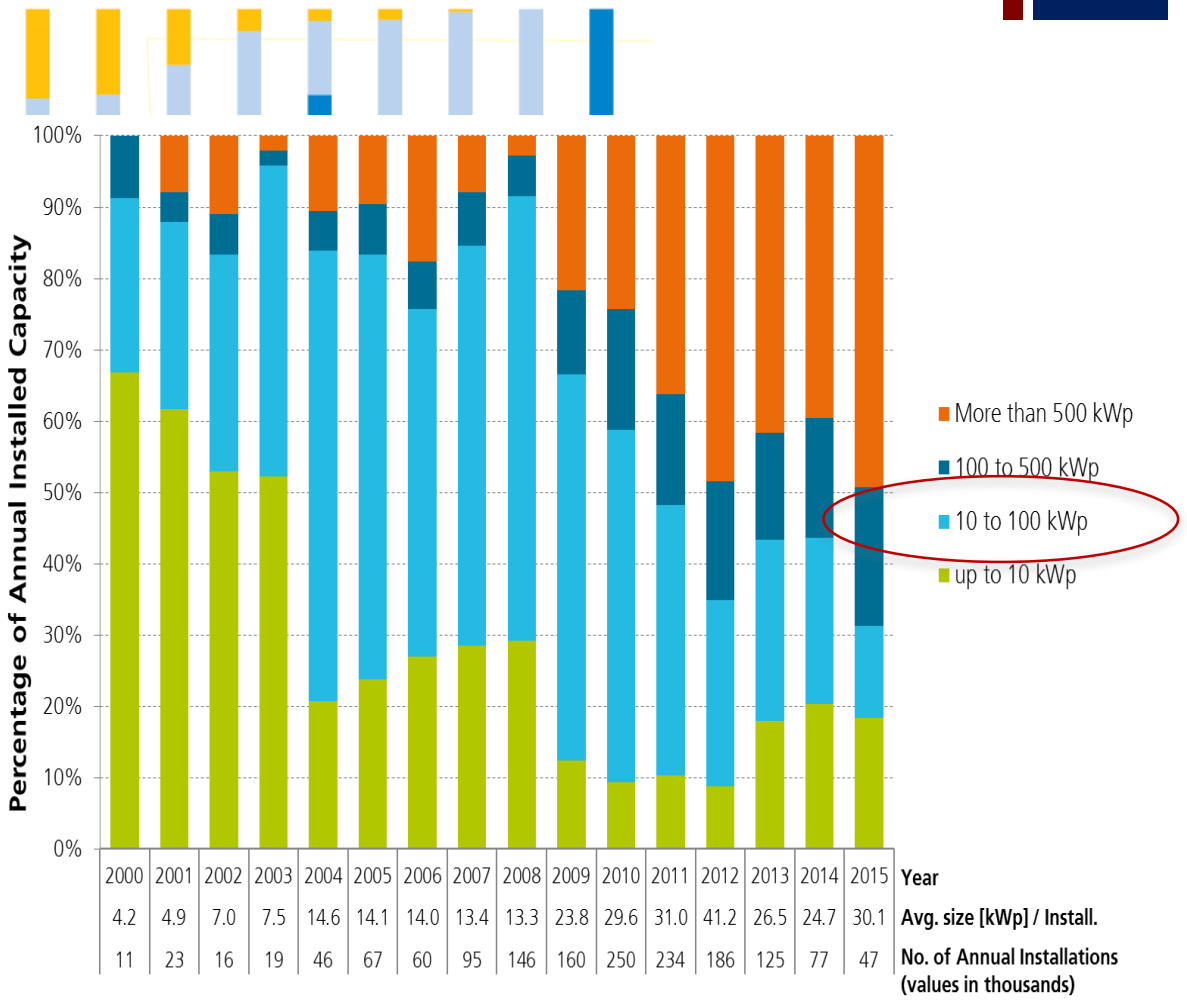
Component 1: Review of EU practices

Component 1: Key Results

The pattern and trend of PV installation in EU



Source: SPE, Global Market Outlook 2016



Source: www.ise.fraunhofer.de

Component 1: Key Results

Prosumer Models (in terms of production based support scheme characteristics)

