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SOLARISE
European Regional Development Fund

Sustainability of the renewable energy sources?

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Solarise Kick-off event 18 June 2018

Energy problem

- Global progress towards clean energy, low carbon economies is still **slow**

- Fundamental challenge is how to manage the contradicting goals of:
    - energy **security**
    - energy **sustainability**
    - energy **equity**

- **Solutions are not straight forward** for different contexts of energy resources, social systems and political arrangements and require careful considerations through empirical and context specific research.

Energy security

- **Accessibility:** geopolitical elements related to energy generation, safety, energy independence and diversification of energy fuels and services,
- **Affordability:** basic costs and prices of energy, equitable access to energy resources/services
- **Reliability:** ability to supply needed quantity and quality of energy under normal operating conditions and in response to unexpected interruptions

- **Other:** infrastructure, efficiency, energy reserves and resources, resource availability and access, technology advances, fuels for the future, role of nuclear energy, renewable energy, implications of changing geopolitical environment and foreign trade

Energy sustainability and energy equity

- **Energy sustainability:**
  - encouraging the use of renewable energy
  - preventing waste emissions (or other environmental risks) from exceeding the relevant assimilative capacities of ecosystems

- **Energy equity:**
  - ensure access to energy (resources/services) in an appropriate manner

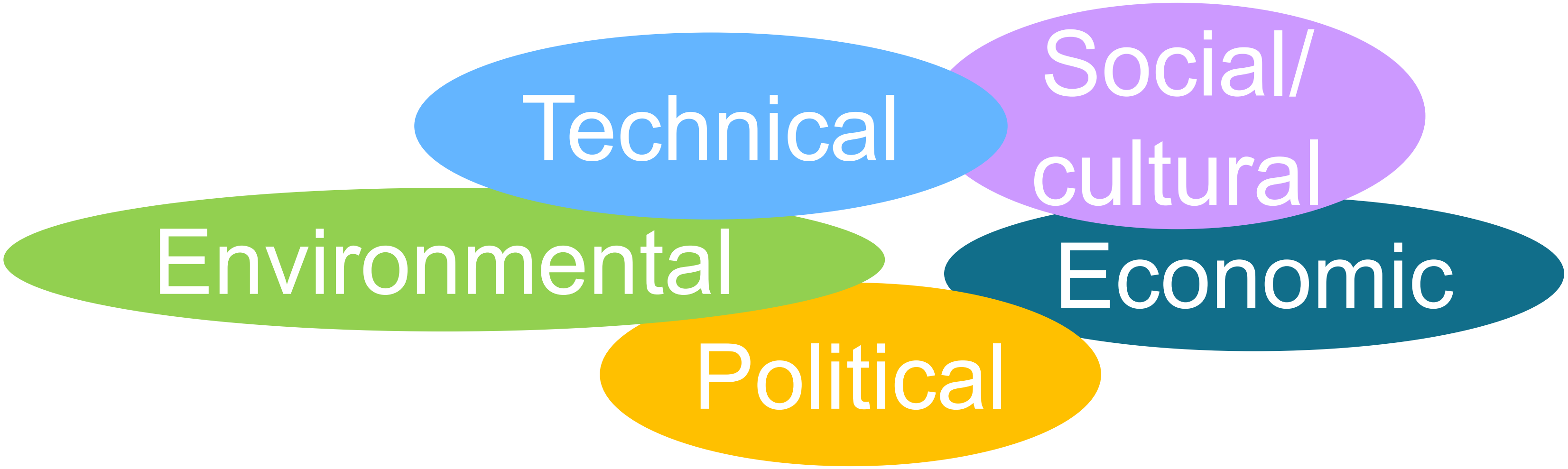
Sustainable development

Brundtland commission (1987):

‘sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs’

Sustainable energy

Enough energy for the present needs + respect for the environment (future needs are also ensured)



Sustainable energy

Renewable energy sources

- Solar
- Wind
- Water (hydropower)
- Geothermal
- Biomass, …

Increased energy efficiency

- Less energy for the same products/results
- Smart grids
- Energy management systems, …

Sustainable energy

Renewable energy sources

- more evenly distributed around the globe compared to fossil fuels
- reduce energy imports and contribute diversification of the portfolio of supply options
- reduce economy's vulnerability to energy price fluctuations

- Non-dispatchable, variable renewable energy (VRE) sources

(intertemporal changing availability and decentralized deployment)

  - Solar
  - Wind
  - Water (hydropower)
  - Geothermal

- Dispatchable renewable energy (VRE) sources

  - Biomass, …

Renewable energy = sustainable energy?

