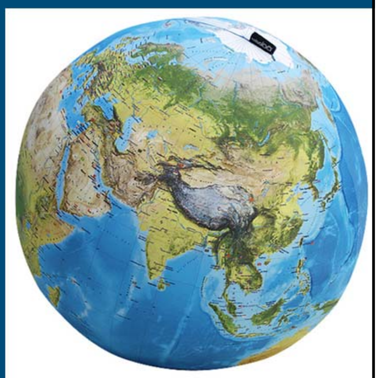
Sustainable greenhouse design – optimum use of resources

S. Hemming Wageningen UR Greenhouse Horticulture
silke.hemming@wur.nl

WAGENINGEN UR
For quality of life

Trends world-wide

- Decrease of availability natural sources (water, gas/oil, fertilizers)
- Increase world population till 2050 from 6 to 9 billion heads
- Consumers more critical
- Strong economic development new countries
- Internationalisation of trade



WAGENINGEN UR
For quality of life

source: GREEN Q

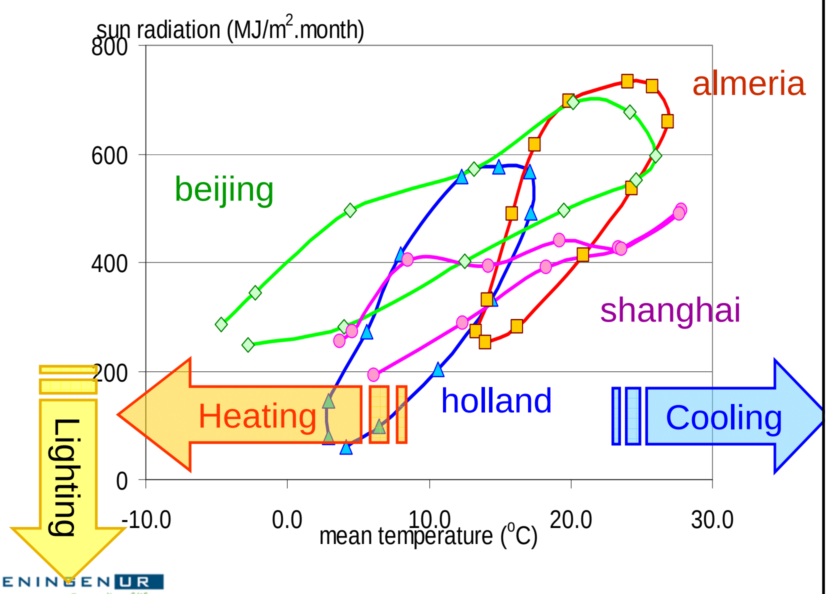
Trends world-wide – greenhouse production

- New production areas are coming up
- From open field production to more protected systems
- Low tech and mid tech growing systems have biggest areas, but move to high tech
- Modern greenhouse industry in Western Europe and US develops more and more to year round production with high quality

WAGENINGEN UR For quality of life

source: GREEN Q

Environmental conditions: different worldwide



WAGENINGEN UR For quality of life

Major challenge

- Design greenhouse systems which combine (economic) production efficiency with minimal input of energy, water and nutrients for different regions in the world:

The "Adaptive Greenhouse"

WAGENINGEN UR
For quality of life

Requirements and objectives

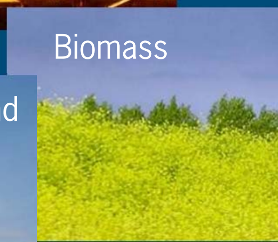
- Requirements*:
  - Market size and regional infrastructure
  - Local climate
  - Availability, type and costs of fuels and electric power
  - Availability and quality of water
  - Soil quality and topography
  - Availability and cost of land, zoning restrictions
  - Availability of capital
  - The availability and cost of labour and the level of education
  - The availability of materials, equipment and service level
  - Legislation in terms of food safety, residuals of chemicals, the use and emission of chemicals to soil, water and air

*Hanan, 1998 and Van Heurn and Van der Post, 2004

WAGENINGEN UR
For quality of life

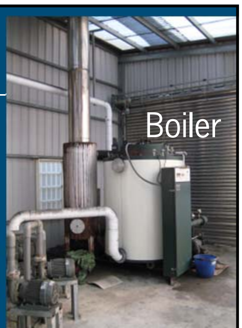
Functions and working principles

- Required functions:
  - Energy supply
  - …
  - …



Functions and working principles

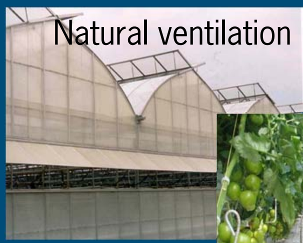
- Required functions:
  - Energy supply
  - Heating
  - …
  - …

