PV through norwegian eyes

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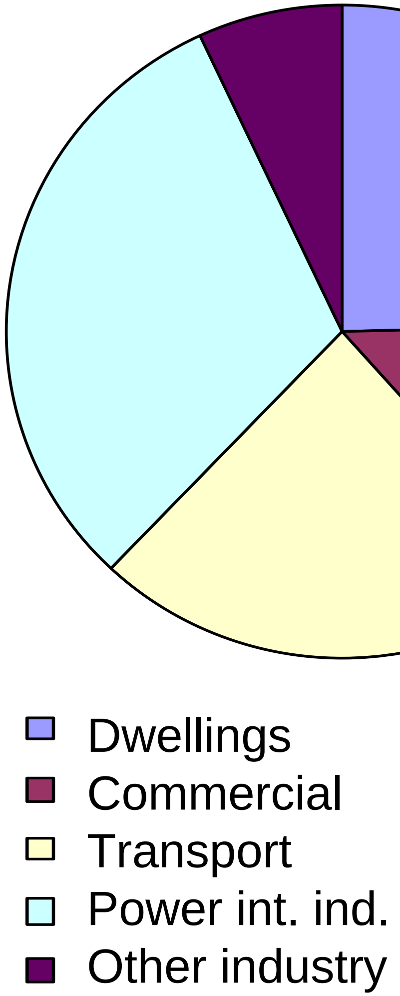
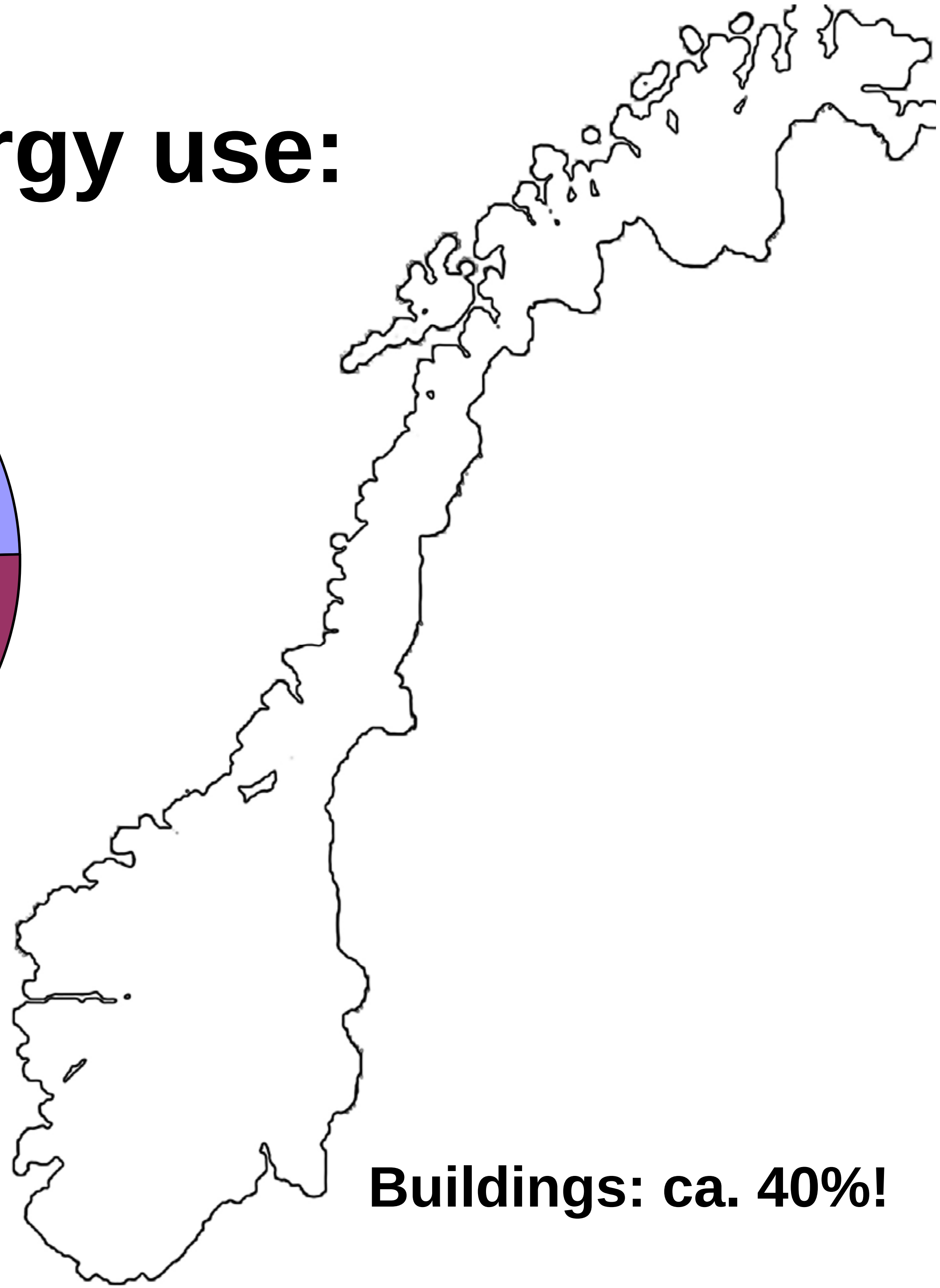
Norwegian energy use:

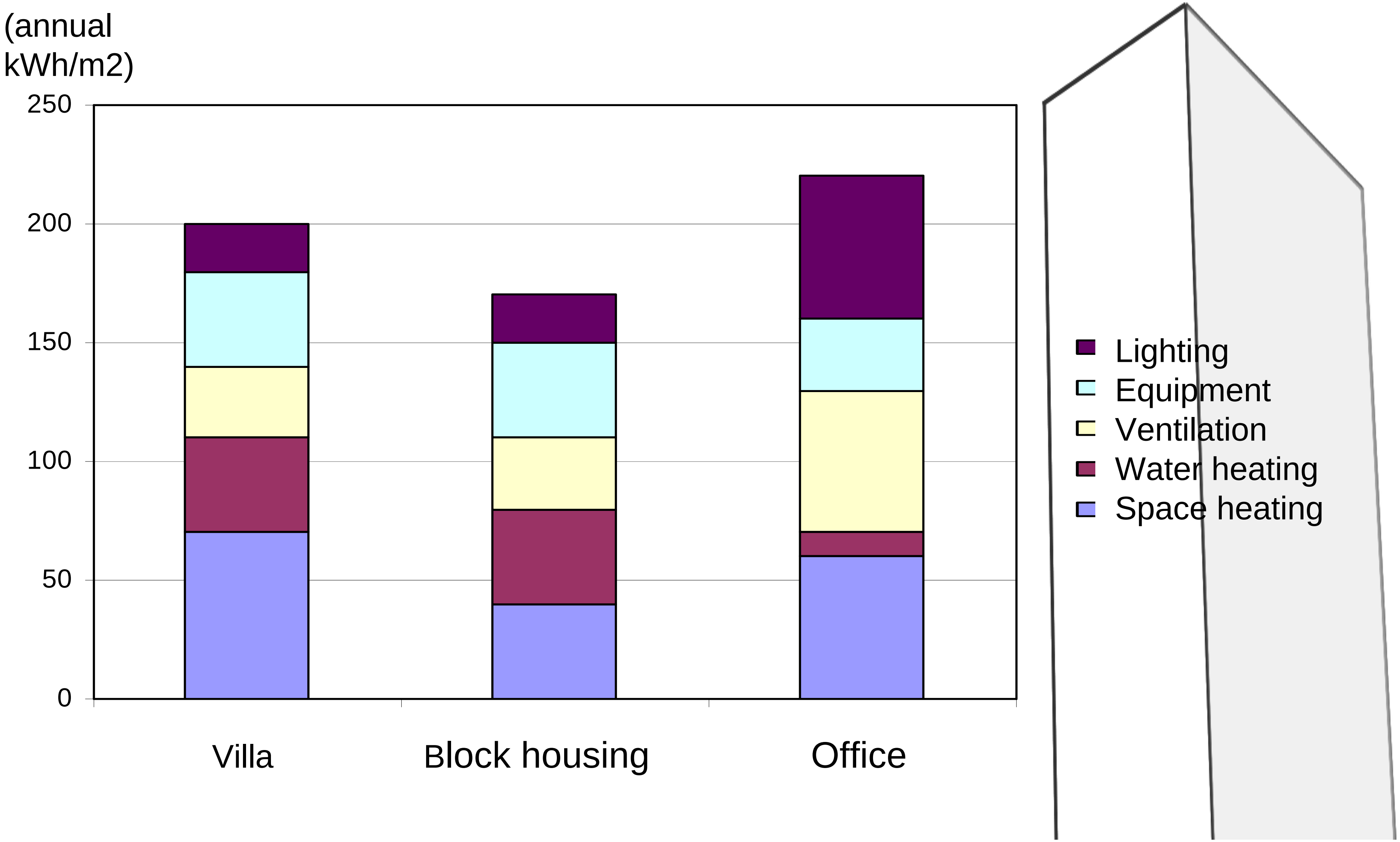
(inland)





Buildings: ca. 40%!

