Energy transition & decarbonisation in greenhouses - update from the Netherlands

Info from Greentech 2023 in Amsterdam

Thanks tomatoes NZ, Vegetables NZ, EECA

Elly Nederhoff Ellynederhoff@gmail.com Christchurch – 2 Aug 2023

COSTS OF ENERGY & CO2 EMISSION IN NL - Extremely high in Aug. '22

DUTCH GLASSHOUSE INDUSTRY - ENERGY

1970s: Natural Gas and oil. Energy crisis. First work on energy efficiency.

2005: 100% Natural Gas, mostly with CHP. Electricity sold. Use of natural gas very high.

2010: Start of '***The new way of growing***' aka '***Growing by Plant Empowerment***'
AIM: Reducing energy input while maintaining productivity.

2023: 'The new way of growing' is adopted. ETS for glasshouses starts. CO2 targets set.

2050: zero carbon emission – zero fossil fuels (target)

2010 – 2050: **reducing energy consumption and transition to new energy sources**

Topics today: Fuels, Boilers, Mechanical ventilation, ATU's, Humidity, CO2

Not discussed: Energy screen, lighting with LED, and more.

FUELS,
SOURCES
OF ENERGY & HEAT

FUELS / ENERGY SOURCES USED IN GLASSHOUSES in NL

2021

Natural gas (most CHP) 70%

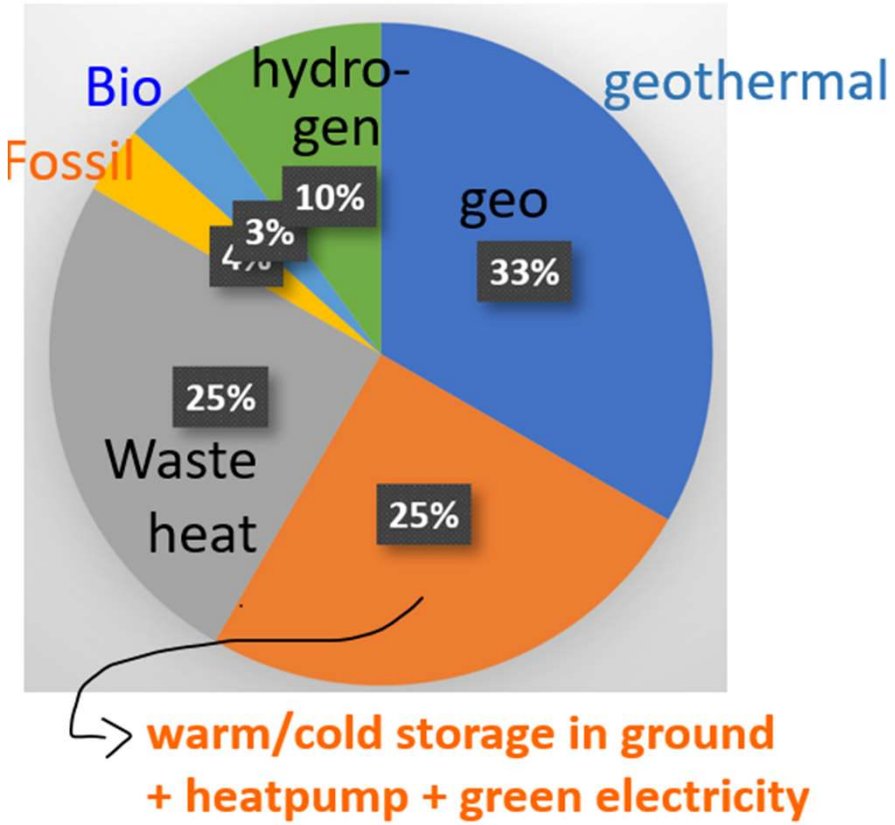
Heat without CO2 emission
(geothermal,
industrial waste heat) 21%

Other sustainable (bio) 11%

Electricity (more sold than used)
negative 3.6 TerraWattHour

Can't make pie-chart with a negative value in it.

Goal for 2040



ELECTRIFICATION

https://overmorgen.nl/waar-wij-aan-werken/zon-en-wind/

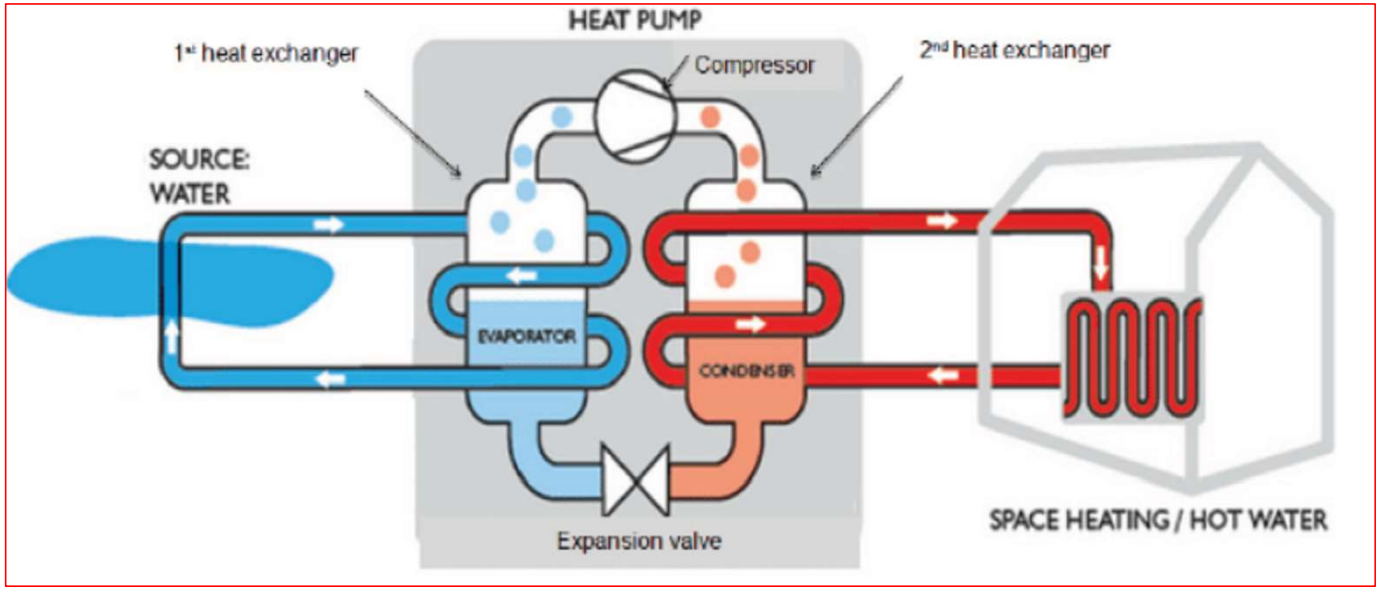
- Huge power production from solar & wind (sustainable electricity or green electricity)
- and power production from CHP's in glasshouses (not sustainable electricity)
- Supply & demand is a balancing act → price fluctuation (per half hour or shorter)
- Sometimes **negative price**: growers **get paid** for electricity consumption & stand-by
- Then they use power to make heat & store it underground, or switch lights on (needless)

