Adaptive greenhouse: Greenhouse design based on local boundary conditions

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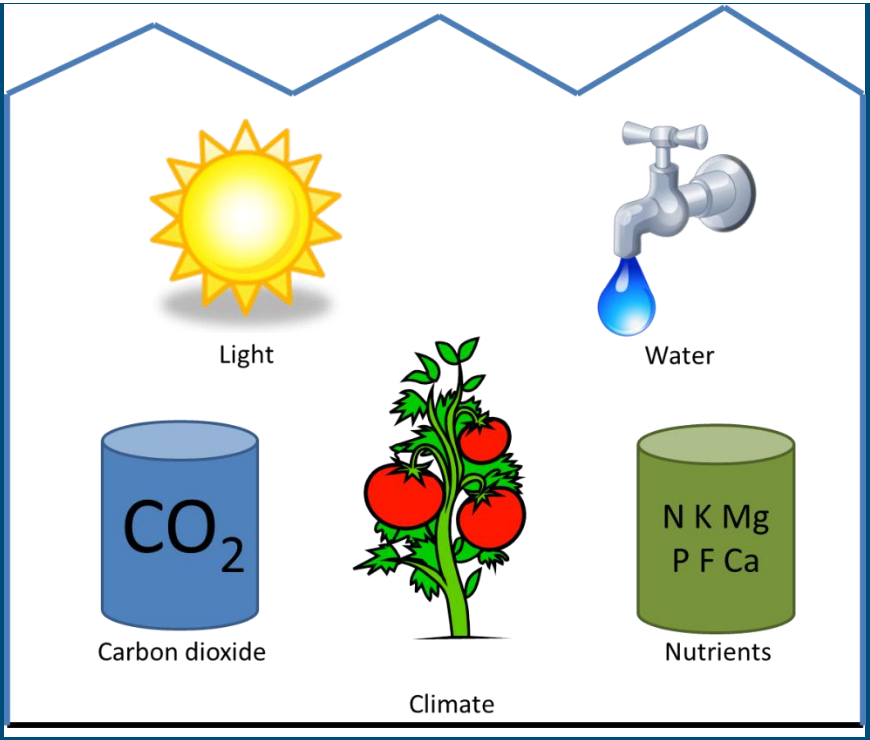
Outside vs. inside: 17 vs. 45 kg m^{-2} y^{-1}

A greenhouse protects a crop against adverse conditions

Basics needs of the crop



- Light
- Water
- CO_2
- Nutrients
- Temperature
- Relative humidity

} homogeneous (Temperature, Relative humidity)

These parameters can be optimised in a greenhouse

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"

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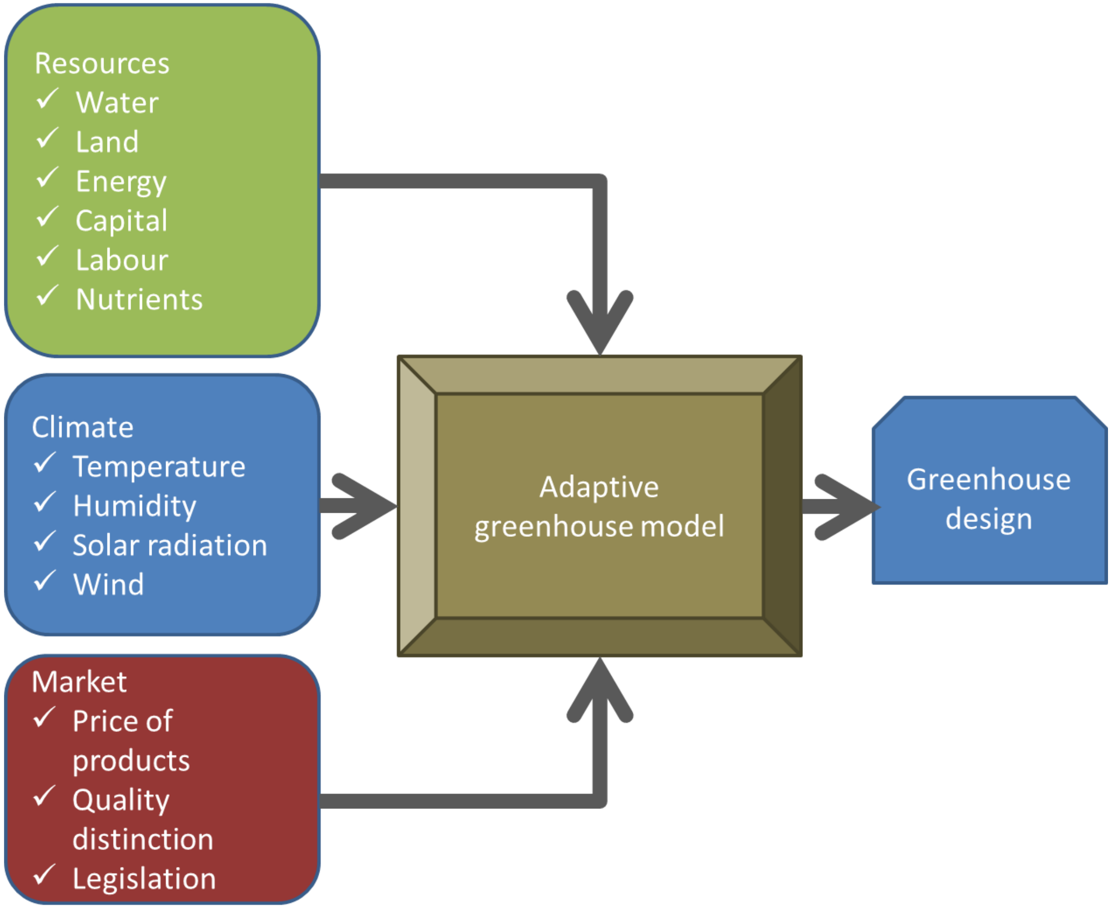
Adaptive greenhouse design scheme