Typical building energy use:



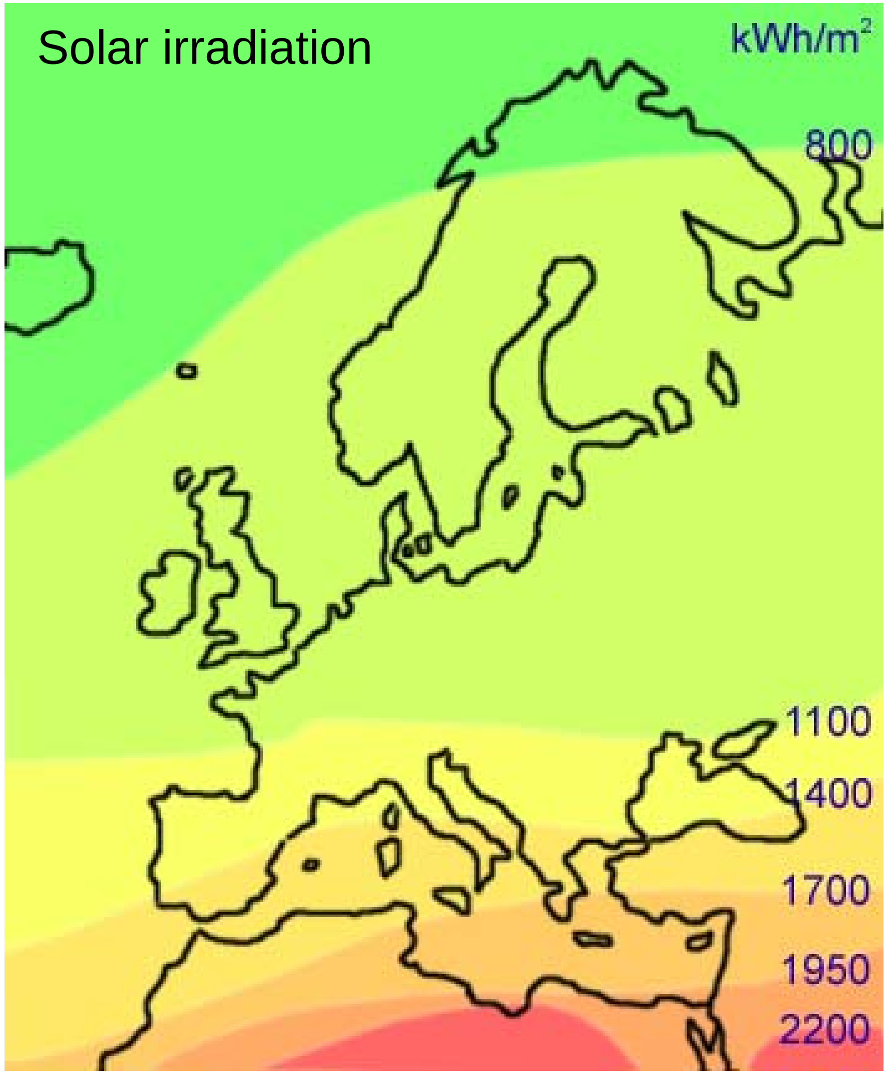
Energy consumption trends:

- The energy needs for heating water and space in dwellings are soon identical
- The need for electricity to lighting, ventilation and equipment is just as big
- Necessary to look at the total need, not only heating - and the building as an integrated system of its technologies
- Architects and engineers must cooperate in the development of the projects

Future buildings:

- **Has reduced energy needs:**
  - Energy economy and –effectivity (though not necessarily self-supplied)
- **Uses renewable energy:**
  - Building integrated solar energy systems, like passive solar heating
  - Other renewable energy systems, like active solar heat, photovoltaics, heat pumps, fuel cells, biomass
- **Covers additional needs with ”green” energy from the supply system.**
- **Uses intelligent control systems for overview, regulation, communication and ”learning”**
- **And they mainly need electricity!**

Why photovoltaics?



The environment
- No emissions
- No installations in nature
- Renewable energy

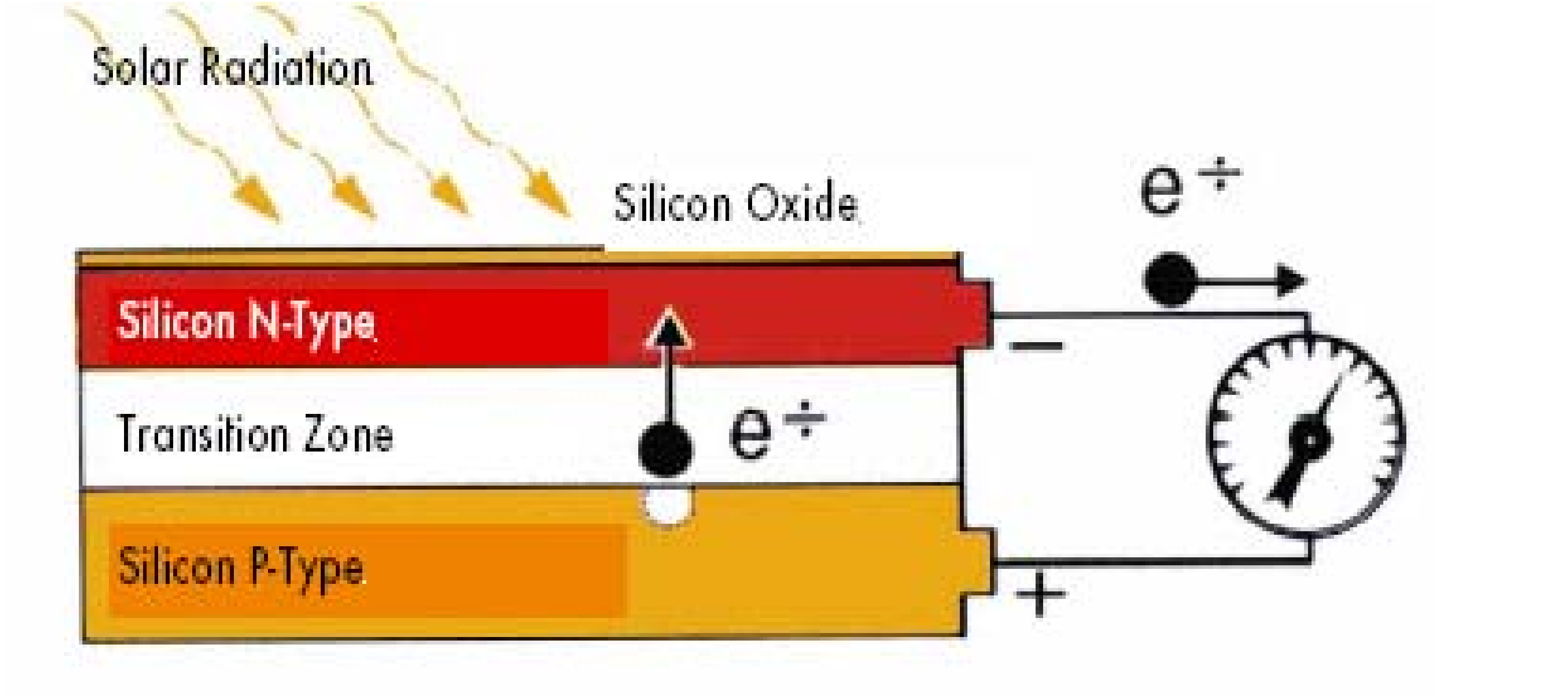
Mutual gains for building/PV
-The building is support for the PV
-(no need for independent support structure)
-PV can be the building skin
(a material with payback function)
-PV can give additional qualities
(light- and material qualities, image, energy)

Local energy
-Energy safety for local basic systems
(security, computer networks, vital functions, f.i. in hospitals or airports)
- Independence of the power prices
(more futuristic perspective)
-Less strain on the main network
(network losses, reduces network expansions)