ELECTRIFICATION - very common

green electricity + heat pump + low-temperature heat (tepid water or air)

Heat source: industrial wastewater, or water from own underground heat store, or heat from water dam, etc.

Heat pump: COP 3-5. Thus power input 1 kW → heat output 3 – 5 kW

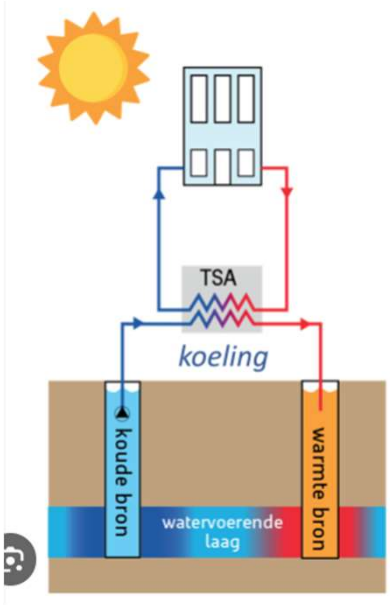


OPTIONS:

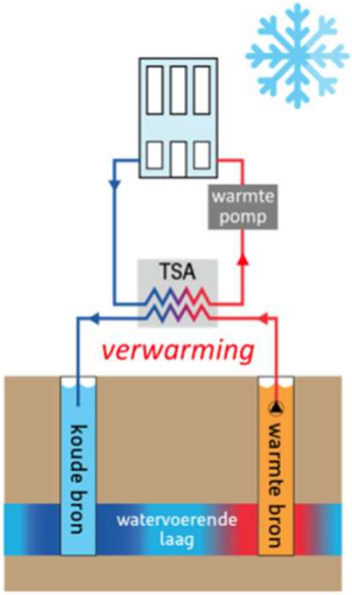
- ***water to water*** *(most efficient)*
- ***water to air***
- ***air to air***
- ***(air to water)*** *less efficient & expensive*

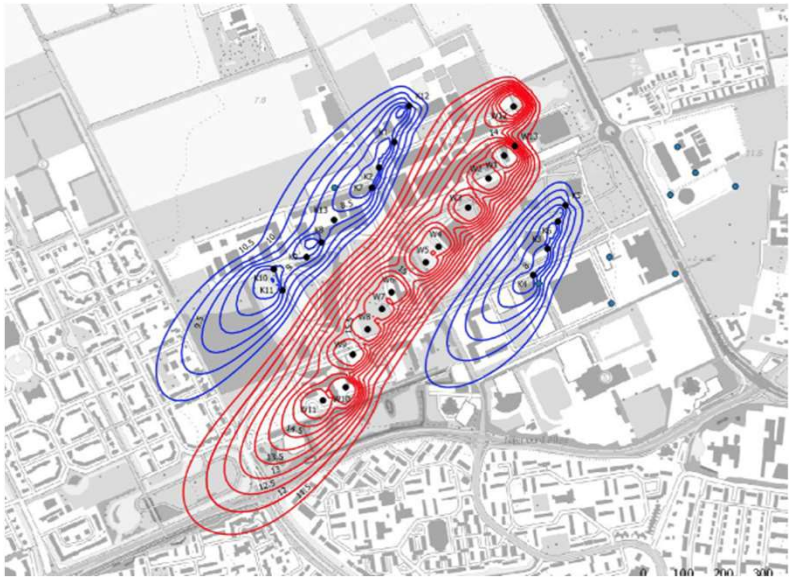
HEAT / COLD STORAGE IN THE GROUND
(some hundred meters deep) – very common!

Summer: surplus
heat from GH stored



Winter: lukewarm
water pumped up





Heat exchangers and heat pumps needed

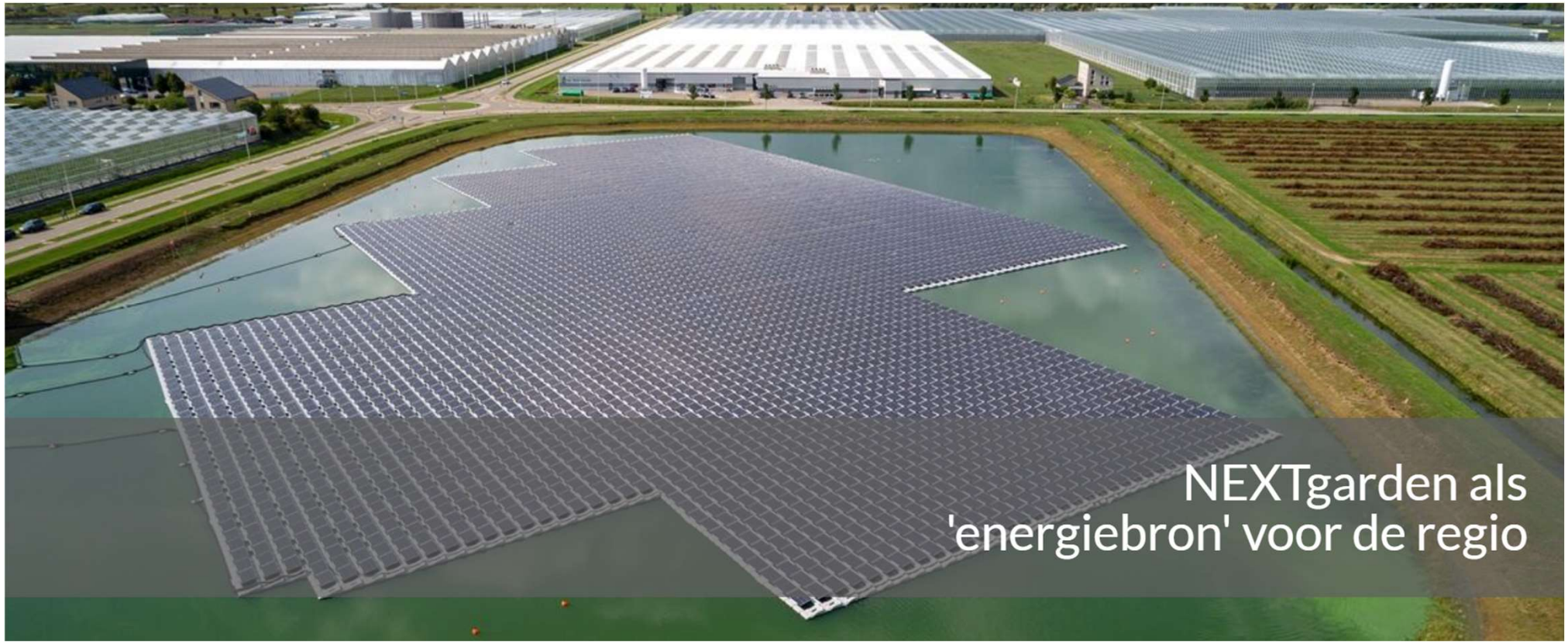
CLUSTER OF GLASSHOUSE BUSINESSES - eg 'NEXT garden' in Lingewaard (NL); 735 ha

