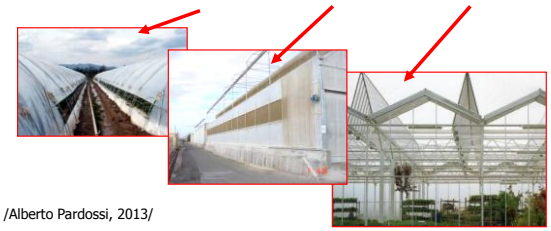
Modern greenhouse technology

Definition of greenhouse

- A **greenhouse** is a specially constructed building for growing plants under controlled conditions.
- It is covered with a transparent material and as such permits entry of natural light.

Greenhouse technology

	Low-tech	Medium-tech	High-tech
• Investment (€/m²)	• < 30	• 30-100	• >100
• Climate control	• Absent/poor	• Fair-advanced	• (Highly-)Advanced
• Mechanisation	• Poor	• Poor-fair	• Advanced
• Automation	• None	• Fair	• Advanced
• Produce quality	• Variable	• Intermediate	• (Very)-high



/Alberto Pardossi, 2013/

Greenhouse design

- **Multi span (gutter connected house) – large, undivided space; easier operation; better heat control, needs less covering material and energy**
- **Poles – metal (aluminium) in concrete footer, their distance is 4,5-5 m**
- **Cross section – A-frame or arched frame (Quonset, Gothic arch, curvilinear, curved eave, dome) ; open-roof concept**
- **Gutter heigth → air volume; bigger is better, how big is still economic?; (minimum 4 m) 5.5 – 6 – 7 m**
- **Span width – at least 8 m (9.6 , 12 m for transplant production)**
- **Double covering?**

Cladding (covering, glazing) materials

- **Glass (3.8 – 4.2 mm) – diffuse type**
- **Flexible film-plastics (100 – 200 µm)**
  - **polyethylene (PE), woven PE, polyvinyl fluoride, polivynil chloride (PVC), ethylene-vinyl acetate(EVA), woven polypropylen (PP)**
- **Rigid plastics**
  - **policarbonate (PC), fiber reinforced polyester (FRP), polymethyl-metachrilate (PMMA)**
- **Plastic mesh**

Characteristics of the ideal plastic sheet covering material 1.

- **at least 5-year lifespan**
- **maximum 200 µm thickness**
- **maximal light transmittance**
- **light transmittance doesn't degrade with time**
- **50% diffuse radiation in the PAR range**
- **UV blocking until 400 nm during the whole lifespan**
- **Near Infra Red blocking in the 800-(1200)-2500 nm range during the whole lifespan**

Characteristics of the ideal covering material 2.

- Far Infra Red transmission max. 10%
- anitdrop (antifog) property during the whole lifespan
- minimal dust accumulation on the surface
- prevents algae growth on the surface
- chemically stable
- great tear resistance

- Multi layered (3, 5, 8?) plastic films

Shading

- The aim is to reduce incoming radiation in order to decrease excessive heat accumulation (the main aim is not to reduce PAR)
- Degrees of shading is 20 to 90%
- Paint and permanent shade screens – reduce PAR regardless of the extent of incoming radiation
- Retractable shade screens – shading effect is adjusted to the extent of incoming radiation

Temperature regulation

- Heating
  - Mainly hot water heating systems: forced water circulation through a network of pipes, which are situating in the air, or on the floor, or in the soil
  - Forced air heating – e.g. heat distribution through perforated polyethylene tubing
- Thermal screen
- Cooling
  - Ventilation – natural, forced
  - Fogging
  - Pad and fan
  - Heat-pump, heat-exchanger → (semi)-closed house

(Semi)-closed greenhouse

- Designed for improving resource use efficiency
- The concept design consists of an active cooling system and temporary heat storage in an aquifer. Air is cooled, heated and dehumidified by air treatment units.
- A closed house has higher cooling capacity.

(Semi)-closed greenhouse

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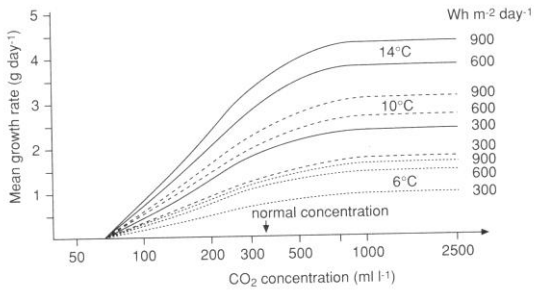
- The concept design consists of an active cooling system and temporary heat storage in an aquifer. Air is cooled, heated and dehumidified by air treatment units.
- A closed house has higher cooling capacity.
- There are 90% less window for ventilation.
- During summer combination of high CO_2 (1000 ppm) and high radiation is possible to achieve
- Air is distributed by ducts. The resulting overpressure prevents insects from flying in.

CO_2 enrichment



/Mann, 1987/