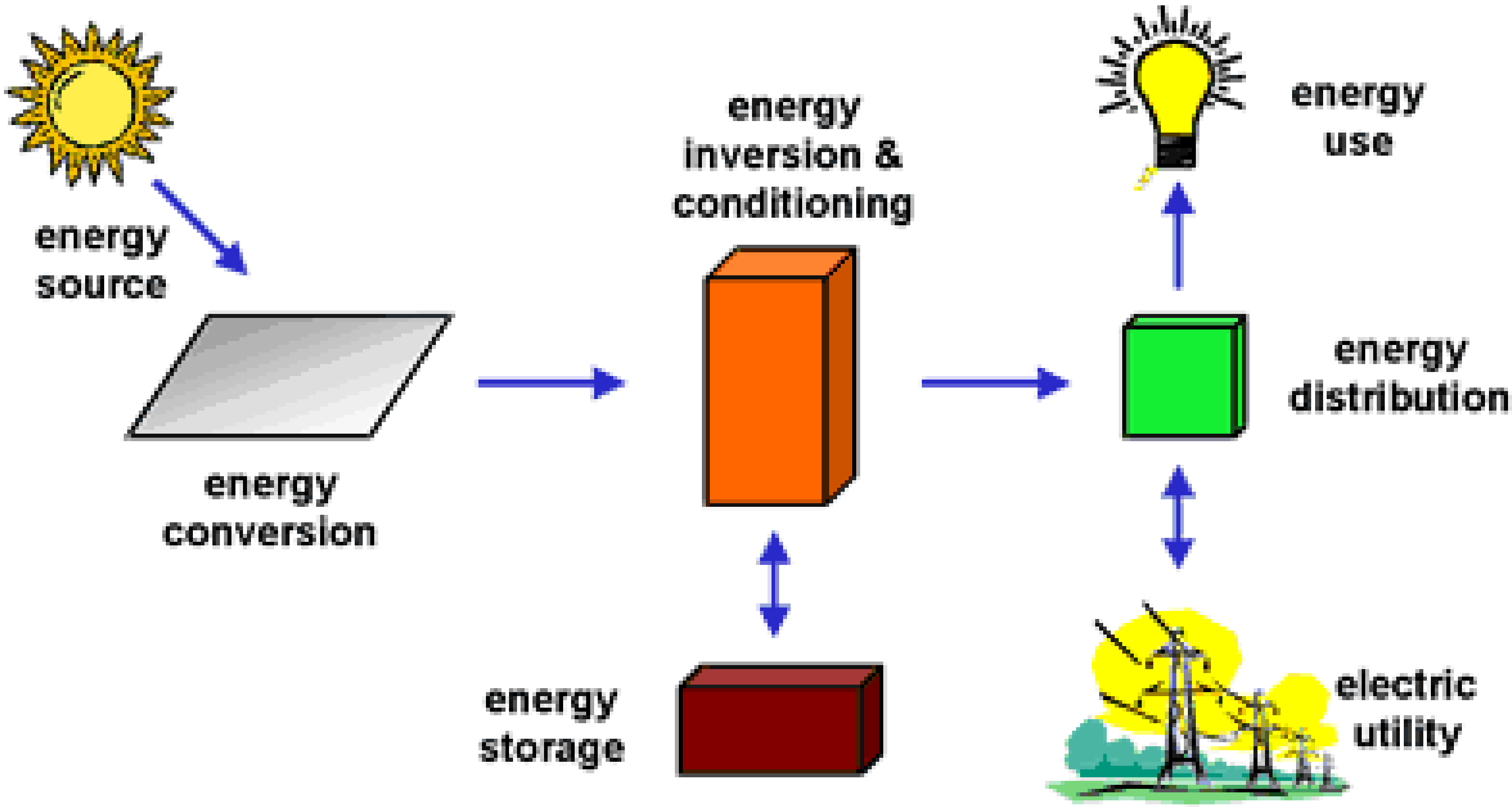
…and what is it, really?

The photovoltaic effect:

When light is absorbed in a semiconductor, an electric voltage is created. If an external circuit is connected to the semi-conductor, the voltage will drive a current through the circuit. The absorbed energy has thus been converted to electricity.



The system:


energy
source
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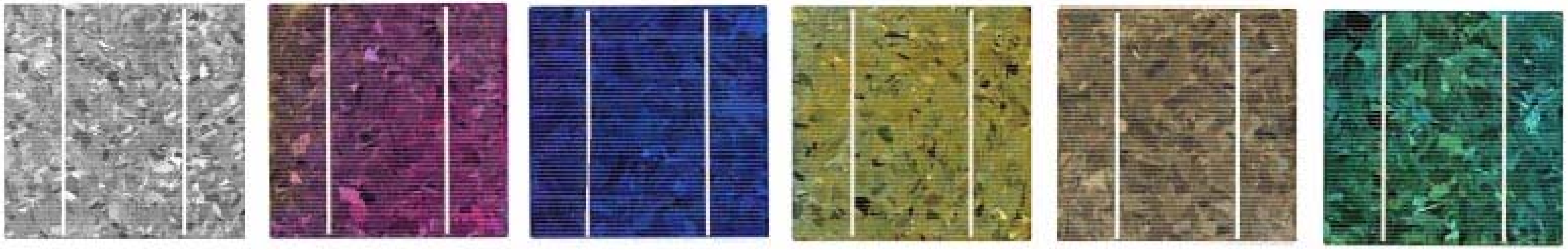
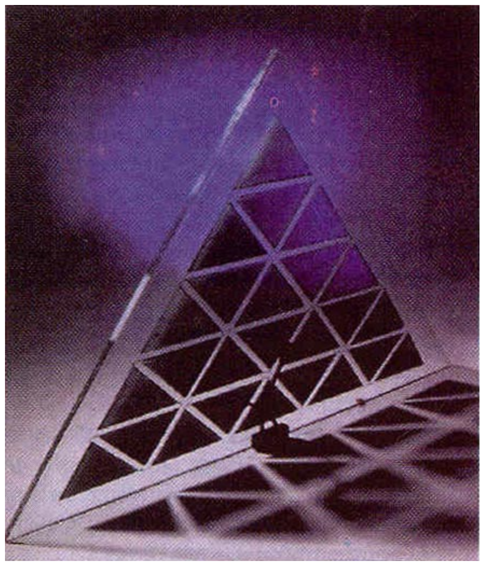
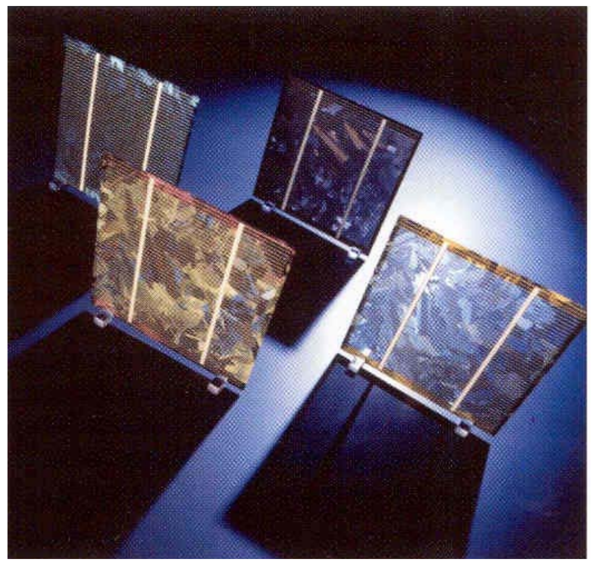
electric
utility