Step 1 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

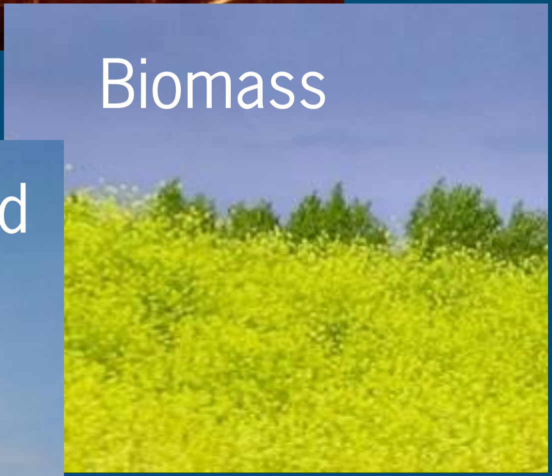
*Hanan, 1998 and Van Heurn and Van der Post, 2004

Step 1 Requirements and objectives

- Objectives:
  - Reduction of energy
  - Minimal water use
  - Better production
  - Better quality
  - ....

Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - …
  - …

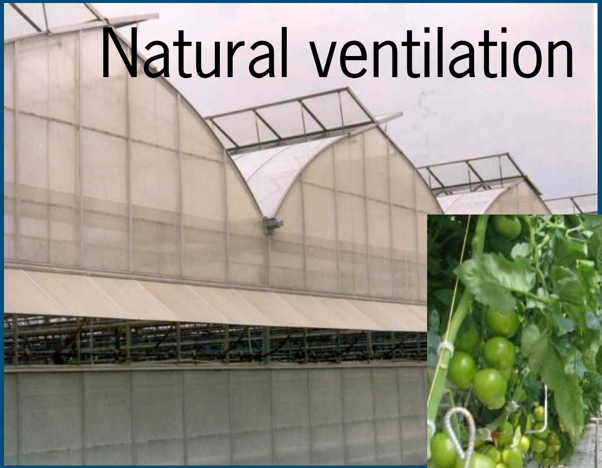


Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - ...
  - ...

