Comparison of different photovoltaic modules within the framework of a technical and cultural project

Aim

Comparison of different photovoltaic panels technologies and the study of an application strategy for an itinerant building

Strategy

1. Inventory of the different technologies of solar cells
2. Life cycle analysis (LCA) of the different technologies with the software Simaprio 7.2 and database Ecoinvent 2.2
3. Determining the best technologies for an itinerant Minergie building in relation with its energy needs

Inventory of technologies

1. Crystalline silicon cells
   - Mono-Si (Monocrystalline silicon)
     - Mean η: 15-18%
     - Lifespan: 30 years
     - ✔ mature technology
     - ✖ expensive, low η under low light
   - Multi-Si (Polycrystalline silicon)
     - Mean η: 13-16%
     - Lifespan: 30 years
     - ✔ Good η / price ratio
     - ✖ Low η under low light
   - Ribbon-Si (Ribbon pulled silicon)
     - Mean η: 10-14%
     - Lifespan: 30 years
     - ✔ Less waste of silicon
     - ✖ Less efficient

2. Thin film cells
   - A-Si (Amorphous silicon)
     - Mean η: 5-7%
     - Lifespan: 10-30 years
     - ✔ Low cost, good η under low light
     - ✖ Low η
   - CIS (Copper indium diselenide)
     - Mean η: 9-11%
     - Lifespan: >25 years
     - ✔ Stable in humid environment
     - ✖ Expensive, tracking needed
   - CdTe (Cadmium Telluride)
     - Mean η: 7-8.5%
     - Lifespan: >25 years
     - ✔ Low cost, good η under low light
     - ✖ Toxicity of Cadmium

3. Organic
   - Mean η: 9%
   - Lifespan: 1.2 years
   - ✔ Low cost, easy fabrication
   - ✖ Low η and lifespan

4. Grätzel
   - Mean η: 11%
   - Lifespan: 20 years
   - ✔ Low cost, good η under low light
   - ✖ Unstable if variation of temperature

5. HIT (hetero-junction with intrinsic thin layer)
   - Mean η: 19.3%
   - Lifespan: 25 years
   - ✔ Good η under low light, simple fabrication

6. Multi-junction
   - Mean η: 30%
   - Lifespan: 25 years
   - ✔ Best η among cells
   - ✖ Expensive, tracking needed

Life cycle analysis

Parameters

- Reference unit: production of 4000 kWh/year
- Lifespan: 30 years
- Location: Lausanne
- Fabrication of PV: Europe

Results

- Mono-PV ➔ biggest EPBT and CO2PBT but smallest surface
- CdTe PV ➔ lowest EPBT and CO2PBT but presence of toxic Cadmium ➔ biggest impacts in term of Ecosystem quality & Human health
- CIS and Ribbon-Si PV ➔ good performance and low impacts
- Production of Mono-Si panel in China ➔ doubles the CO2PBT

Optimal technology for an itinerant building

Parameters

- Surface of the building: 100m²
- Surface of PV: 60m²
- Location: Lausanne
- Electronic devices: 4000 kWh/year
- Heating & sanitary water heating: 4000 kWh/year + concentration panels

Electric needs of the building and electricity production of PV

Optimal technology

- Optimal technologies in terms of autonomy ➔ Mono-Si, Poly-Si and Ribbon-Si: 9 months
- Ribbon-Si ➔ best balance between autonomy of the building and environmental impacts

Improvements

- Updating the process of the Ecoinvent database
- Including the LCA of new technologies
- Including the degradation factors of the cells