Different types and features

- Silicon cells
-
- Organic cells



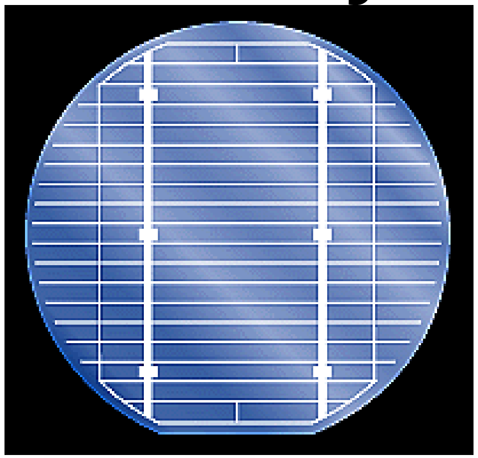


Types and efficiencies

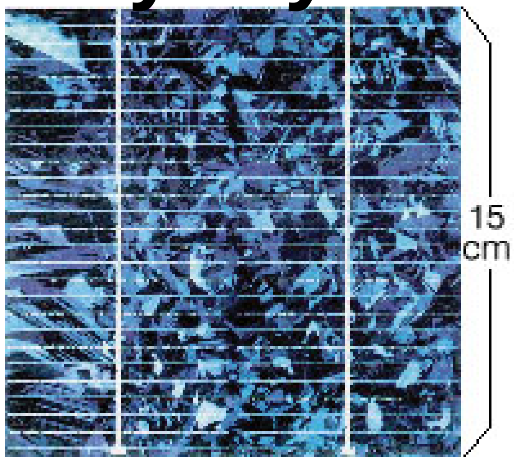
Category	***Type***	***Typical module efficiency[%]***	***Max recorded module efficiency[%]***	***Max recorded laboratory efficiency[%]***
Crystalline	Mono-crystalline silicon	12-15	22,7	24,7
	Poly-crystalline silicon	11-14	15,3	19,8
Thin- film	Amorphous silicon	5-7	-	12,7
	Cadmium telluride	7	10.5	16.0
	CIS	-	10,2	17,7
	CIGS		12,1	18,2

The most common type: **Silicone cells**

Mono-crystalline 15-20%



Poly-crystalline 10-15%

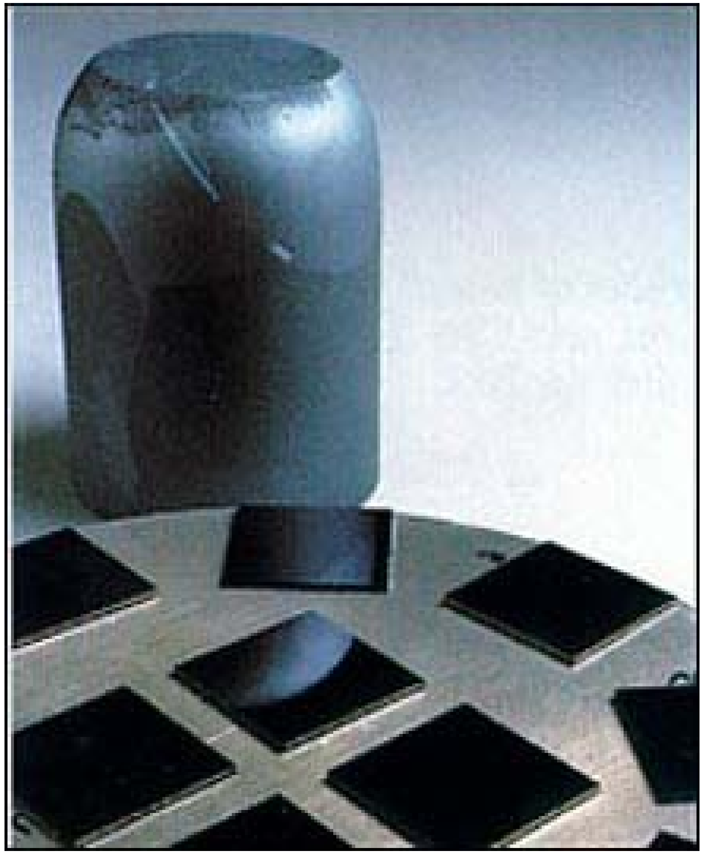


Amorphous 5-10%

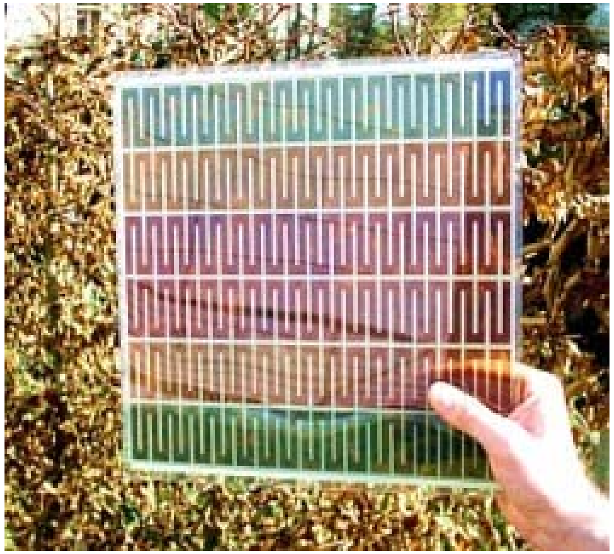
Types that didn't really make it

- **Cadmium Telluride**
- Toxic components

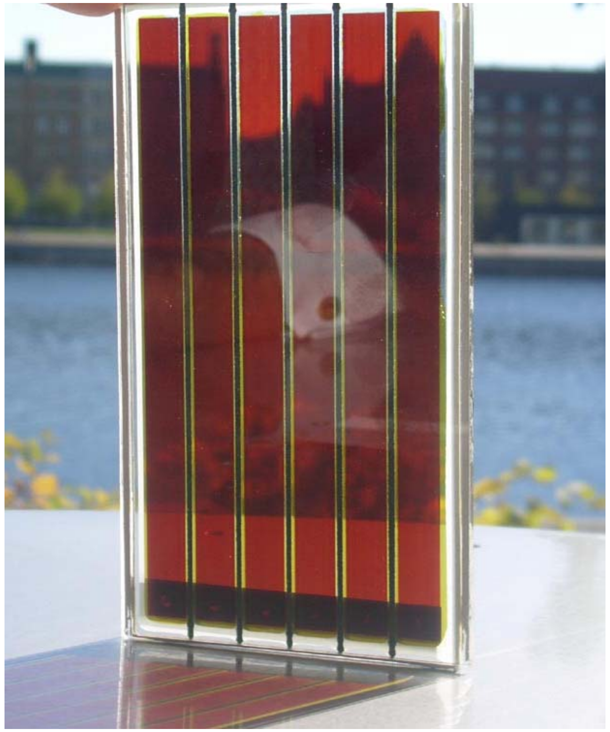
- **Copper-(Indium-Gallium)-diSelenide**
- Lack of materials



Organic cells – future low cost PV?



Low efficiency, BUT:
- Low cost
- New material qualities
- Simpler production methods
- Environmentally more friendly?