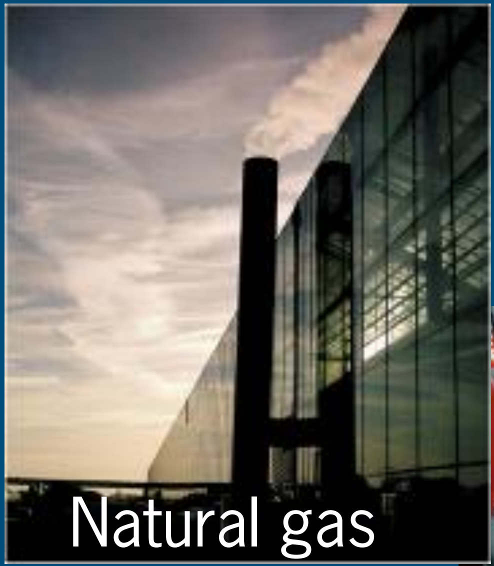
Step 2: Functions and working principles

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



Step 2: Functions and working principles

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



Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - …
  - …

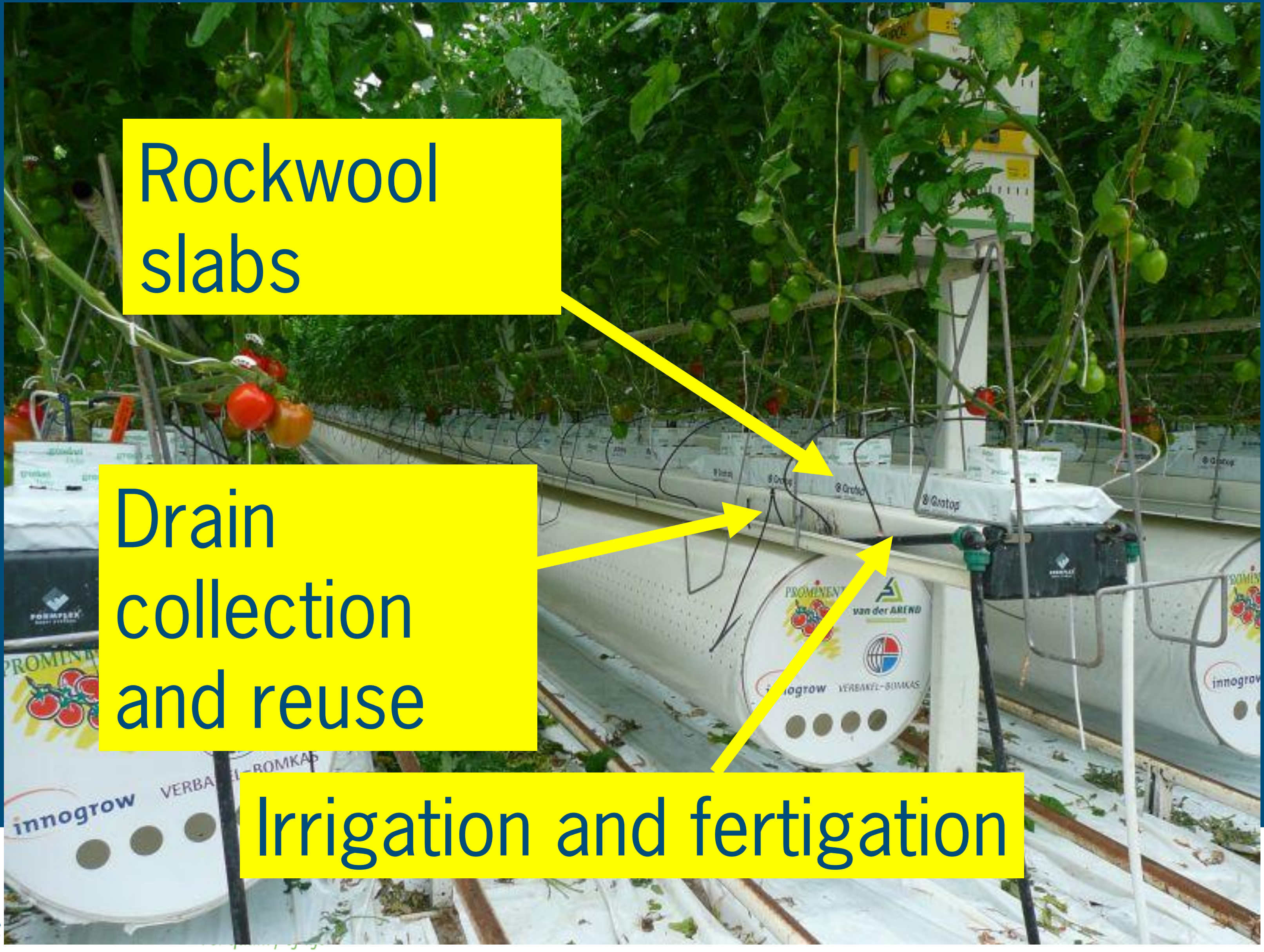
Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - …
  - …

Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - Cultivation systems
  - …

Hydroponics / soilless culture



Fertigation unit and water treatment

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Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - Cultivation systems
  - Crop protection
  - .....