Their aim: carbon neutral / fossil fuel free in 2030. Sources: sun, wind, bio waste.

Future: geothermal; wind to heat; solar to heat; underground heat storage; heat net

FLOATING SOLAR PARK (in cluster NEXTgarden)

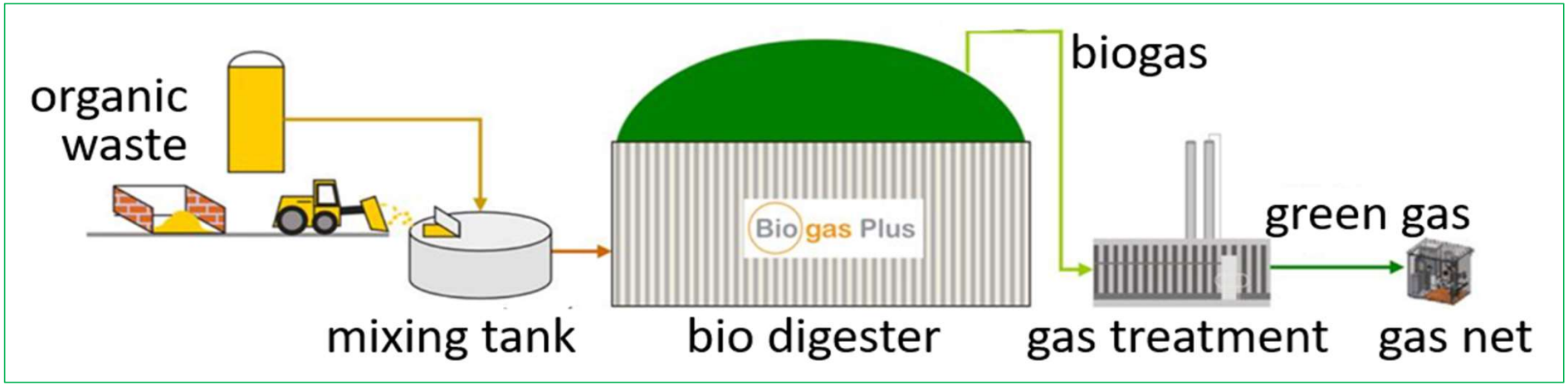
- pond for closed irrigation water circuit
- 6,150 solar panels
- 13 MegaWatt
- also panels on roofs
- produce electricity for heatpumps and lighting + 600 households




POWER PLANT WITH CO-GENERATION
FIRED BY BIOMASS FROM FORESTRY
in 'NEXTgarden' in Lingewaard (NL)
built by HoSt group
heat & CO2
for glasshouses;
electricity partly
to grid

BIOGAS FROM ORGANIC WASTE DIGESTION (in NEXTgarden)

- 72,000 tons of biomass per year
- grass, manure, waste from horticulture
- 6,9 million m^3 green gas
- 10,000 people get gas from here
- CO2 is used, CO2 emission reduced



SOURCES OF ENERGY / HEAT in NL in 2021

#1 Natural Gas in CHP. Growers utilise heat, power, CO2. No other industry does that!

CLUSTERS (hundreds of hectares of glasshouses) use combination of heat sources:

SOURCES: (1) Geothermal **+** (2) industrial waste heat **+** (3) electricity* **+** (4) gas/CHP **+** (5) bio-boiler **+** (6) storage in buffers **+** (7) storage in the ground

STAND-ALONE GLASSHOUSES (not clustered) use mostly 1 or 2 sources:

SOURCES: (1) natural gas in CHP** **or** (2) biomass/gas, (3) electricity*, storage

* Electricity from solar & wind, used in heat pumps, also for lighting (common in NL)

ISSUE: no CO2 is available from geo, waste heat, electricity, (hydrogen in future)