- Renewable energy refers only to the energy resources

- **A rapid expansion of renewable energy technology is not necessarily sustainable** (solar and wind energy are growing rapidly, but while the energy is renewable, every solar panel and wind turbine has limited lifespan and is largely made from non-renewable resources)

- The process of extracting, transporting, refining and including RE- resources in the energy system **still requires fossil fuel input/use**

Renewable energy = sustainable energy?

Potential negative environmental impacts of RE

- **Water** (hydropower): habitat loss, defforestation, waterflow interference, water quality deterioration, …
- **Solar**: visual pollution, habitat loss, degradation of soil, effect on surface albedo,
- **Wind**: visual/acoustic pollution, land degradation,
- **Geothermal**: air/water pollution, land degradation, …
- **Biomass**: land degradation, water consumption, …

A successful switch to renewable energy sources includes **not only installing renewable energy generation facilities** (RE-mix based on sustainable associated industries), but also to **integrate RE** into the power grid and subsequently into an **overall demand/supply system** with inherent mismatch.

Impact of RE use for manufacturing industry

A successful switch to renewable energy sources includes not only installing renewable energy generation facilities (RE-mix based on sustainable associated industries), but also to integrate RE into the power grid and subsequently into an overall demand/supply system with inherent mismatch.

- Energy supply becomes more volatile and **prices fluctuate more**
- **Electric energy has to be treated as a limited production capacity**, whose usage has to be planned and controlled during production (included in PPC: production planning and control)
- Producing companies are forced to **rethink their energy policy**: become energy efficient by **minimizing their energy demand** and **synchronize their energy consumption with the available energy supply**

Sustainable energy

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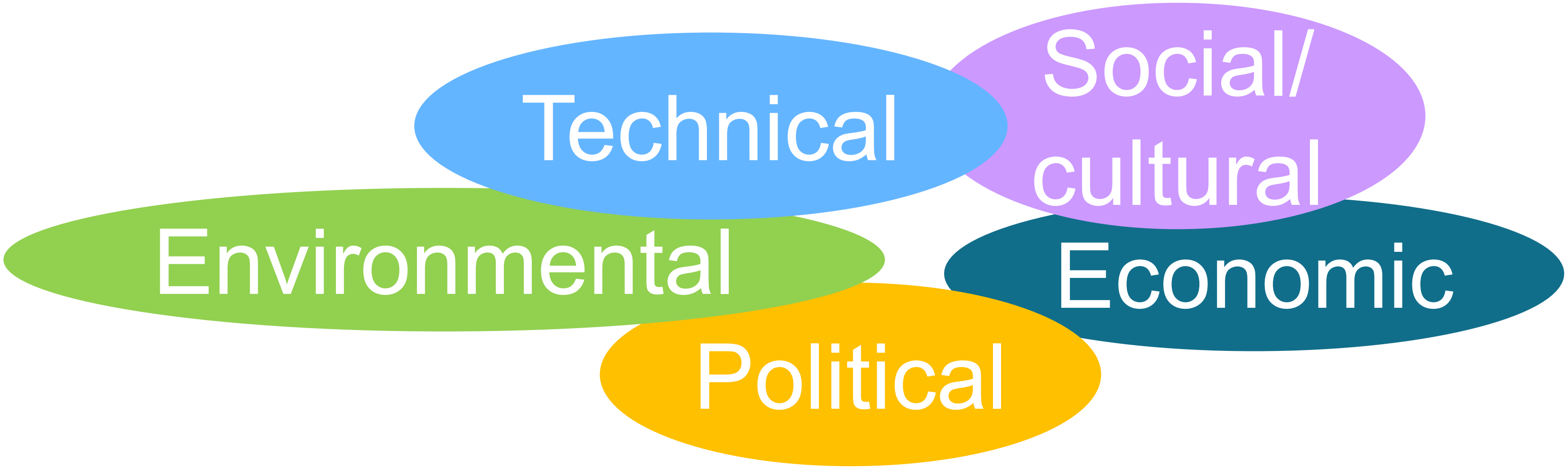