Chemicals

or IPM

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Robotics

Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - Cultivation systems
  - Crop protection
  - Labour

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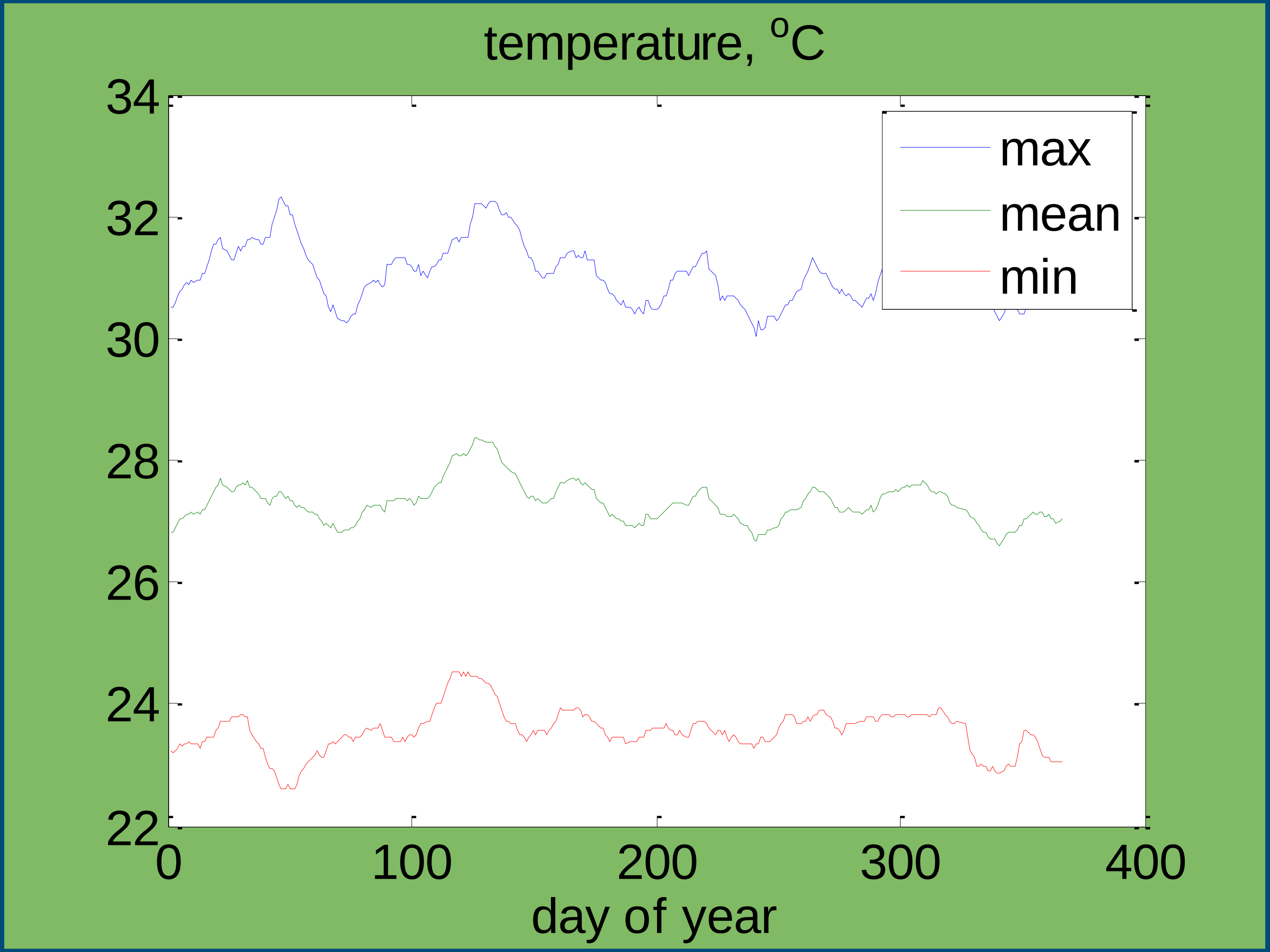
Implementation