		Production based: classical "FiT" - style. No self-consumption	Self-consumption with constraints	Self-consumption + FiT	Net-billing	Net-metering	Self-consumption + Premium
1	Right to self-consume	Not Allowed	Yes	Yes	Yes	Yes	Yes
2	Revenues from self-consumed PV	N/A	Savings on the electricity bill	Savings on the electricity bill	Netting of production revenues and consumption costs	Savings on the electricity bill	Savings on the electricity bill
	Additional revenues on self-consumed PV	N/A	No	No	No	No	Premium
3	Charges to finance T&D cost	N/A	Yes	No	No	No	No
4	Revenues from excess electricity	N/A	Zero	< retail price	<= retail price	= retail price	> retail price
5	Maximum timeframe for compensation	N/A	Real-time	Real-time	Long period	Long period	Real time

(Source:IEA-PVPS, 2016)

Component 1: Key Results

Business Models Taxonomy

Solar PV Ownership Models

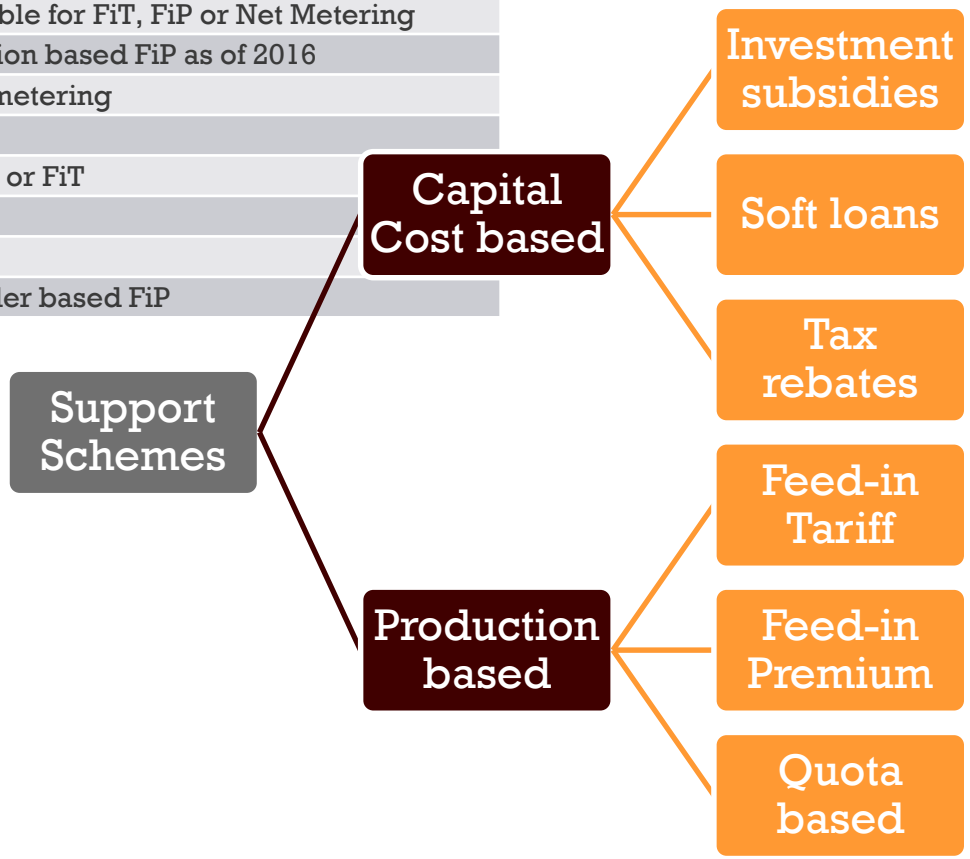
- **Third Party Ownership (TPO)**
  - PPA
  - Lease
- **Direct Ownership**
  - PPA, Net metering, etc.

Component 1: Key Results

Support Schemes & their taxonomy

Member State	PV Category	Main Support Scheme
Germany	P<100kW	FiT
	P>100kW	Auction based FiP
Greece	Rooftop PV (P<10kW)	FiT or Net Metering
	Gr. Mounted (P<500kW)	Eligible for FiT, FiP or Net Metering
	Gr. Mounted (P>500kW)	Auction based FiP as of 2016
IT	P<500kW	Net metering
UK	P<50kW	FiT
	50kW<P<5MW	ROO or FiT
	P>5MW	CfD
PT	P<500kW	FiT
	P>500kW	Tender based FiP

- Great plurality in the EU
- Emerged as part of the overall energy market organisation
- Can co-exist for a certain period
- Must be compliant to EU legislation (including state-aid regulations)