Evaluation of sustainability parameters

- **Technical** (! a good technical solution does not meant it will be adopted)
- **Economic** assessment methods do not include all indirect costs and do not lead to results that are independent of time because they are influenced by market developments
- **Political (institutional/governance):** often ignored; indicators to measure effectiveness of national sustainable energy security development strategy/plan, capabilities, adequacy and effectiveness of investments in capacity building, R&D development, and also monitor progress towards appropriate and effective legislative, regulatory, measures to foster efficient energy systems, availability of policies, private sector participation.
- **Environmental (ecological)**: no consensus about the applied assessment models and weighting factors
- **Social (cultural):** assessment methods suffer from the availability and qualitative or semi-quantitative nature of data

Evaluation of sustainability parameters

Life Cycle Analysis (LCA) enriched with temporal dynamics and geographic diversity and complexity

- **Energy analysis**: to identify/quantify all the energy and material inputs/outputs in a product's life cycle (Energy Input to Output Ratio; Primary Energy Demand per functional unit; Primary Energy Input to Output Ratio)

- **LCC – Life Cycle Costs**: costs associated with the life cycle of a product system that are directly covered by one or more actors in the product life cycle (installation/operation/maintenance/disposal costs)

Evaluation of sustainability parameters

Life Cycle Analysis (LCA) enriched with temporal dynamics and geographic diversity and complexity

- **Social life cycle assessment:** social indicators to measure the degree of societal values and to what extend life's goals can be achieved.; social assessment still lacks of a broad consensus on adequate indicators or standardized methods (health and safety, people development, economic development)
- **Environmental impacts** directly associated with the life-cycle of a product given in a wide range of categories (e.g. climate change, ozone depletion, global warming potential, impact on environment, human health, used resources, ecosystem etc.)

Assessment of RE-systems

- Various **software tools** (HOMER, RETScreeen) are available to quantify technologies, costs, energy, emissions …
- Social/cultural/political aspects cannot be evaluated automatically

Proliferation of assessment tools (fragmented developments in a variety of research disciplines) allows analysis of many aspects of sustainability, but also induces confusion and may lead to **conflicting assessment results.**

Solar energy

- Photovoltaics (PV)
- Thermal energy
- Combined hybrid systems

Solar energy: PV

Advantages

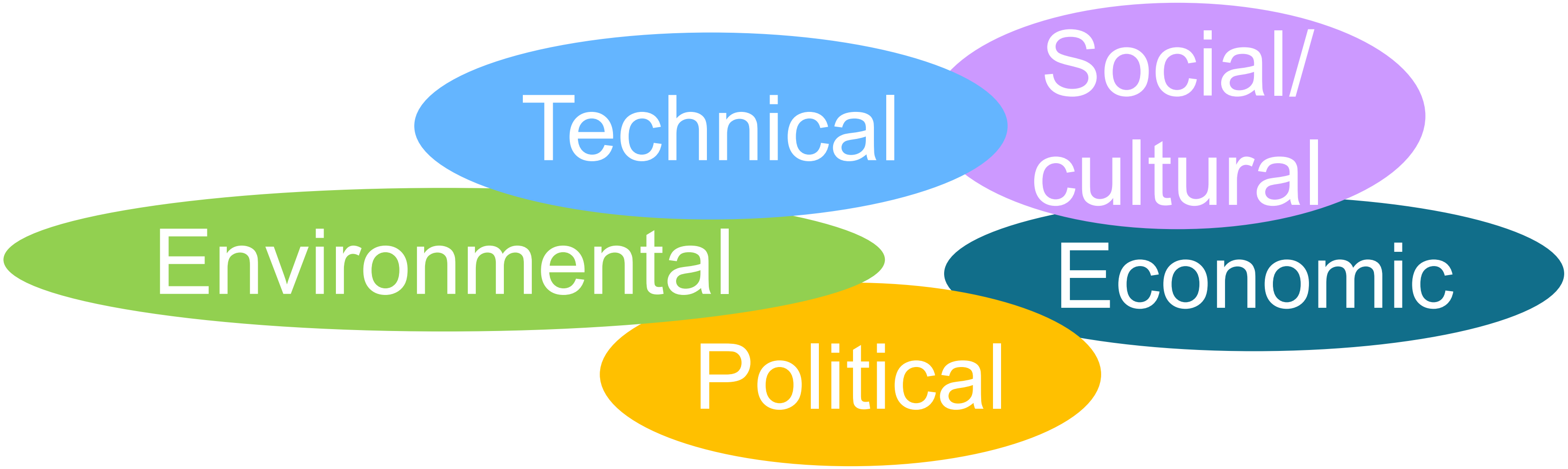
- No pollution/clean system without emissions during its operation
- No moving parts = less maintenance and noiseless operation
- It may operate as a stand-alone system that requires a smaller area compared to conventional power plants