- Market
- Management
- Capacity building
- Commitment
- Communication

Design example: Low cost passive greenhouses

- Example Lowlands of Malaysia
  - Low investment cost
  - High outside temperatures
  - High radiation levels
  - Fluctuation in wind speed and direction
  - Application of biological control
  - Proper fertigation using recirculation

Yearly temperature in Malaysia



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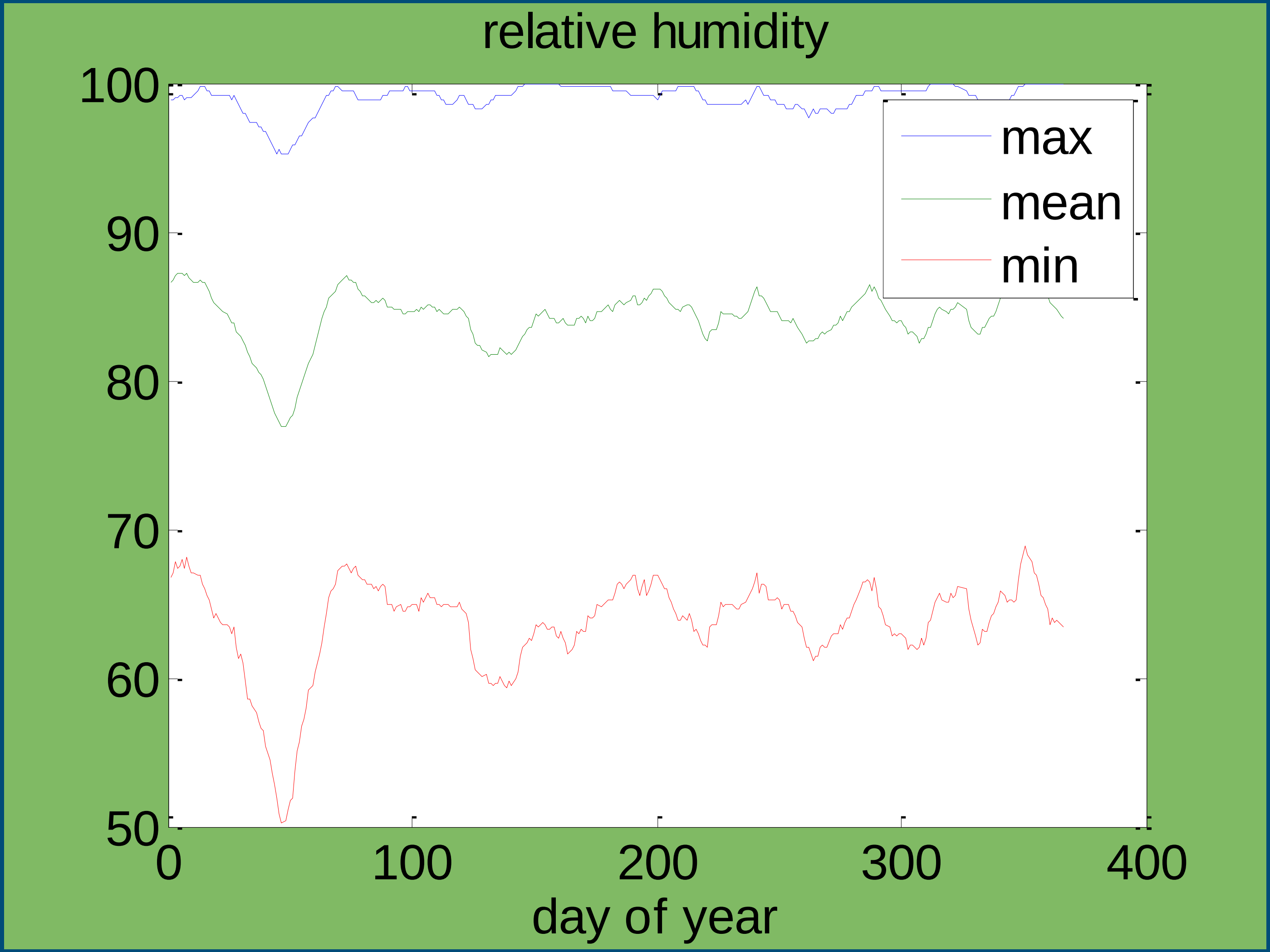
Relative humidity in Malaysia