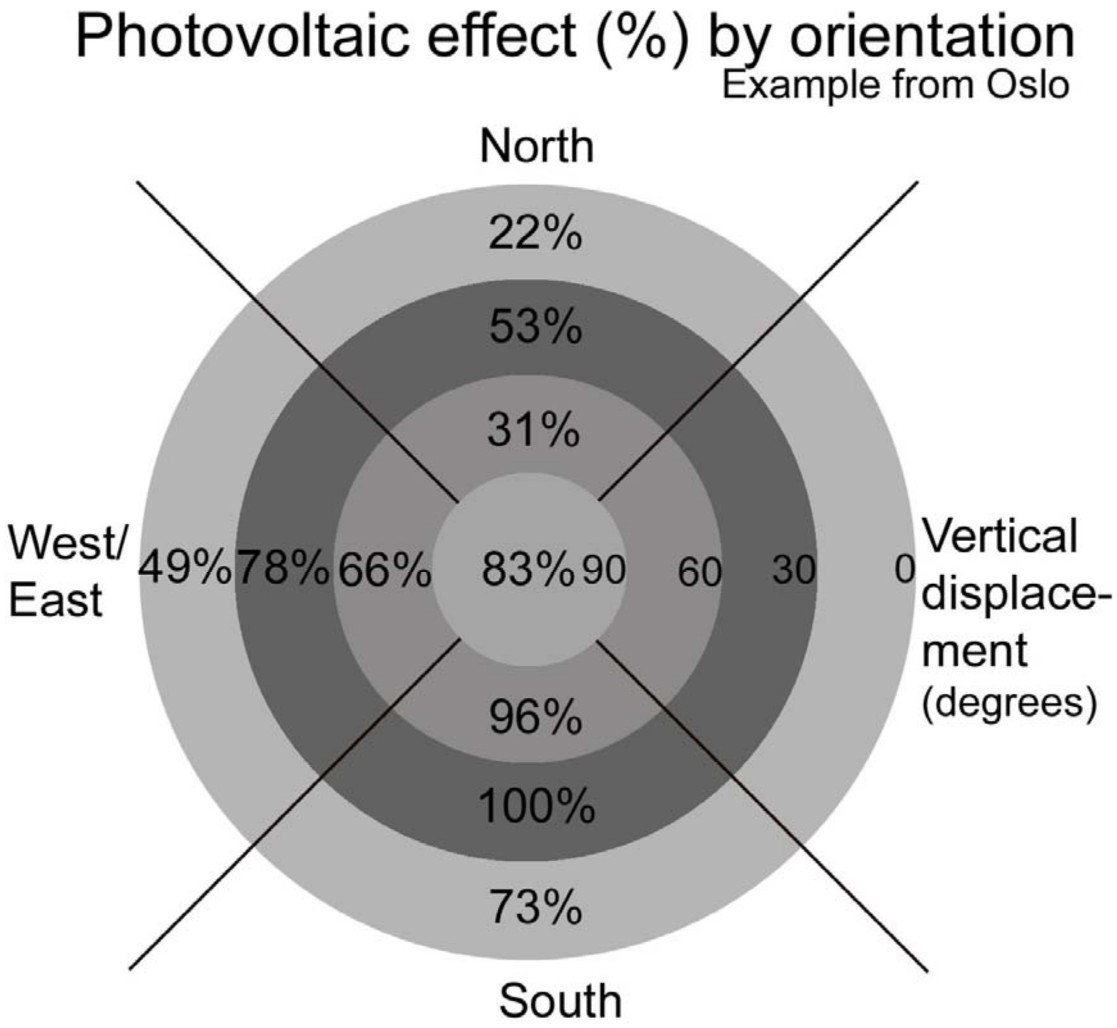
Building integration – rules of thumb

- Orientation
- Cell temperature
- Shading ☹
- Output
- Cost

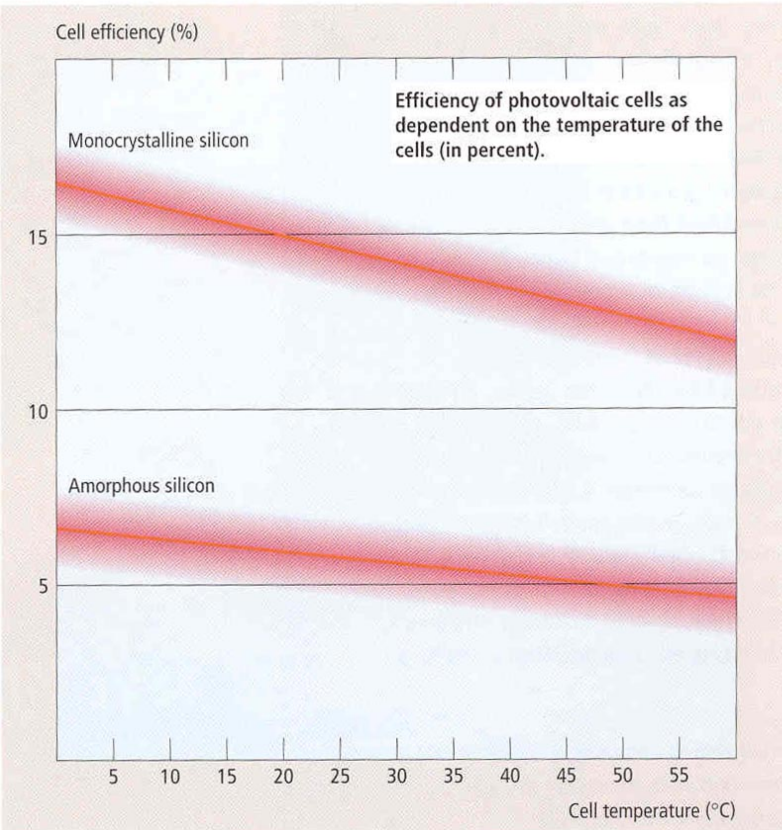
Orientation

- Vertical
- (optimal = 90 degrees minus latitude)

- Horisontal
- (optimal is due south, but up to 45 degrees off this direction is acceptable)

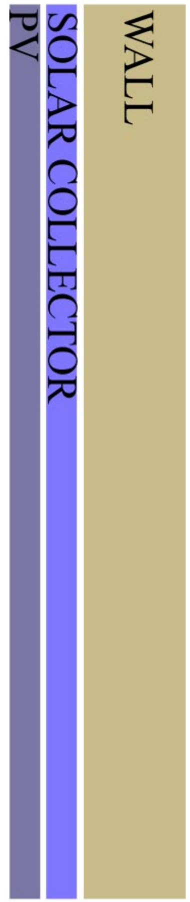


Temperature



- Cell efficiency is depending on cell temperature

- Cooling the cells by extracting useful energy is an efficient means of handling the problem

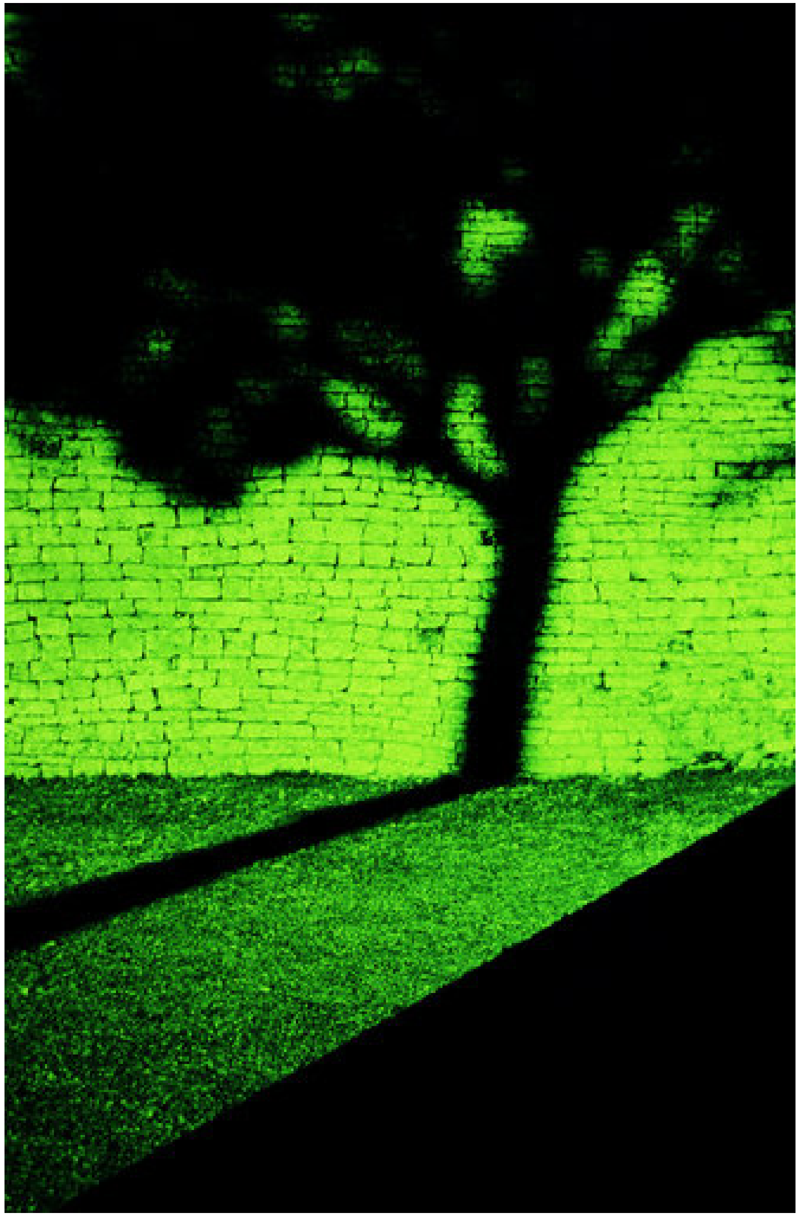


Merge of PV and solar heat

Shading

- In a serial connected PV array, its the cell with the lowest outcome that decides the effectivity of the whole array. Cells are connected in series to increase the voltage in the circuit.

- By connecting the cells in patterns that make considerations for shading problems, one can reduce the effect of shading.