(repeat): FUELS / ENERGY SOURCES USED IN GLASSHOUSES in NL

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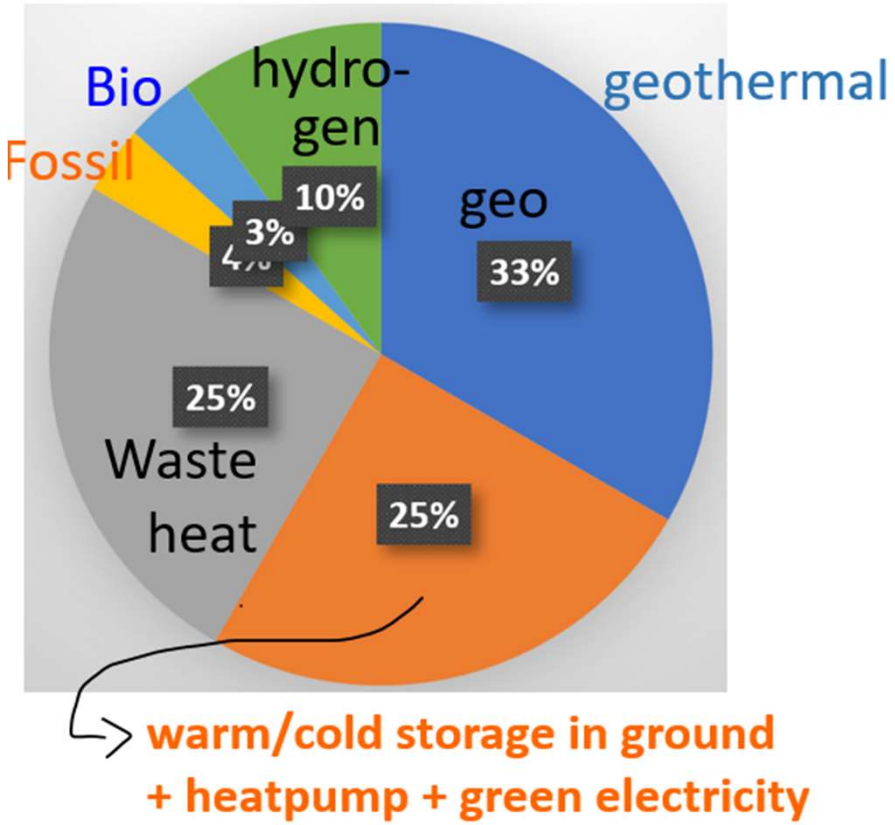
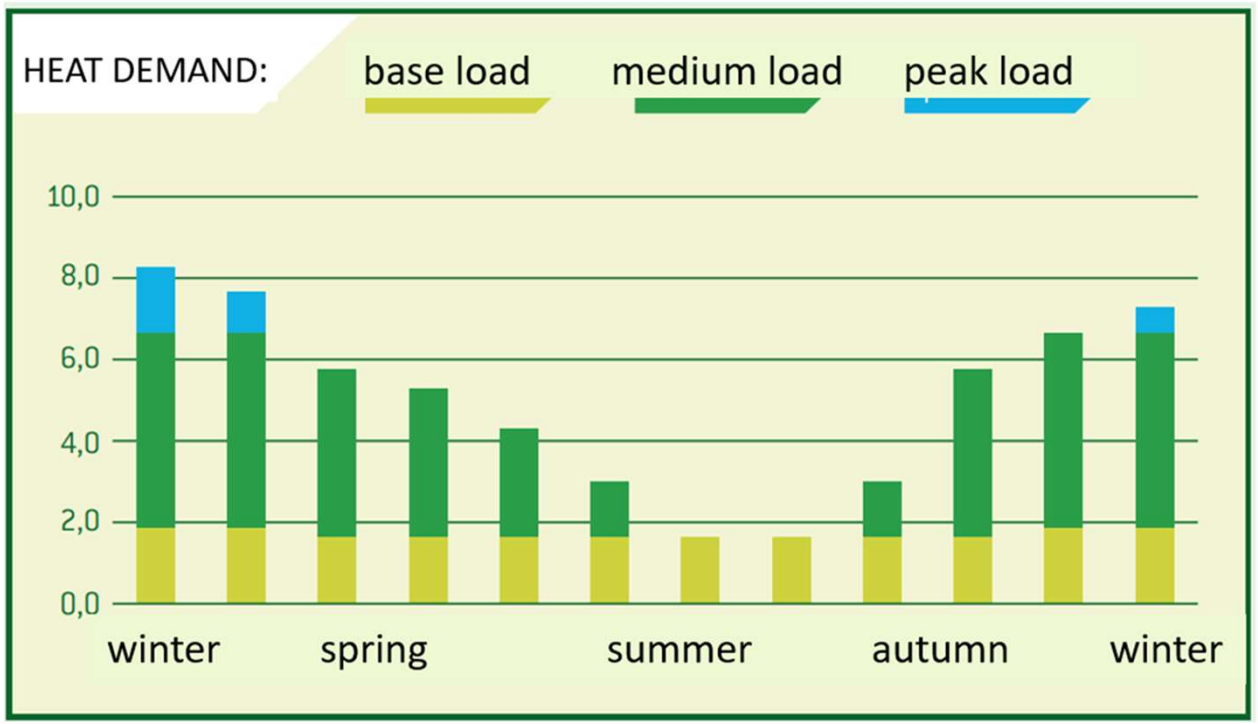


BOILERS

There is more variety in
capacity and fuels now then ever before.

Brands/models shown are random examples.
There are many more brands on the market

HEAT DEMAND BREAKDOWN



Peaks in winter:
electric heat pump
or small boiler (gas*, electr.)

Medium (spring, autumn):
Gas*, Biomass. Difficult!

Base load all year round:
In Netherlands: gas (CHP)*
geo, waste heat, biomass

* *Natural gas will be phased out*

https://www.glastuinbouwnederland.nl/content/glastuinbouwnederland/docs/Verantwoorde_Glastuinbouw/Visiedocumenten_2023/Visiedocument_Energie_2023.pdf

ELECTRIC BIOLERS

One brand, 20 models/sizes:

(Zantingh, NL), manufacturer Varmeteknikk, Norway)

Wattage:	375 - 1200 kiloWatt (1.2 MW)
Voltage:	230, 400 or 690 Volt
Water volume:	310 - 620 liter
Size from:	0.7 x 1.3 x 1.3 meter
Temperature, 30 steps:	5 - 100 °C
Max pressure:	6 bar, optional 16 bar

Many more brands & models, small to medium

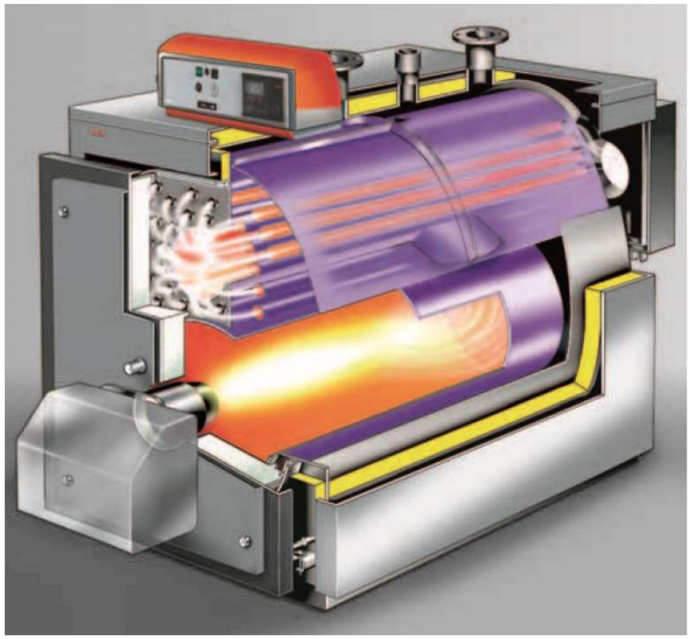
VERY SMALL GAS / OIL BOILER (65 - 730 kW)

Unical ZANTINGH TRIOPREX N.