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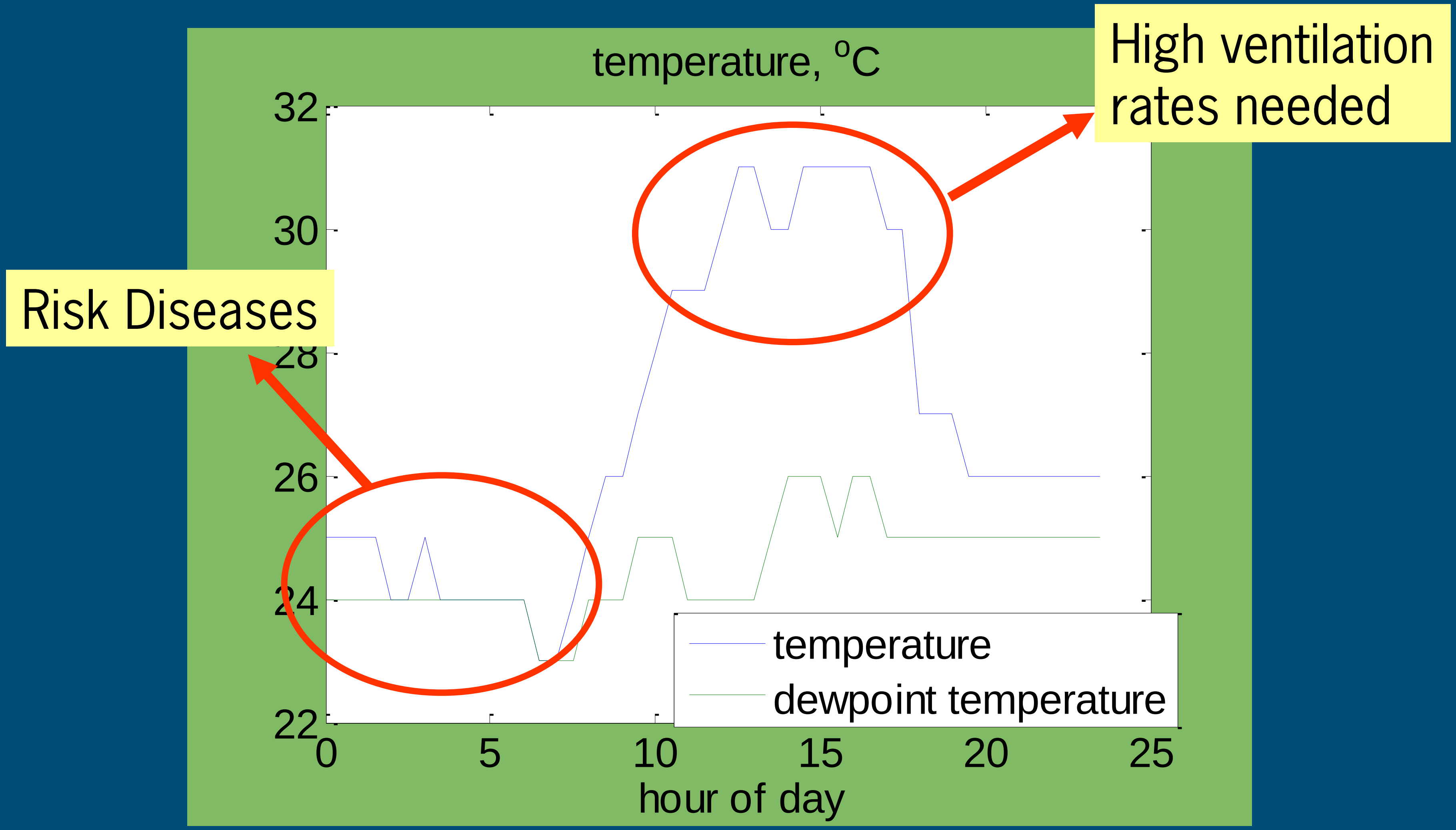
Daily temperature in Malaysia