Output

- Energy production
- A building integrated array in Norway produces about 100 kWh/m2 per year
- It also produces heat that can be harvested

- Selling and buying
- Arrays/buildings are usually connected to the general power net. One can sell power to the net in periods with a surplus and buy when necessary. This eliminates the need for large battery arrays

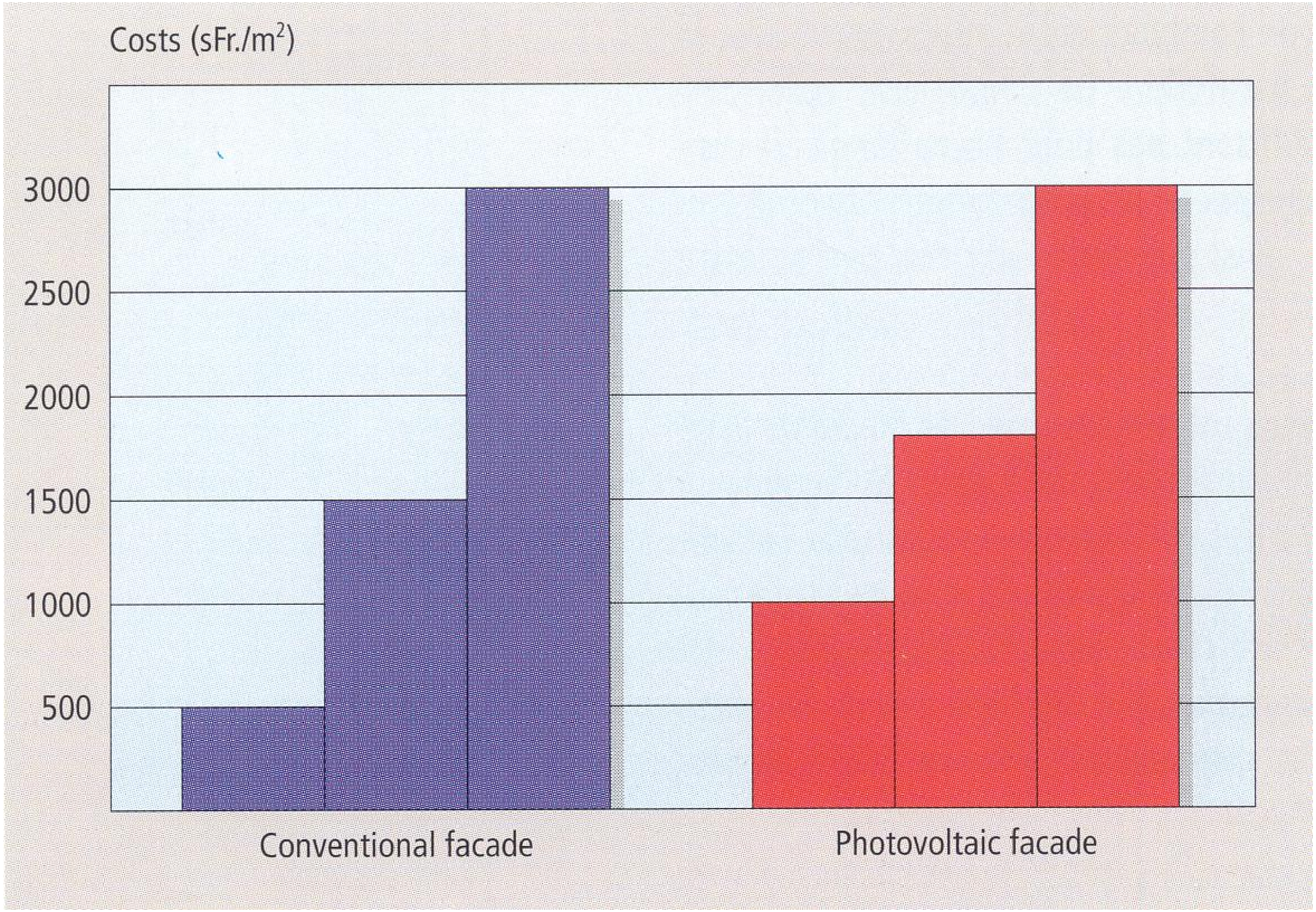
Cost of BIPV

4-8 NOK/kWh, if no subsidies for market introduction are available.

Additional cost vs a glass facade	~ 1000 kr/m2
Max. Energy outcome	~ 100 kWh/m2
	~ 50 kr/m2/year
Energy pay-back times	~ 1-4 years

However, if the BIPV is regarded as building elements, their cost compete with that of the more expensive conventional façade elements, such as natural stone and coloured glass.

Which means one should use PV only if used to give additional advantages/qualities to a project.


Costs (sFr./m2)
3000
2500
2000
1500
1000
500
Conventional facade
Photovoltaic facade

Main PV barriers for architects

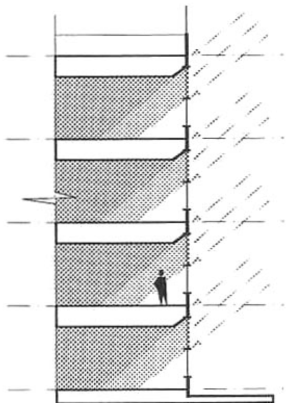
- Technically complex but
  - 2-dimentional
  - static
  - numerous similar products
- Initial competence is expensive
  - Introduced as an engineer application
  - introduced late in the design process
- Conceptually rigid
  - Expensive, but often hidden away
- Associations
- The architect must sell it

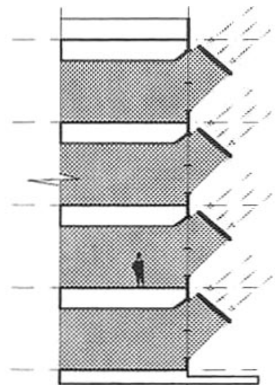
Approach for success

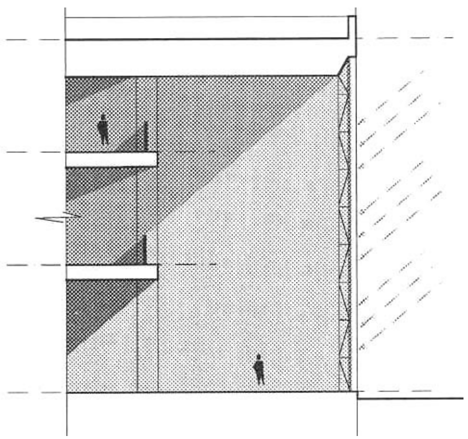
- Work with PV from the language of architecture
  - The system requirements are also design tools
  - Investigation of aesthetical potential
  - Early integration with conceptual development
- Material and technology development and re-thinking
  - Broad product range
  - Broad conceptual possibilities
- System development
  - Compatible products/systems

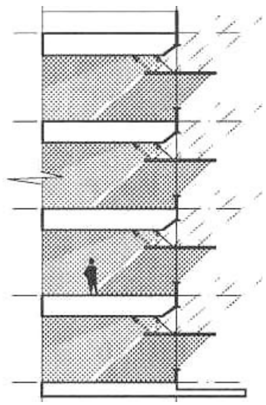
Some BIPV-principles – in walls

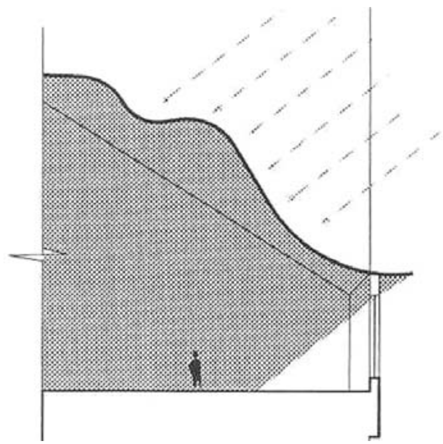
The sketches show some usual ways to use PV in buildings. All examples show PV with sun shading tasks for the interior.