High efficienty boiler (> 91%)
Suitable for low NOx burner (< 120 mg/kWh)
Burner comes separate (gas, oil)

From Zanthing (NL), manufactured by Unigas (Italy)

burner sold separately



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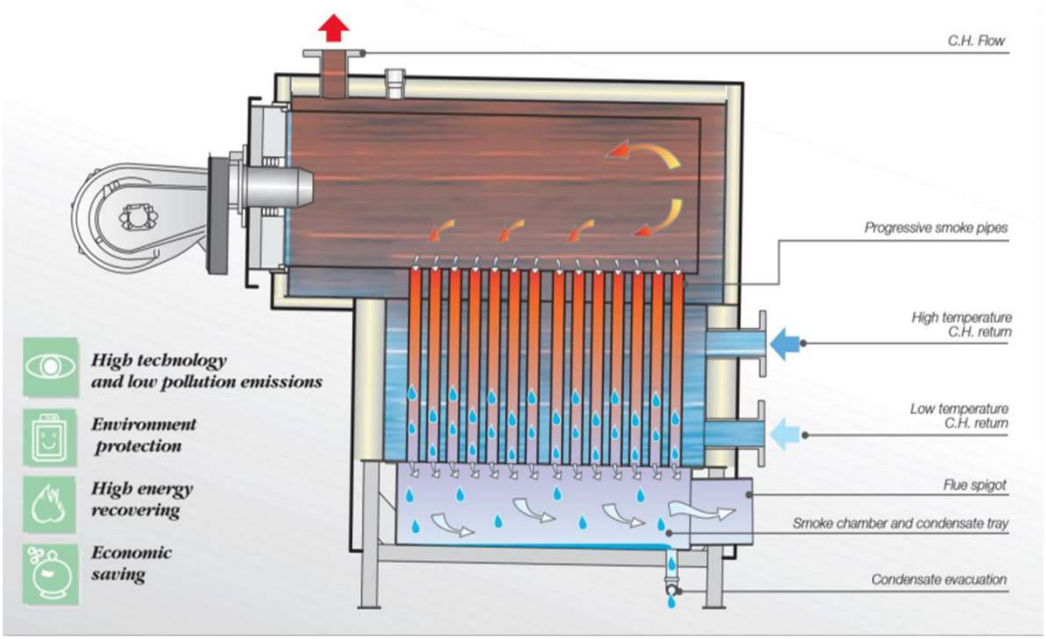
SOMEWHAT BIGGER BOILER (150 kW – 1MW)

Burner (separate): natural gas, LPG, oil
Water content: 248 – 907 liter (8 models)
Size from: 0.8 x 1.5 x 1.5 meter
Efficiency: 109 % (?)
Flue gas cooled down: from 800 to 60 °C



ZANTINGH

Unical
ZANTINGH
INOXIA GJ.
ROESTVRIJSTALEN HR- KETEL MET GROTE WATERINHOUD

Zanthing (NL) manufactured by Unigas (Italy)

LARGE GAS BURNERS 1 - 20 MW

- **Now more fuel options**: all gases
- Combinations: gas & oil, natural gas & propane, biogas & oil
- CO-free
- Low NOx due to 'in-furnace' technology

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RENEWABLE ENERGY PLANTS (huge scale)
Turnkey project by HoSt GROUP

Boilers on biomass, wood or waste: 8 - 25 MW (thermal)

Cogeneration (CHP) on biomass or waste: 1 - 10 MW (electr)

Also:
anaerobic digesters, fluidized bed gasifiers, bio-LNG,
biogas upgrading, carbon capture, CO2 liquefaction, etc

Flue gas cleaning technology & CO2 production

Have built 350 bio-energy plants worldwide

MECHANICAL VENTILATION, ACTIVE DEHUMIDIFICATION, AIR TREATMENT UNITS (ATU'S)

MECHANICAL VENTILATION / ACTIVE DEHUMIDIFICATION / ATU's (1)

Forget:

- minimum pipe & venting
- pulse venting
- opening a gap in a screen

because they waste energy!

Instead, use:

- mechanical ventilation
- air treatment units (**ATU's**)
- latent heat recovery
- air movement
- and keep CO2 inside

MECHANICAL VENTILATION / ACTIVE DEHUMIDIFICATION / ATU's (2)

Here are some examples and there are many more …..

MECHANICAL VENTILATION / ACTIVE DEHUMIDIFICATION / ATU's (3)