Drawbacks

- Still expensive, production is not (yet) environmental friendly
- Mostly applied on flat surfaces
- Cannot be applied everywhere: houses not suitable, orientation is not good
- Depends on geographical position, season, weather condtions
- Log and less esthetic (not attractive)

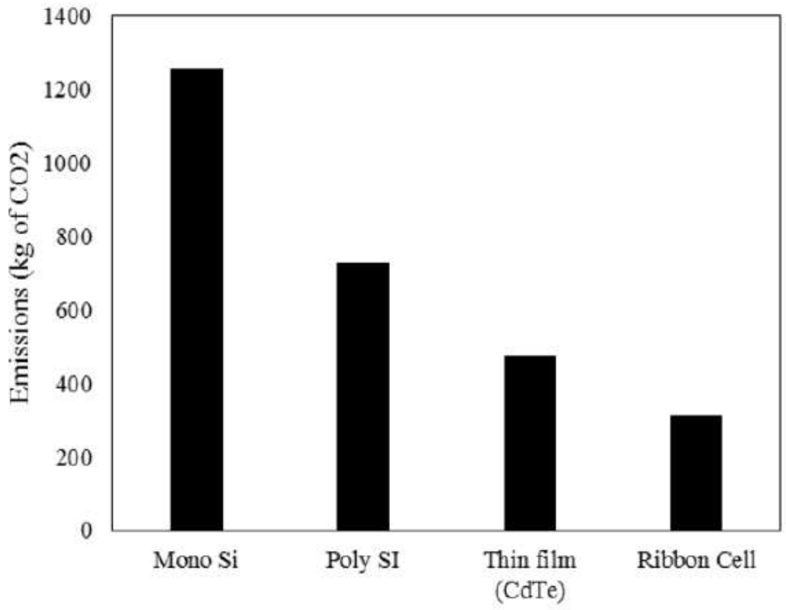
Sustainable energy

Enough energy for the present needs + respect for the environment (future needs are also ensured)

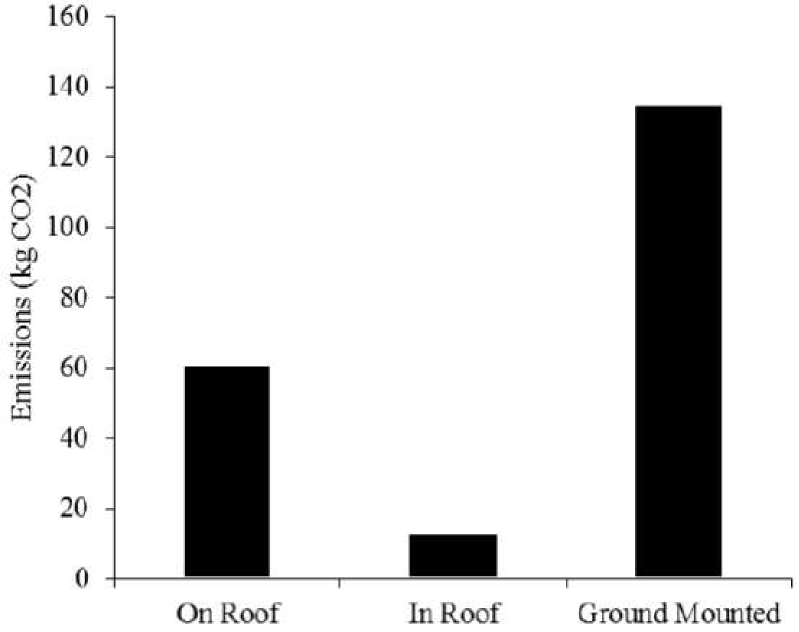


Emissions related to PV-systems

LCA for 1 kWp of production



LCA for mounting structures



Source: S.Reddy, Environmental Sustainability Analysis of Solar Photovoltaic (SPV) Systems

Solar energy: actual situation

- Potential for solar energy production in **urban environments** is limited;
- **Rural areas** should be used more for solar energy production

- Paradox: **“No Smart Cities without Smart Rural”** (Net-Zero Energy Municipality = rural areas become green energy exporters for urban areas)
- Off-grid applications are more suitable for rural areas