Component 1: Key Results

Funding of support schemes

	No support schemes in place	General taxation paid by all citizens	Through specific non-tax levies like PSOs paid by all customers via electricity bills	Other
Austria	x			
Belgium		x		
Czech Republic				x
Denmark			x	
Estonia	x			
Finland				x
France		x		
Germany			x	
Greece				x
Hungary				x
Ireland		x		
Italy				x
Lithuania				x
Luxembourg		x	x	
Netherlands			x	
Norway			x	
Poland	x			
Portugal		x		
Romania	x			
Spain		x		
Sweden	x			
UK		x		

(Source:CEER, 2015)

HiQSTEP Building Solar Power Study

Component 2: Review of EaP Countries practices

Component 2: EaP counties status quo

Contents of the Component 2 report:

An overview of building PV (common & national specificities)

6 Specific Country Profiles

Conclusions and country recommendations

Review criteria provided by C1

An overview of the criteria (1/2)

Electricity Market

- Liberalised & liquid ?
- Vertically integrated ?

RES Law

- Targets (by year, by technology)
- Institutional setting

2ndary framework

- RES support scheme
- Cost coverage & distribution

An overview of the criteria (2/2)

Licenses & Permits

- Generation, Construction
- Environmental (Exemptions?)

Connection & Access

- Simplified connection procedure
- Access (curtailment rules)

Ownership & finance

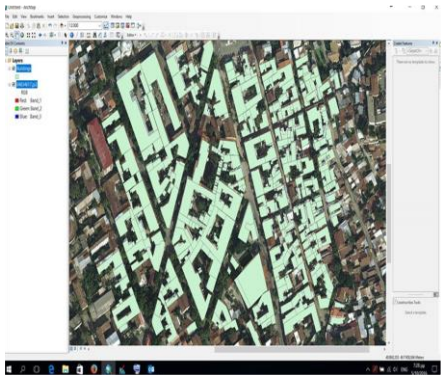
- Business model
- Programme/Project finance

HiQSTEP Building Solar Power Study

Component 3: Surface-based building-PV potential assessment

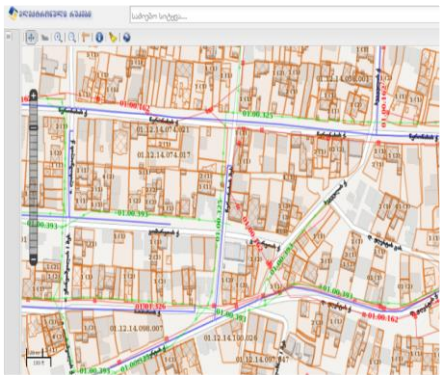
Component 3: Methodology in a nutshell - 1

Assessment of existing GIS data



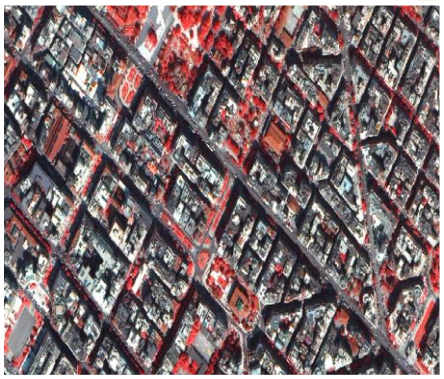
Existing GIS data

Option-1



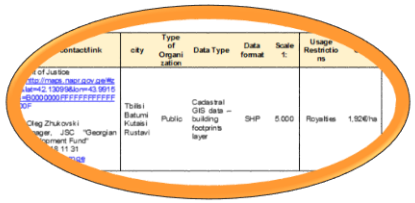
Existing Cadastral data

Option-2



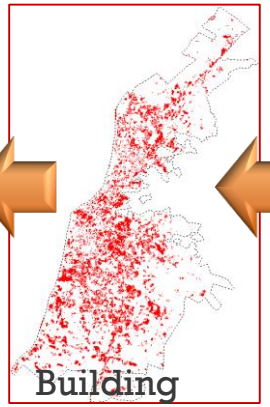
Aerial/Satellite imagery

Option-3



City	Total number of buildings	Total building roof area (m^2)	Average building roof area (m^2)
Tbilisi	245.639	24.634.075	100
Batumi	10.143	2.879.820	284
Kutaisi	28.835	4.816.095	167
Rustavi	16.233	2.904.118	179