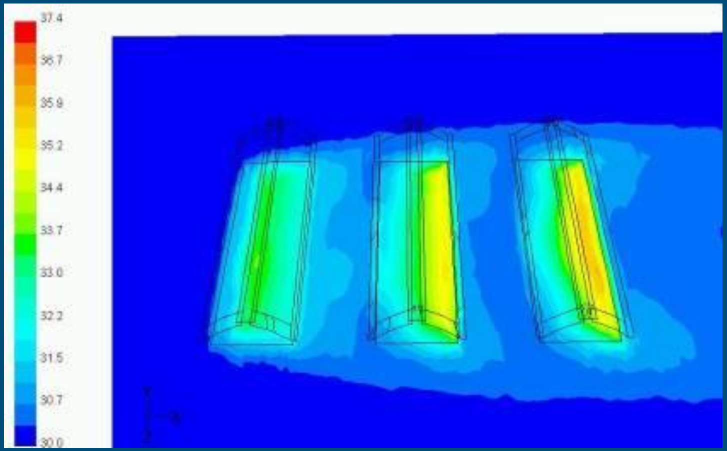


Climate restrains

- Outside temperature is within limits but the greenhouse has to be ventilated extensively
- Evaporative cooling is done by the crop

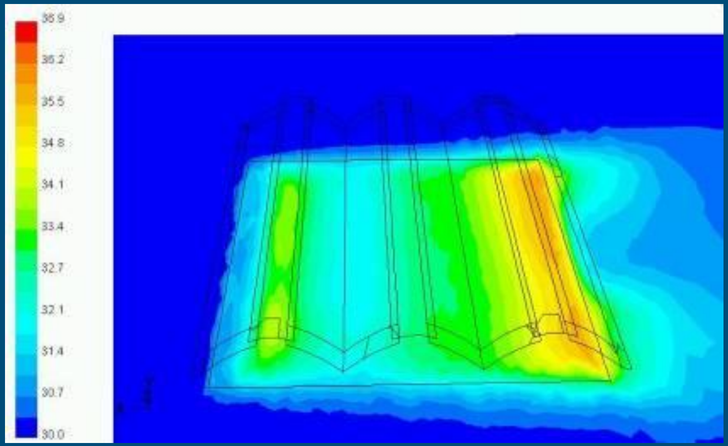
Design example: Low cost passive greenhouses

Computational fluid dynamics simulations are used in the design process



Temperature:

Configuration	3 m/s wind	No wind
single greenhouses	31.3	33.5
	31.4	33.6
	31.3	33.6
multi-span	32.1	33.8



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Open top en side vents for maximum ventilation

High light transmissivity with diffusing cover

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Pollination using bees is possible due to the air tightness