Solar energy: social/cultural and political issues

Reduced long-term success of many solar programs in developing countries (mostly for rural regions) because of **limited affordability**

- High initial capital costs for RE-generation projects: rural and/or poor communities **cannot afford** them or are **not aware of financing models**
- **Projects funded through capital grants** provided by either donor organisations or by governments

Solar energy: social/cultural and political issues

- **User attitude**: too high expectations because not fully understanding nature/operation characteristics of RE (different availability, …)

- **Limited social and cultural inclusion of local communities** from the start of the projects; appropriate communication means and use of the 'diffusion of innovation' theory in the given social/cultural/politic context; training programs available for users to develop awareness

- Less attention for **local after-sale servicing/maintentance**; servicing and maintentance directly by the community may be beneficial and creates ownership feelings for the users; continuous monioring and technical support

Solar energy: social/cultural and political issues

Limited long-term success of many solar programs in developing countries (mostly for rural regions) because of:

- **Lack of confidence of governments and policy makers** in the ability of RE-technologies to provide reliable and affordable electricity
- **Not clear electrification goals**: off-grid vs grid-connected; grid extensions are a potential threat to solar PV installations

Solar energy

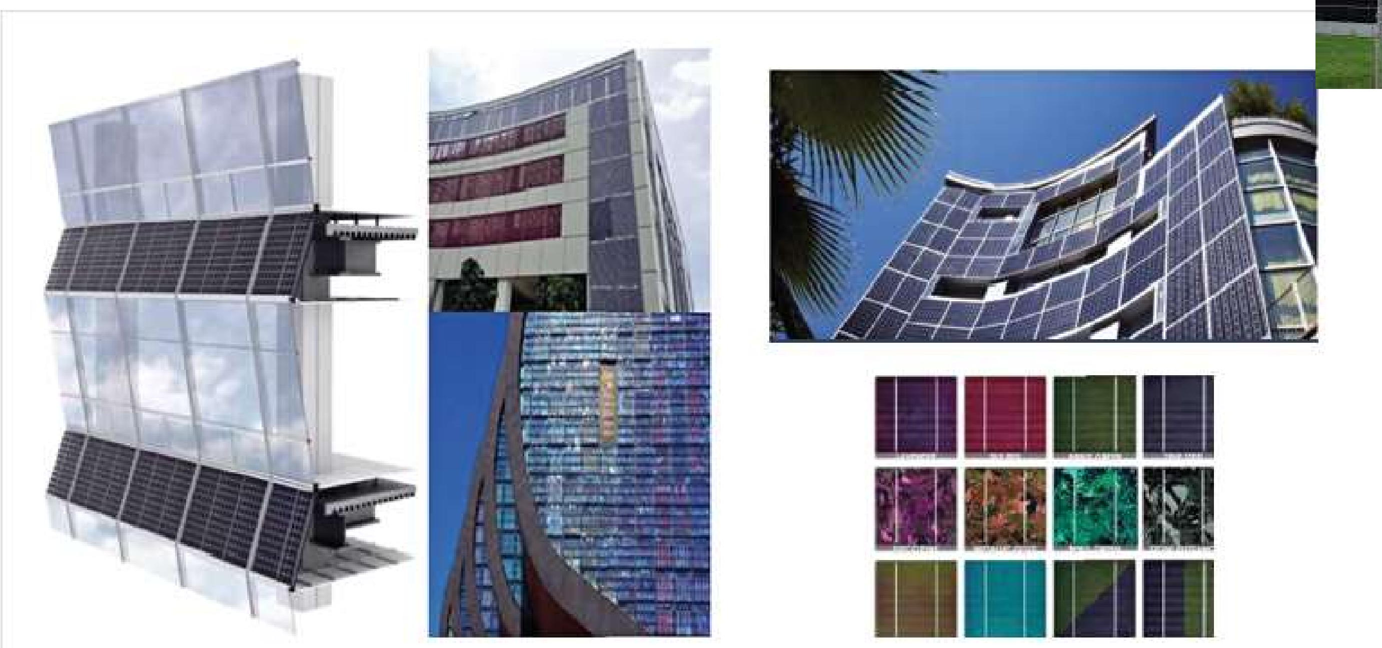
- Photovoltaics (PV)

  - Log and less esthetic
  - Non-transparent
  - Application on flat surfaces with good orientation