GIS output



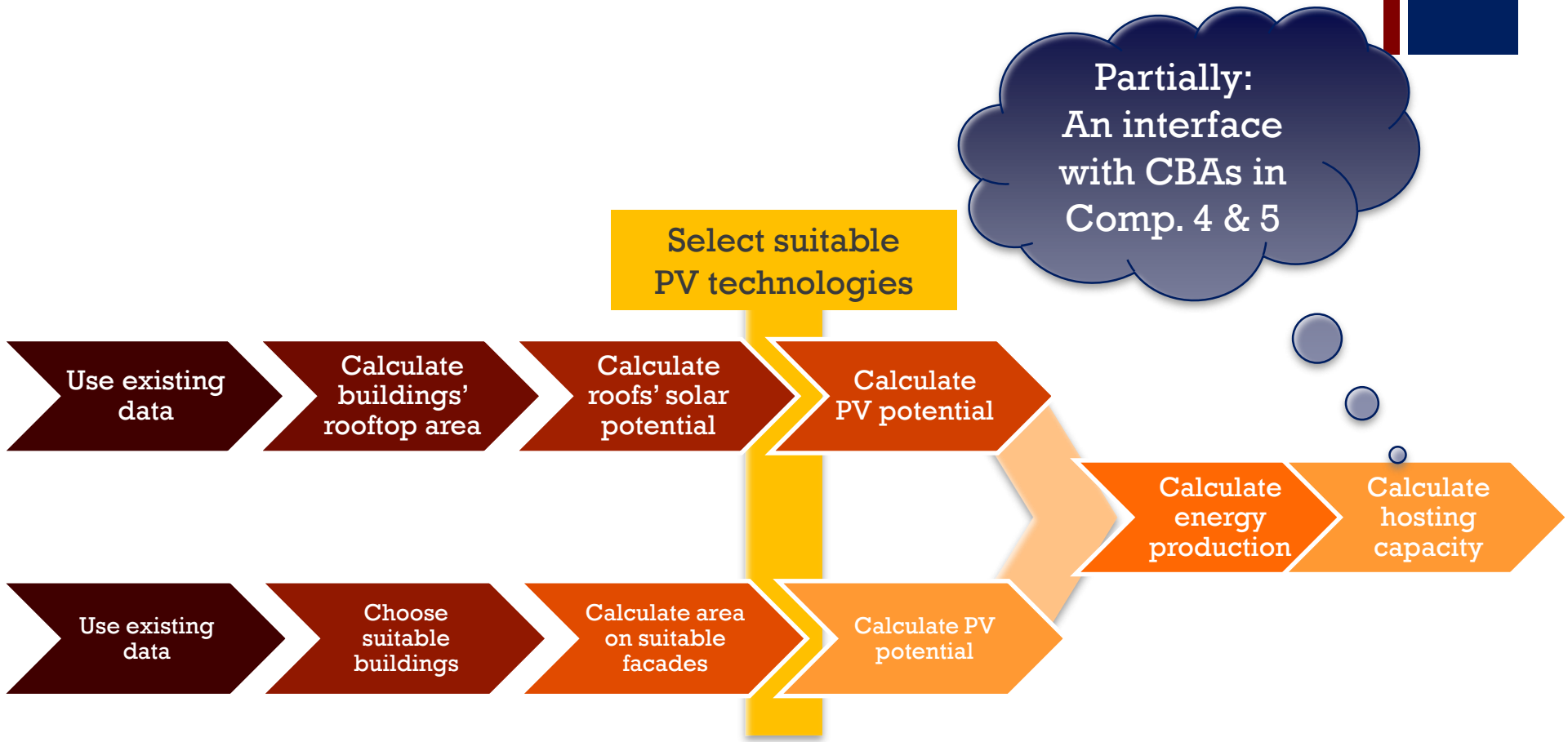
Building classification

Satellite image

Expected accuracy reduction of Option-3 vs. Option-1: ≤ 10%

Component 3: Methodology in a nutshell - 2

Estimation of PV potential



Component 3: Market Segments