Demonstration results


Local materials

Dutch computers


Monitoring


Crop growth


Fruit ripening


Harvest

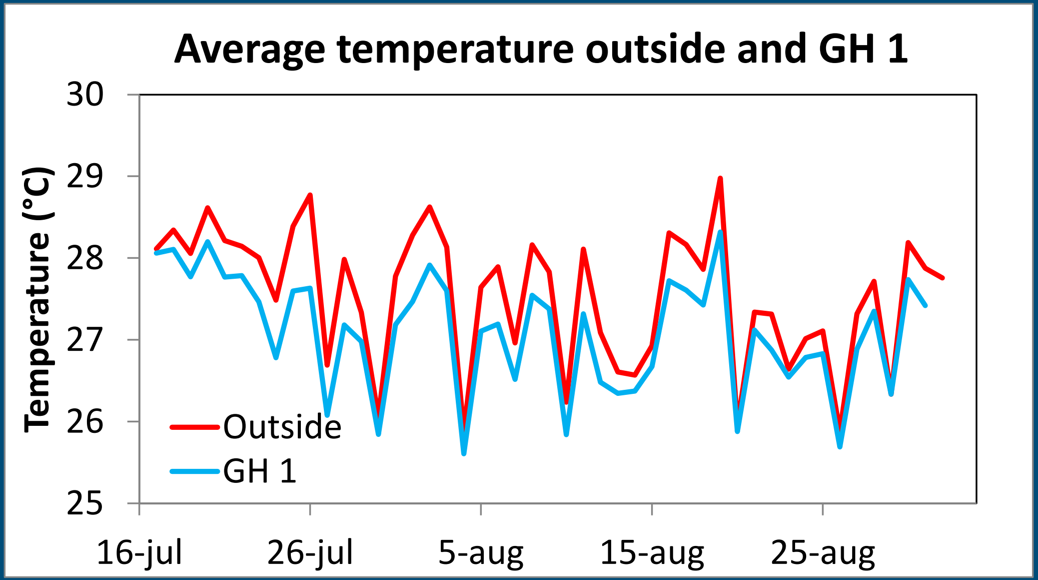
Collaboration in innovation processes

Department of Agriculture
Asian Perlite Industries
WUR

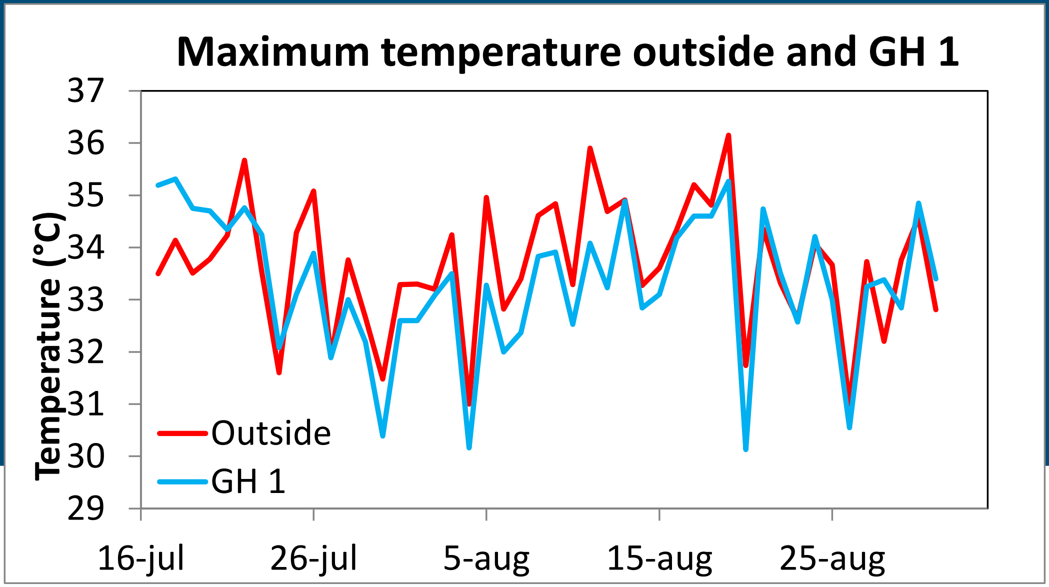
Farmers

Dutch government

The proof of the pudding



temperature GH < temperature outside



Business case

- Pay-back time 3-4 years

Science applied

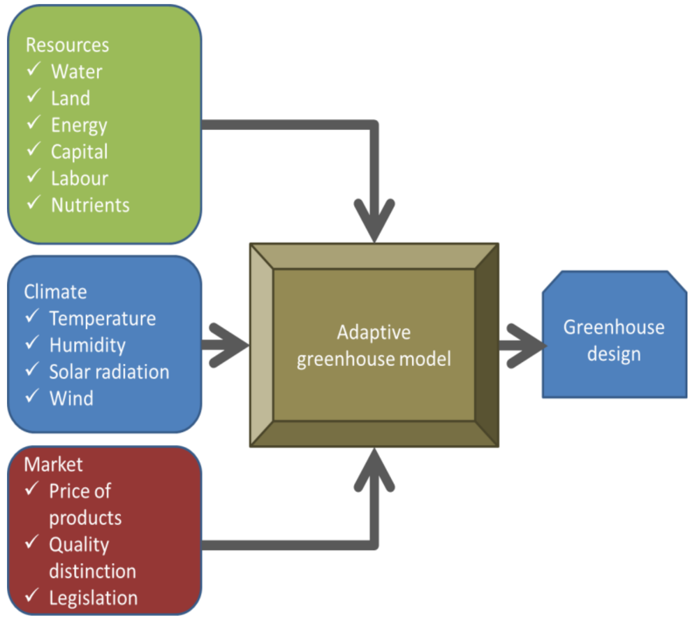
- Indonesia:
  - First demo
  - Dr. Impron: 'A Greenhouse Crop Production System for Tropical Lowland Conditions'
    - PhD at WUR
    - 4 refereed journal articles

- Malaysia: bringing into practice
- Thailand: a re-design?

In short

The design of efficient greenhouses requires:

- A market analysis on products and prices
- Location specific parameters (climate, resources and legislation)
- Other goals being economically viable like sustainability and food safety



Adaptive greenhouse design:

for optimal results world wide

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