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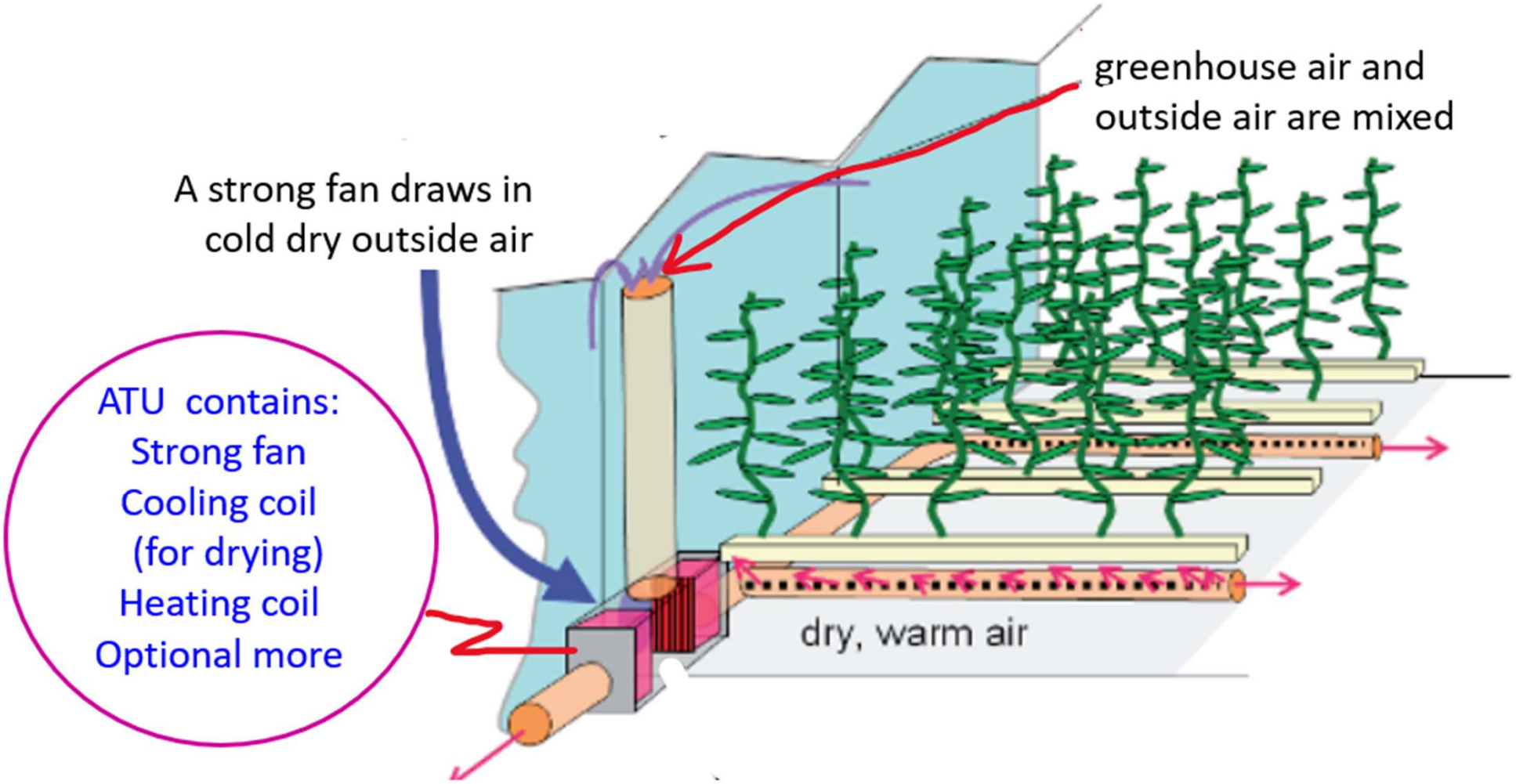
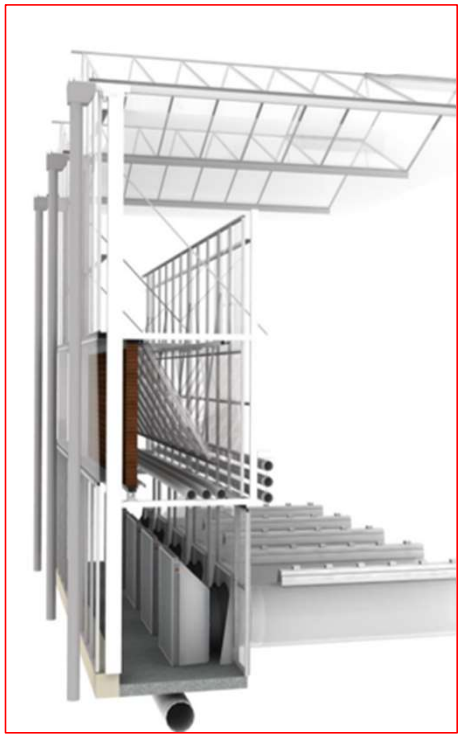
AIR TREATMENT UNIT (ATU) – design from 2008

design Sunenergiekas, WUR, 2008



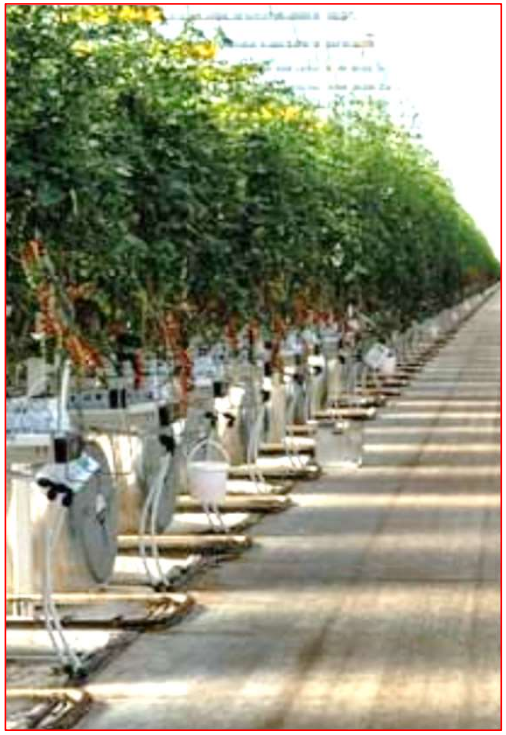
ULTRA CLIMA GLASSHOUSE from Kubo (NL) - from design in 2008 to reality ca 2016:

Air is treated/conditioned in a 'corridor'; then dispersed in the greenhouse via sleeves



schematic

treatment corridor

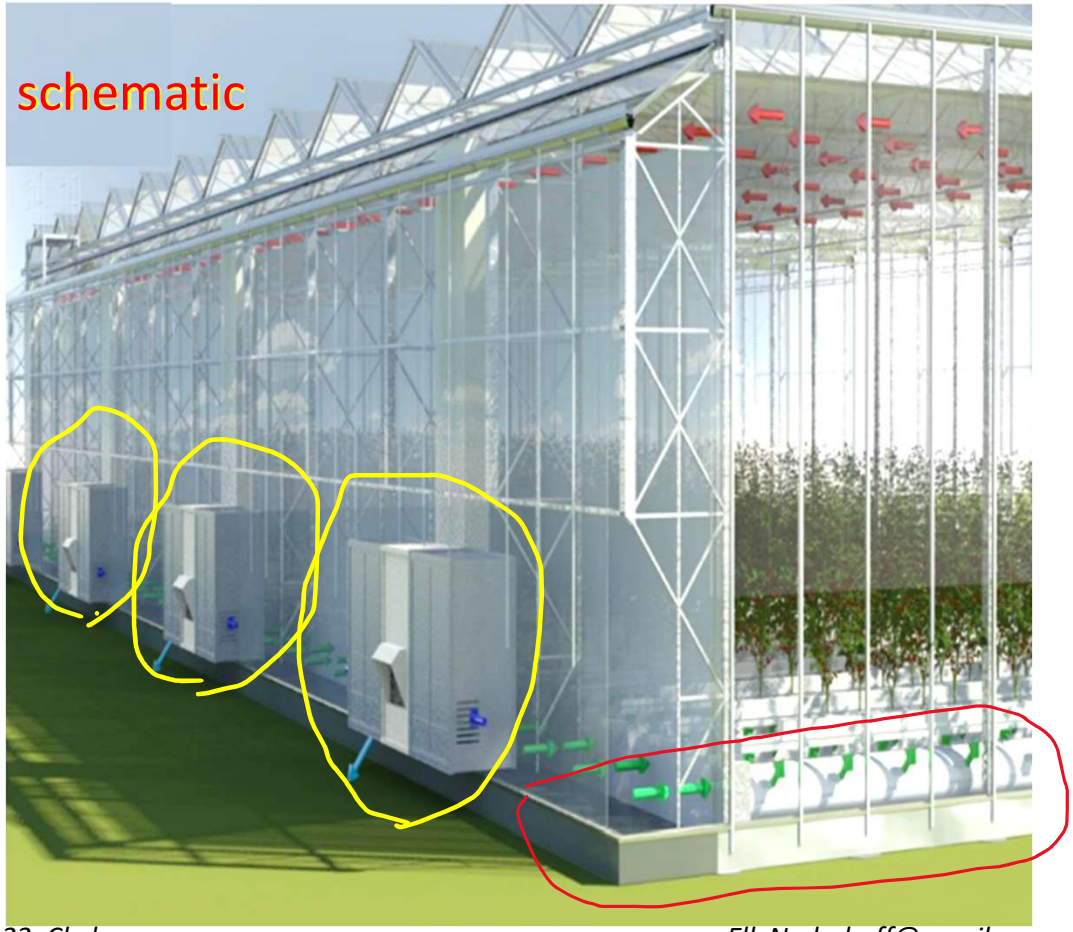


inside glasshouse

Several have followed this concept, eg Horconex

AIR & ENERGY GLASSHOUSE from Ammerlaan (NL) - on of many brands ATU's

Air is treated in ATU's, dispersed via sleeves



DRYGAIR (from Israel) – purely for drying the air

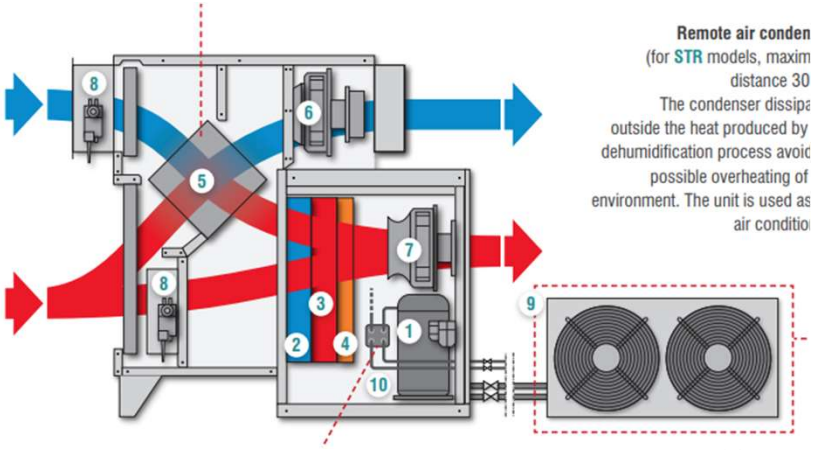
- Many sizes. Large unit can serve 4,000 - 5,000 m^2
- Takes in greenhouse air (not outside air), CO2 stays inside
- Independent of weather
- Two fans combined draw in (max) 22,000 m^3 air per hour
- A cooling coil causes condensation, thus dries the air
- Condensation up to 48 liter/hour (4 liter/kWh, high!)
- Blows treated air from the top to 4 sides
- DryGair is normally switched off when vents open
- Heating pipes remain in place
- Additional fans used sometimes for better spreading the air
- Easy to install. Relocatable!
- Dutch grower saved 50% on gas
- Expensive in NZ - you can import directly

DEHUMIDIFIER HiDew (from Italy)

For pools & industries, used in greenhouses

Controls humidity, temperature, air flow rate, and does heat-transfer

20 models:
- Dehumidifying: from 100 to 48,000 liter/day
- Air circulation: from 900 to 35,000 m^3/hour
- Heating coil: from 5.5 to 168 kW
- Dimensions: from 0.5 x 1.4 x 1.3 m to 2.5 x 4.4 x 2.3 m



MECHANICAL VENTILATION THROUGH SCREEN for DEHUMIDIFICATION

Air mix screen fan

Ventilation Jet screen fan

They work well for reducing humidity under a screen

So the screen does not have to be opened (or set on a gap) to get rid of moisture.

These fans increase the screen hours.