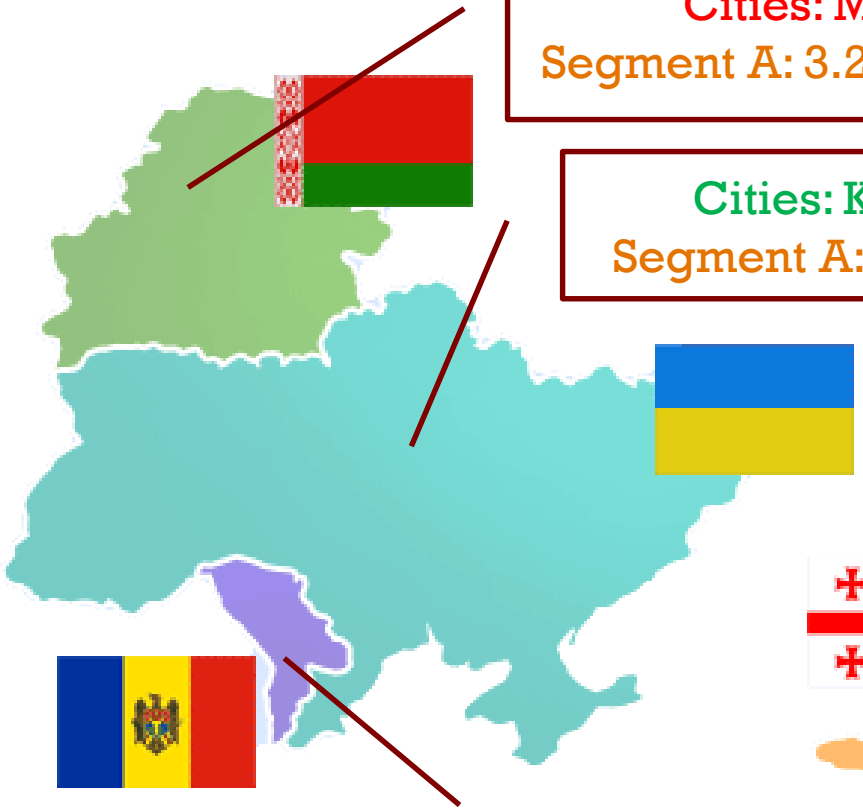
Segment A (Residential):

- Single-family houses
- Larger but more **fragmented** market

Segment B (Non-residential):

- Multi-family, commercial, industrial, public
- Smaller but more **attainable** market segment