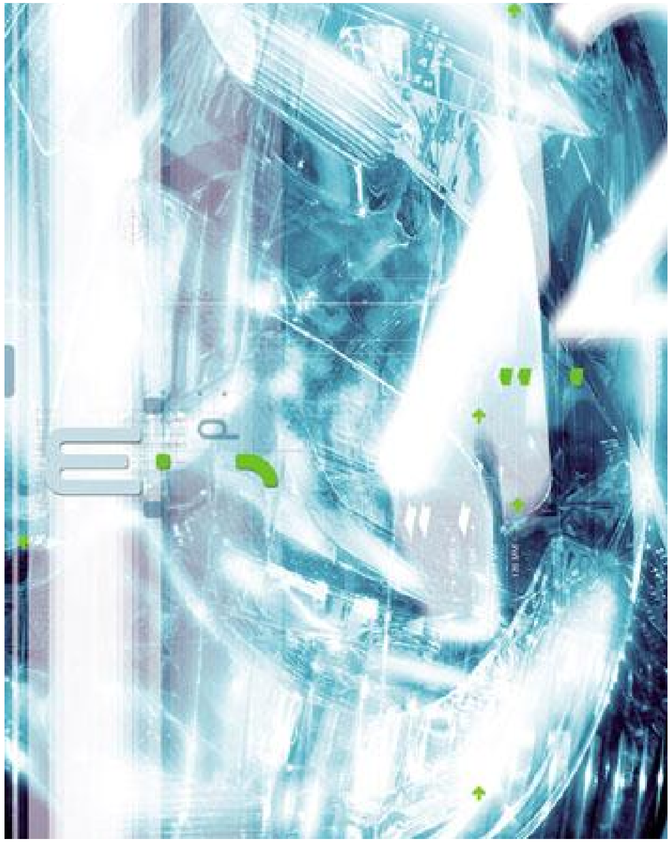
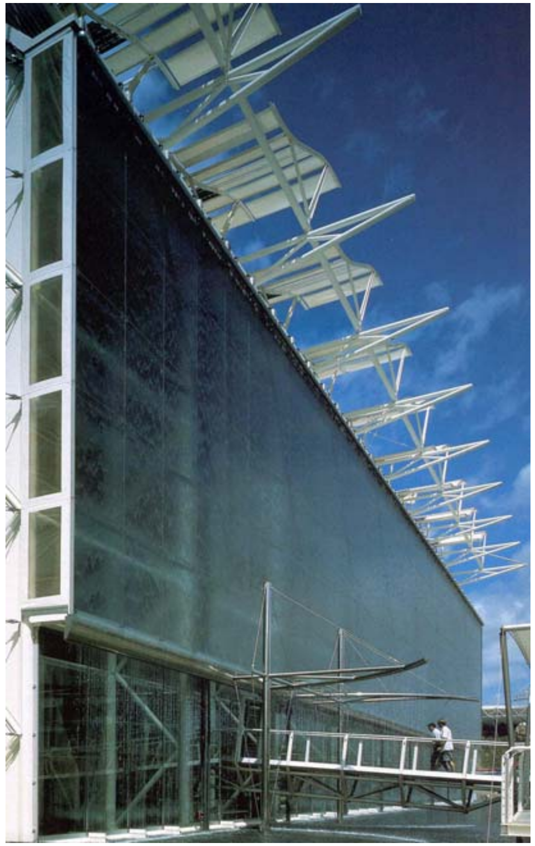
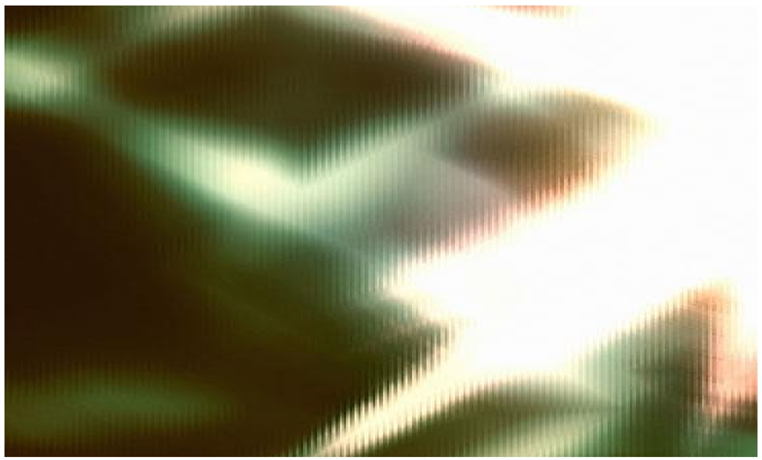
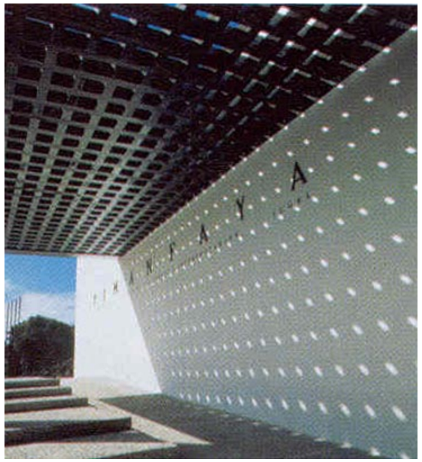






Variations

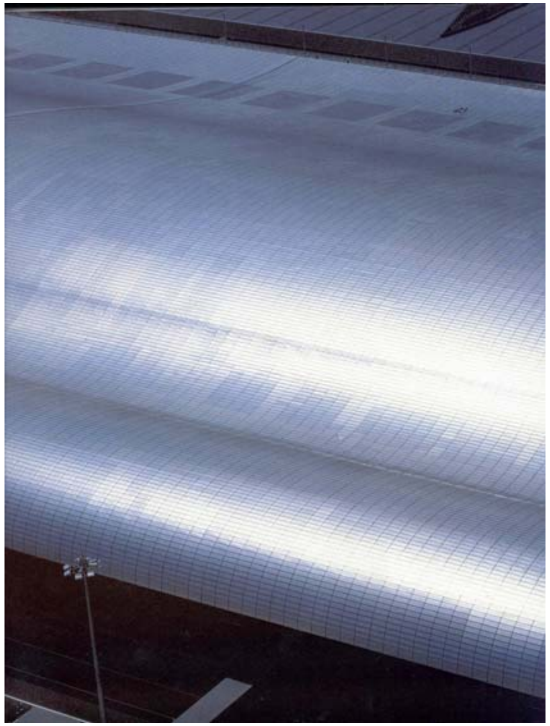
- Light
  - Shadowpatterns
  - Colours
  - Transparency
  - Effects

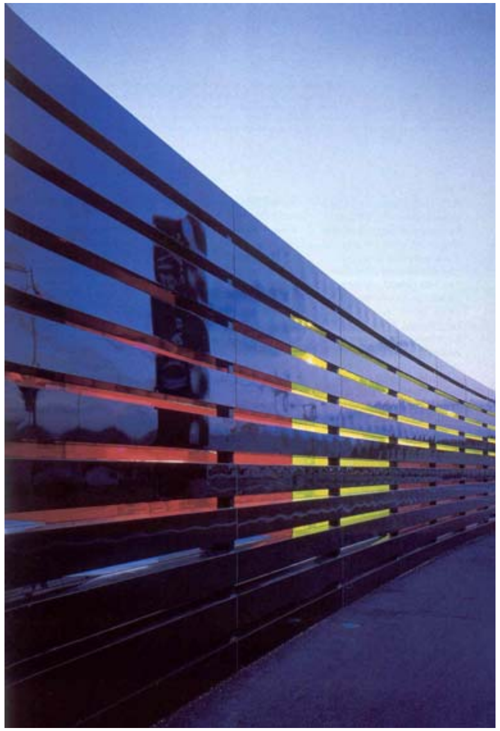






Variations

- Light
  - Shadowpatterns
  - Colours
  - Transparency
  - Effects

- Materials
  - Weight
  - Surfaces
  - Dimensions



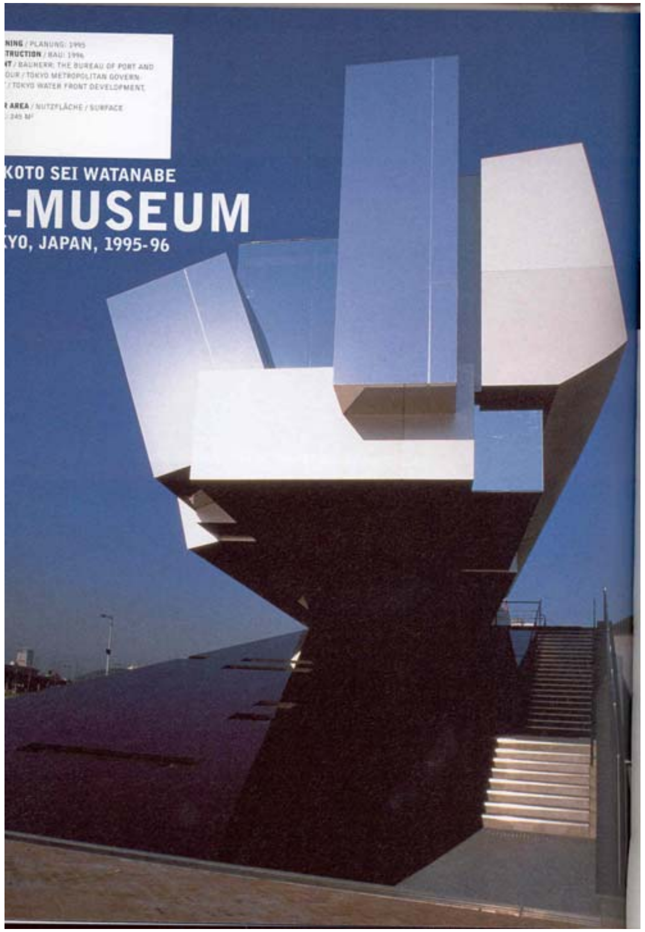


Variations

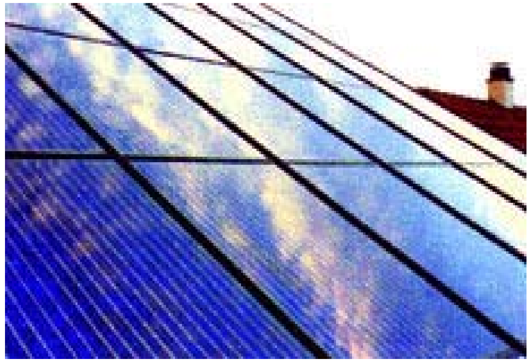
- Light
  - Shadowpatterns
  - Colours
  - Transparency
  - Effects