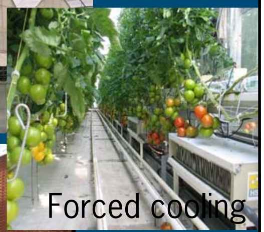


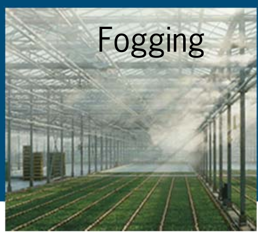
Waste heat from industry

Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - …
  - …



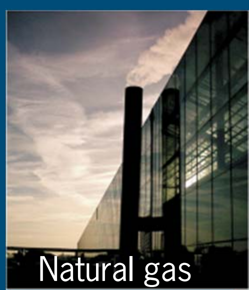




WAGENINGEN UR
For quality of life

Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - …
  - …

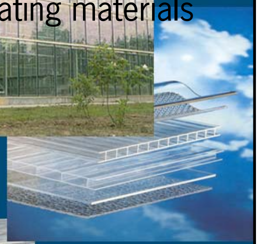


Pipeline from industry

WAGENINGEN UR
For quality of life

Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Covering and screens
  - …
  - …




WAGENINGEN UR
For quality of life

Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Covering and screeens
  - Additional light
  - …
  - …

WAGENINGEN UR
For quality of life

Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Covering and screens
  - Additional light
  - Growing systems
  - …

WAGENINGEN UR For quality of life

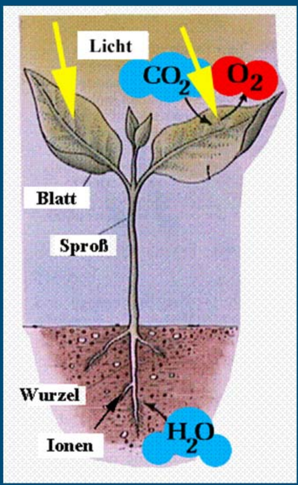
Sustainable greenhouse production in Taiwan

- Design greenhouse systems which combine (economic) production efficiency with minimal input of energy, water and nutrients

- High **production**, product quality, predictability
- High **energy** efficiency and use of sustainble energy
- Low pesticide use, high food safety
- High **water** use efficiency, low nutrient losses
- High ratio benefit – costs of the production system

WAGENINGEN UR For quality of life

Sustainable crop production



- CO_2 + water + light → sugar + O_2
- Sugars and nutrients are used for growth
- Growth → yield
- Reactions are temperature dependent

→ control growth factors at same time
→ CO_2 needed for high production!

WAGENINGEN UR *For quality of life*

Resource use - CO_2

Case	Natural ventilation	Natural ventilation with CO_2	Active cooling
Biomass (dry matter)	3.9 kg	5.4 kg	7.9 kg
CO_2 dosing	-	41.9 kg	12.3 kg

Example tomato crop in Taiwan

WAGENINGEN UR *For quality of life*

Resource use - CO_2

- Cover CO_2 demand
  - → use of waste CO_2 form other processes such as oil industry
  - → extract CO_2 from geothermal sources?

WAGENINGEN UR For quality of life

Resource use - energy

Case	Natural ventilation	Pad and fan	Active cooling and heat pump
Biomass (dry matter)	3.9 kg	5.0 kg	7.9 kg
Heating	141 MJ	187 MJ	462 MJ
Cooling	-	-	2500 MJ
Electricity use	-	92 MJ	800 MJ (COP =3)

Example tomato crop in Taiwan

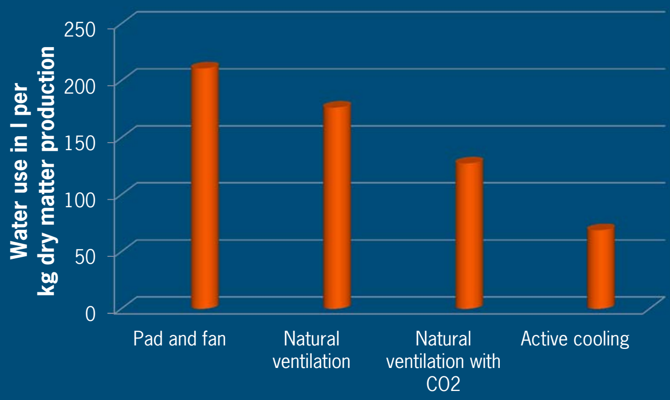
WAGENINGEN UR For quality of life

Resource use - energy

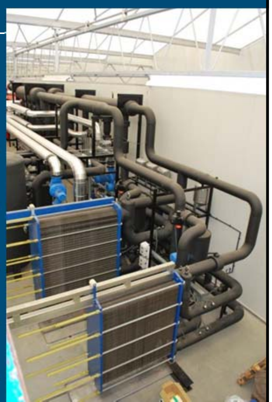
- Cover heating demand
  - → use waste heat from industry
  - → use ground heat
  - → use heat extracted from river/lake/deep sea
- Cover cooling demand
  - → deliver waste heat to mushroom production
  - → deliver waste heat to other industry?

WAGENINGEN UR
For quality of life

Resource use - water



Example tomato crop in Taiwan



WAGENINGEN UR
For quality of life

Resource use - water

- Collect rain water
  - (rainfall in Taiwan ca. 1700 mm,
    consumption 800-1300 mm depending on system and crop)
  - → deliver surplus to others?
- Recirculate irrigation water

Resource use

- Basic idea: Provide greenhouses with resources needed
- Principle: Share resources with others only if useful!

Wageningen UR Greenhouse Horticulture

WAGENINGEN UR
For quality of life