Component 3: Potential



Cities: Minsk, Mogilev, Vitebsk
Segment A: 3.2 GWp / Segment B: 0.5 GWp

Cities: Kiev, Odessa, Lviv, Zaporizhia
Segment A: 7.7 GWp / Segment B: 1.2 GWp

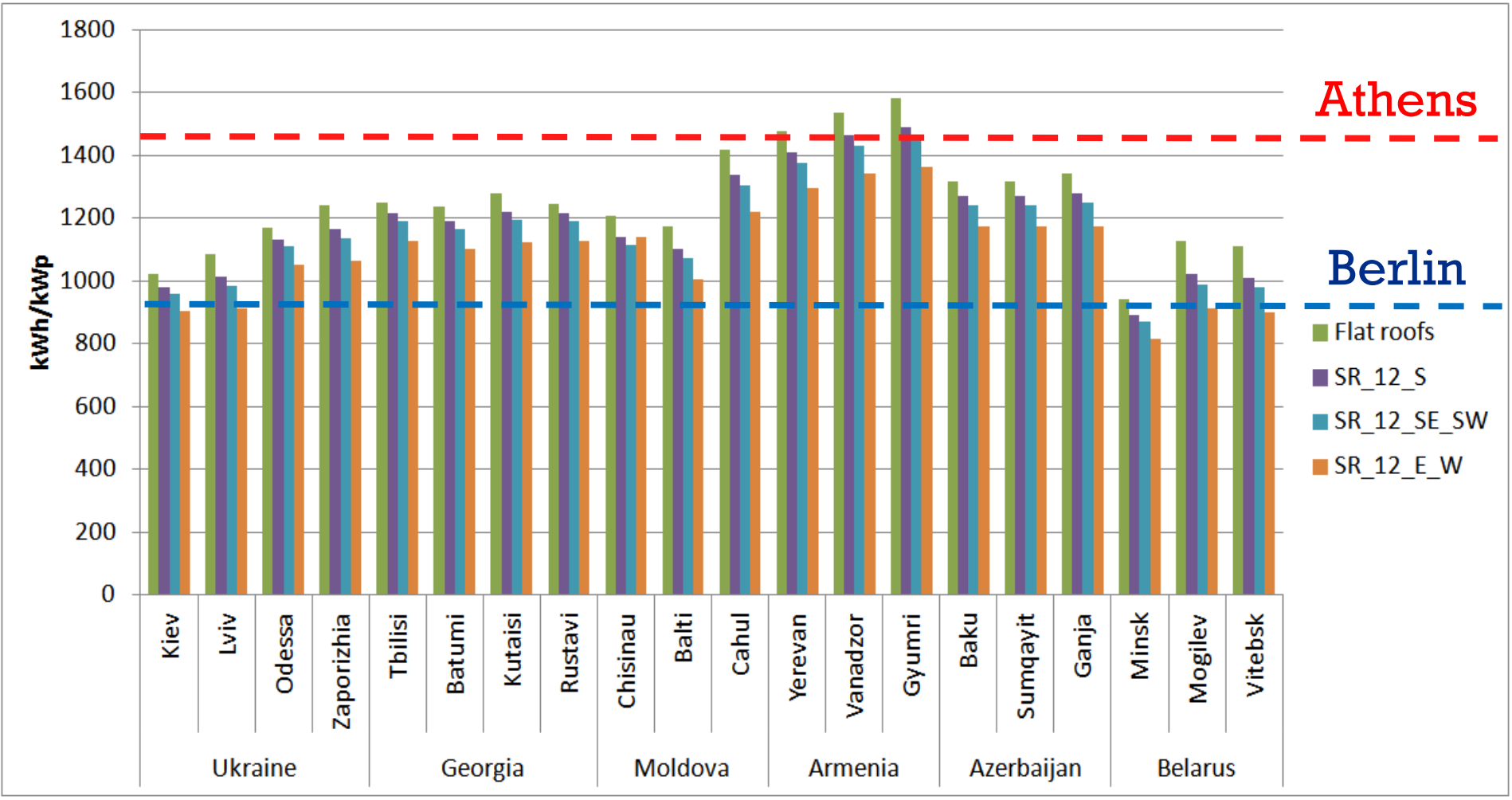
Cities: Tbilisi, Batumi, Kutaisi, Rustavi
Segm. A: 0.8 GWp / Segment B: 1 GWp

Cities: Baku, Sumgayit, Ganja
Seg. A: 2.8 GWp / Seg. B: 0.8 GWp

Target Cities: Chisinau, Balti, Cahul
Seg. A: 0.16 GWp / Seg. B: 0.34 GWp

Cities: Yerevan, Vanazdor, Gyumri
Seg. A: 1.8 GWp / Seg. B: 0.5 GWp

Component 3: Average Specific Annual Yield (kWh/kWp)



HiQSTEP Building Solar Power Study

Component 5: Programme planning based on Costs & Benefits

Components 4 & 5: CBAs and Programming

- Staged development scenarios (Market segment, MWp/y, level of support)
- End-user point of view
- CBA = social planner's view
  - Cost of policy support
  - Environmental/social benefits
  - Grid benefits/costs
- Other potential issues:
  - Relation with national RES targets
  - Relation with CoM SEAPs
  - Off-grid applications
  - Source of financing (NIF/E5P, etc.)

From theoretical potential to scenario building

Components in progress: 4 and 5

Surface-based calculation of roof area and installed PV capacity (C3)

Only 20% of Residential

- Multiple constraints (International experience)

30% (2018-24)
70 % (2025-30)