- Materials
  - Weight
  - Surfaces
  - Dimensions

- Image
  - Materials and detailing
  - System design
  - Placement

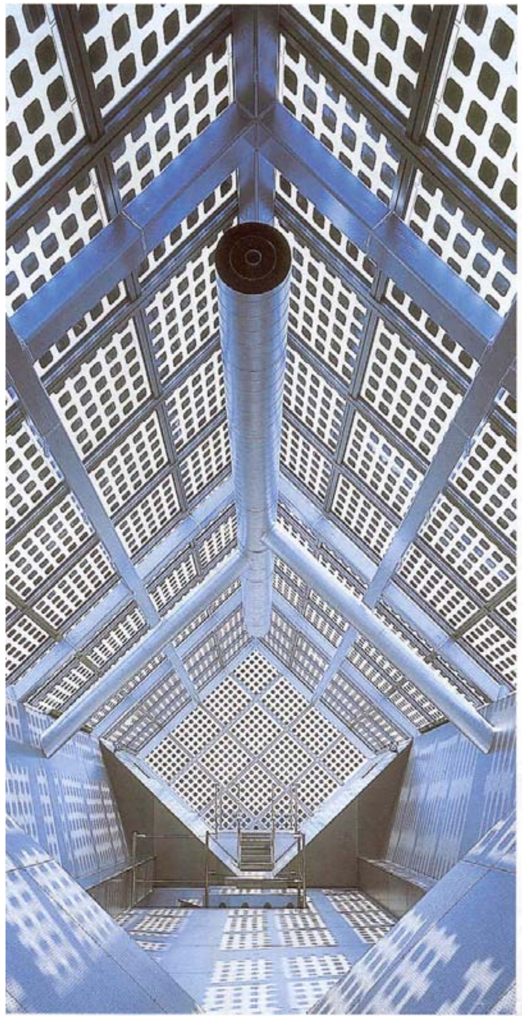


Examples – solid roof



Examples – solid roof

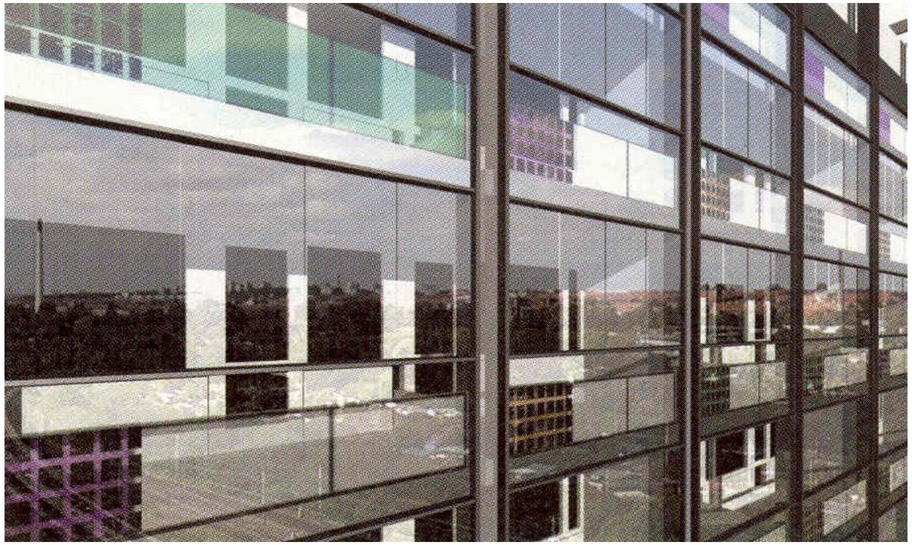
Examples - skylights



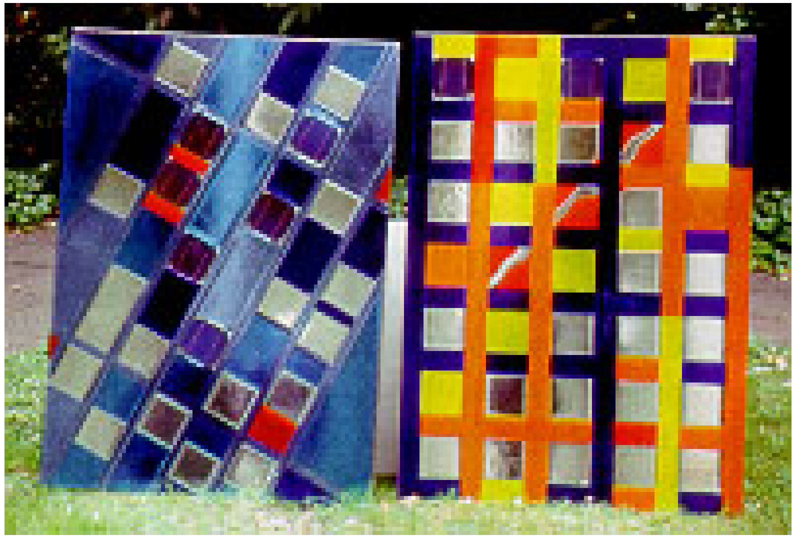
Examples - windows

Examples – walls

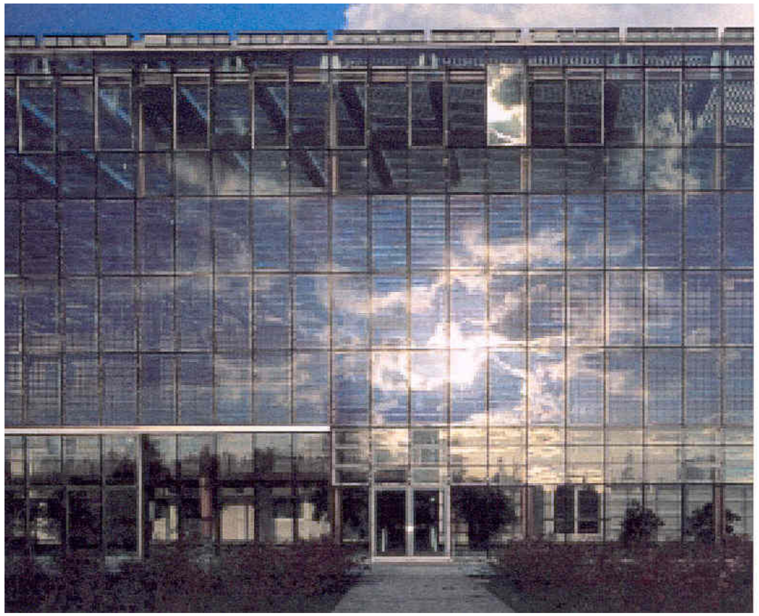
Examples – balconies

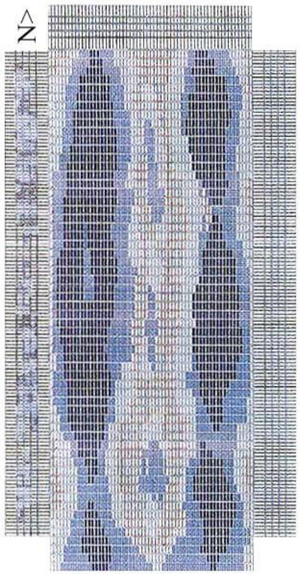


Examples – special installations



Examples – large scale





…and then it's up to you ☺