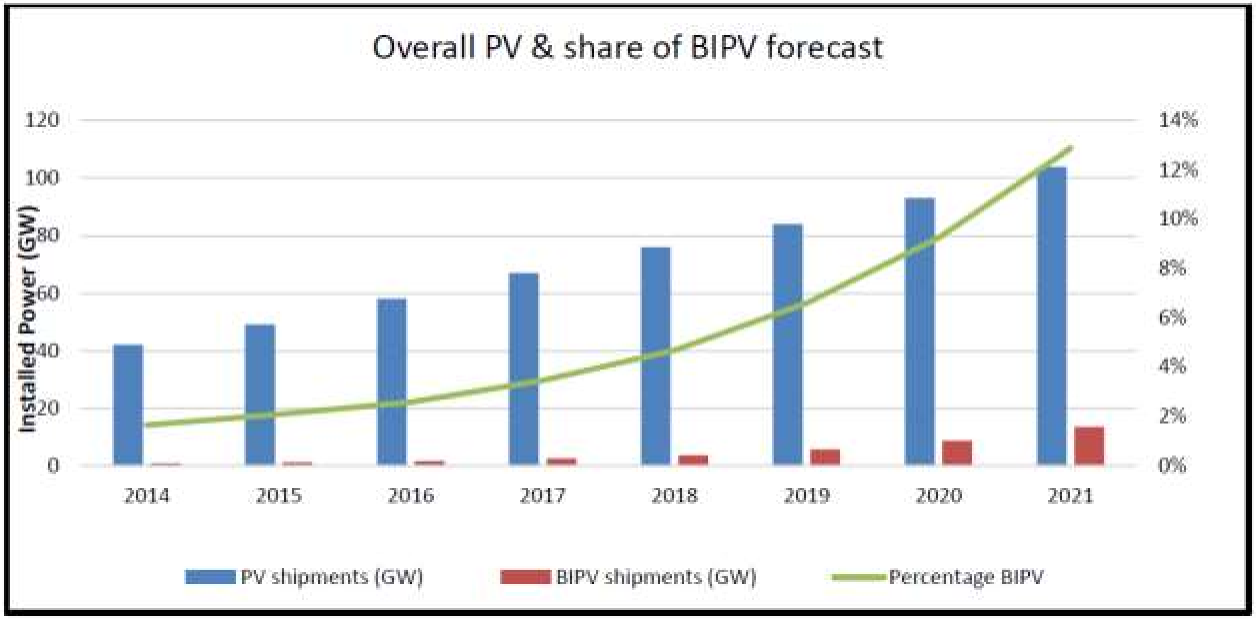
? **BIPV/BAPV**

Building-integrated/applied photovoltaics

- **BIPV** – new buildings (building-integrated PV) (easy maintenance)
- **BAPV** – retrofit buildings (building-applied PV) (difficult maintenance)



Building-integrated/applied photovoltaics



Needed: the right combination of performance, aesthetics, price and durability

Building-integrated/applied photovoltaics

Barriers/Challenges:

- Persistent **lack of awareness of designers and consumers for BIPV** due to more convenient price of BAPV for roofing's and opaque facades
- **Drop of the PV modules price** due to increase of the PV-production
- **Complex design of BIPV** as multifunctional architectural components (both the consideration of regulation and technical constraints and a wide expertise on technical and aesthetic issues)
- A difficult challenge is represented by the **integration of PV systems in architectural glazing**: homogeneous, highly transparent and multifunctional PV technologies are still an open issue.

Building-integrated/applied photovoltaics

Opportunities:

- Combinations with traditional materials (bamboo, wood, …)
- More esthethic integration in buildings







Sustainable energy solutions?

MiaSolé

Build Solar

Tesla Solar roof

Floating Solar farm

Achieving sustainable energy?

- **Technologies and knowledge** required to use scientific and technological advances **are insufficient to change unsustainable into sustainable behaviour**.
- Values such as **moderation and justice**, that play a crucial role in making communities really sustainable, **oppose the dominant materialistic values of consumer societies.**
- **Information and knowledge must be influenced by a strong hierarchy of values** that include sustainability.

The real challenge is to deliver the appropriate values to people so that they adopt sustainability as a code of conduct by
combining technical with behavioral strategies
towards
"a culture of sustainability"
(shared assumptions and beliefs about the importance of balancing economic efficiency, social equity and environmental issues)