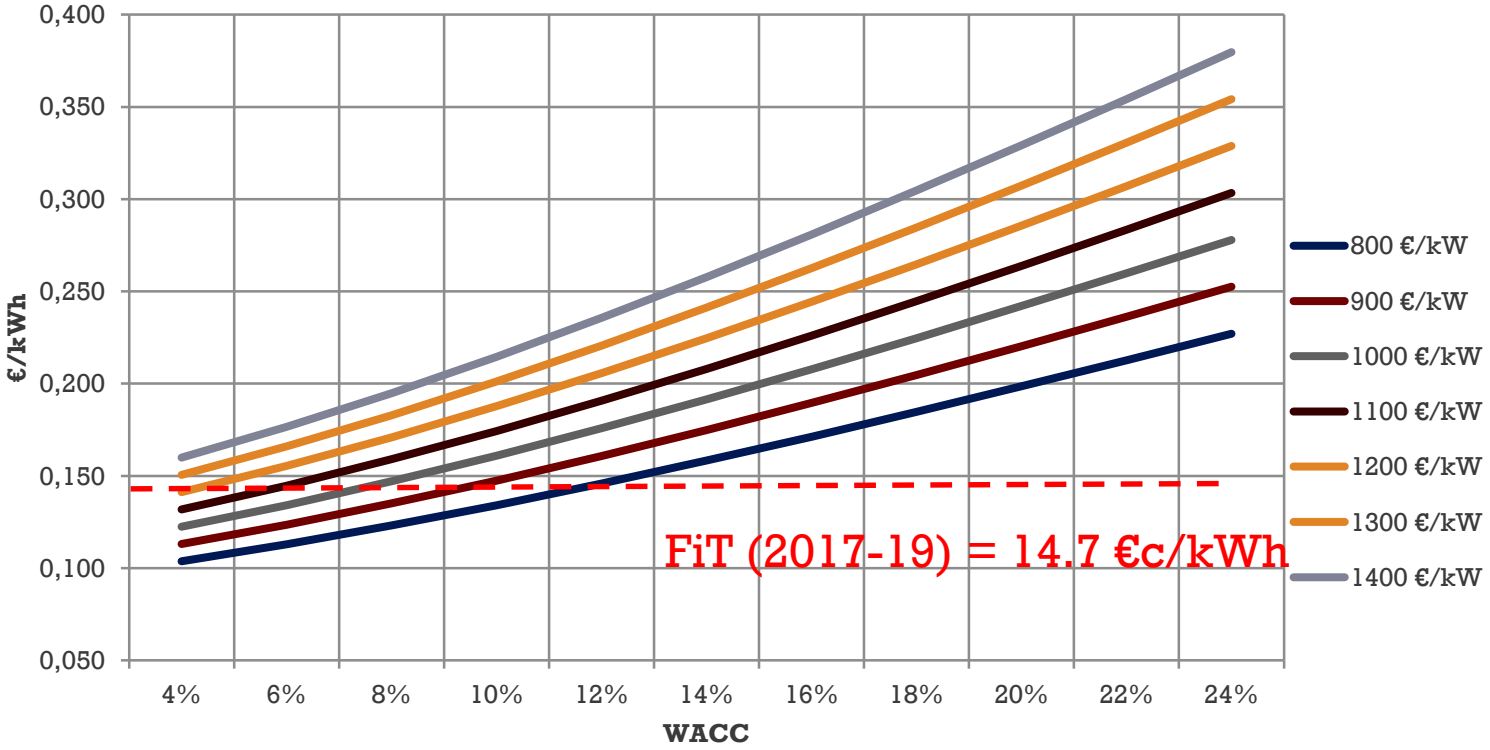
- S-curve effect

Low (5%)
Mid (50%)
High (100%)

- Level of support as a driver

Example: Attractiveness of building PV in Ukraine

Levelised Cost of Electricity (LCOE)



$$= \frac{\text{Initial Investment} - \sum_{n=1}^{N} \frac{\text{Depreciation}^n}{(1+\text{Discount Rate})^n} \times (\text{Tax Rate}) + \sum_{n=1}^{N} \frac{\text{Annual Costs}^n}{(1+\text{Discount Rate})^n} \times (1-\text{Tax Rate}) - \frac{\text{Residual Value}}{(1+\text{Discount Rate})^n}}{\sum_{n=1}^{N} \frac{\text{Initial kWh/kWp} \times (1 - \text{System Degradation Rate})^n}{(1 + \text{Discount Rate})^n}}$$

Costs and Benefits

Policy level cost and environmental benefits:

PV capacity potential, MW (Component 3)	2618.22			
	Medium Scenario		**High Scenario**	
Estimated total installed capacity over 2018-2022 (MW)	**280.5**		**561.0**	
Total electricity produced over lifetime (kWh)	5,613,013,949		11,223,176,081	
Policy implemented	`	**FiT €/kWh**	**Capital Grant €/MW**	**FiT €/kWh**
Total Capital Grant cost, over 2018-2022 (€/MW)	**€ 176,901,750**		**€ 414,690,993**	
Average annual Capital Grant cost (€/year)	**€ 35,380,350**		**€ 82,938,199**	
Capital Grant cost per kWh produced (€/kWh)	**€ 0.03**		**€ 0.04**	
Total FiT Cost, over lifetime (€/kWh)		***€ 809,266,685***		**€ 1,932,172,314**
Average annual FiT cost (€/year)		***€ 32,370,667.41***		**€ 77,286,893**
Cost of FiT per kWh produced		***€ 0.14***		**€ 0.17**
Benefits				
CO2 emissions saved (tCO2)	**4,529,702**		**9,057,103**	
Value of CO2 emission saved (€/tCO2)	**€ 30,258,411**		**€ 60,501,449**	
Jobs creation (jobs-year/MW)	**7,139**		**14,279**	
Impact of FIT on consumers		**Annual Average over lifetime**		**Annual Average over lifetime**
Annual total electricity consumption - Armenia, kWh		126,215,932,991		126,215,932,991
Total annual FiT cost - High Scenario		€ 32,370,667		€ 77,286,893
Cost per kWh consumed		€ 0.000		€ 0.001
Average retail electr. price (resid+non-resid) over the period €/kWh		€ 0.087		€ 0.087
Impact on average retail electr. price		€ 0.003		€ 0.007
Household consumption kWh/year		2080		2080
Impact on Household bill €/year		**€ 0.53**		**€ 1.27**

Can this work in the GCC region

Food for thought:

- What would be the motives (including benefits expected) for introducing rooftop PV in the region particularly in the light of higher LCOE compared to other RES (and in particular solar technologies)?
- What would be the most promising support schemes for the technology and how the extra cost may be covered/distributed?
- Is there any assessment of the technical potential (in installed capacity or expected annual yield) at city level in the region?
- Is there any anticipation for specific market segments which may comprise attractive application areas e.g. tertiary sector buildings?

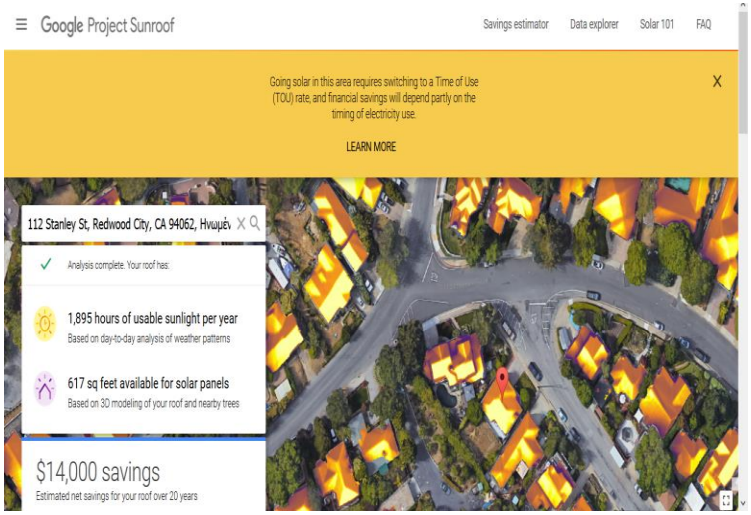
Can this work in the GCC region

Food for thought:

- Is there any obligation for RES in buildings imposed by means of building energy performance regulations?
- How can an investment programme on rooftop PV be envisaged? Based on sovereign funds, with private lending or by a combination of the above? Are there any applications in which project financing has been used?
- Can PV prosumers interact with the electricity market?
- Is there any assessment on the penetration limits for Variable Renewable Energy additions to the national/regional electricity system?

Closing remark: the future is now

- Google Project Sunroof



- The 3 D's of our electricity future

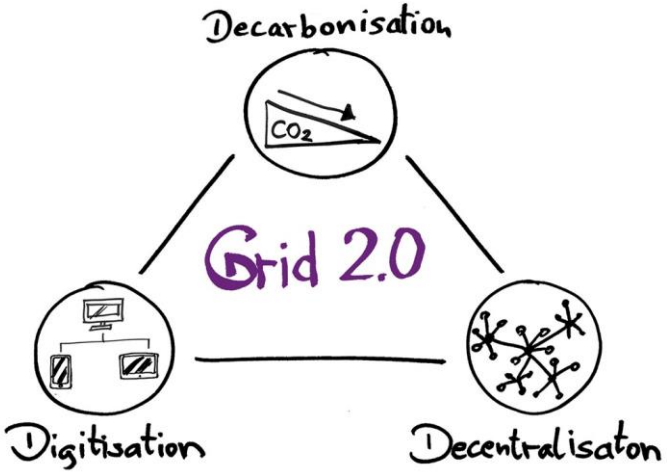


Image: Younicos

"By failing to prepare, you are preparing to fail" **- Benjamin Franklin**

Thank you

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