SUMMARY: MECHANICAL VENTILATION / ACTIVE DEHUMIDIFICATION/ ATU's (4)

Air Treatment Units (can) contain:

- Fan to inhale air (options: outside air, inside air, or mix)
- Cooling coil (to remove moisture by condensation)
- Heating coil (for heating after the cooling coil)
- Heat exchanger
- Mini heat pump
- Latent heat recovery
- Fogging (not often in NL)
- Tubes / sleeves for dispersion of dry warm air

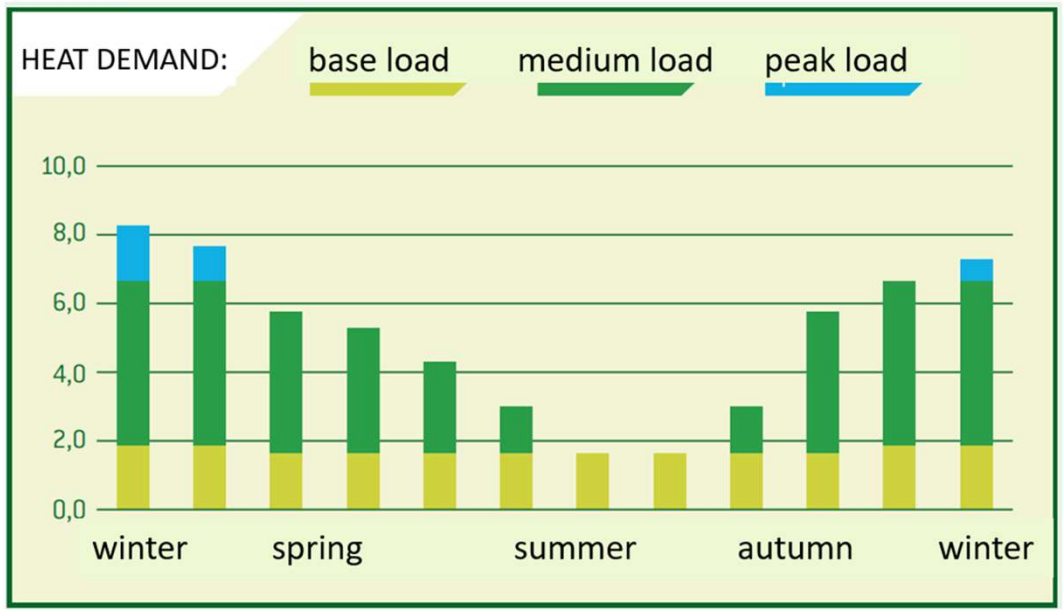
Heating dry air requires less energy than heating humid air !

Result: dry & warm climate with less energy (than heating & venting)
Latent heat energy & CO2 kept inside

Picture: AVS (Active Ventilation System) by Verkade & Van Dijk. Suitable for retro-fit

HUMIDITY, LATENT HEAT, CONDENSATION

Q: WHAT IS ENERGY USED FOR ?



In *mild* weather (spring, autumn): not much heating **for temperature**

Often, most energy used for **humidity control** (drying)

Other: lighting, CO2, pumps

To reduce energy consumption year-round, target HUMIDITY CONTROL (DRYING / DEHUMIDIFYING)

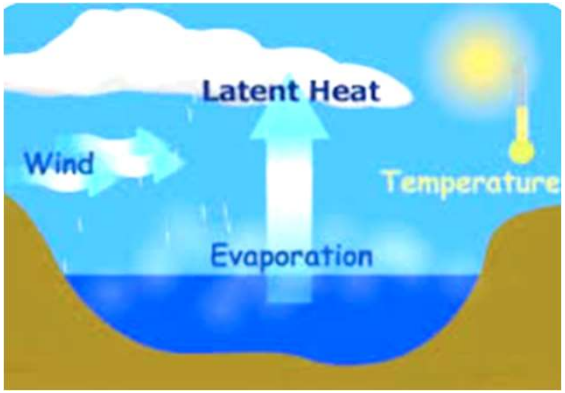
https://www.glastuinbouwnederland.nl/content/glastuinbouwnederland/docs/Verantwoorde_Glastuinbouw/Visiedocumenten_2023/Visiedocument_Energie_2023.pdf

RECOVERING ‘LATENT HEAT’ - important part

What is latent heat?

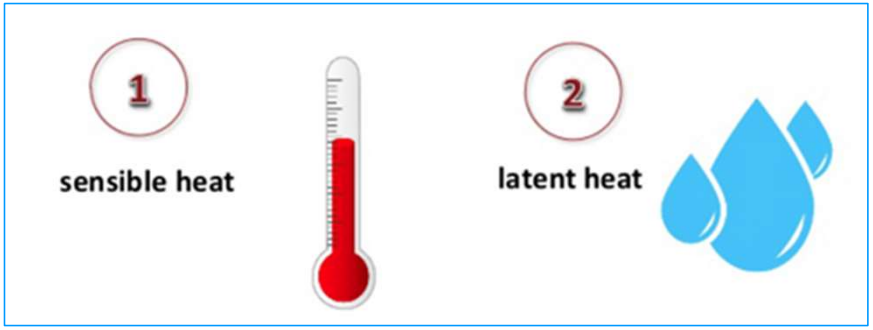
- *A lot of* energy is needed to evaporate water (kettle, sun)
- Evaporation produces steam and/or water vapour
- Thus, water vapour contains *a lot of* energy
- This energy is released again when water condenses

‘Latent heat’ = energy in moisture = energy gained by condensation



Sensible heat = heat you can feel

Latent heat = ‘hidden heat’ = energy in moisture



RECOVERING LATENT HEAT BY A FLUE GAS CONDENSOR (a well-known concept)

Flue gases contain a lot of water vapour = lot of latent heat energy. Condenser recoups it

A cold coil (colder than dew point)
makes that the water vapour condenses

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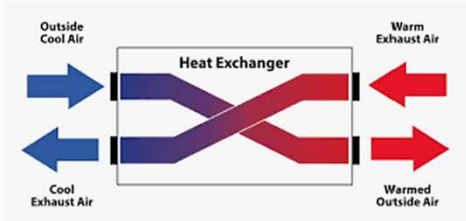
RECOVERING LATENT HEAT

There is a lot of energy in water vapour

Ventilation wastes all energy (latent heat & sensible heat & CO2)

How to retain them?

1. **By condensation** on a coil, cooled by a compressor & evaporator (fridge)
   Examples: ***DryGair, HiDew, Vifra, Verkade, VanWijk***



2. **By condensation** on a coil, cooled by outside air flowing through
   Latent heat energy is absorbed by this incoming outside air
   Examples: ***most ATU's that draw in outside air, see HiDew***

3. By absorption in a hygroscopic salt
   Examples: ***Claime Converter, Condair.*** *Most for low-temperature crops*

Once latent heat is recouped, it's used directly, or added to water from boiler, or stored

THESE AIR TREATMENT UNITS (ATU'S) ALL RECOVER LATENT HEAT

And there are many more …..

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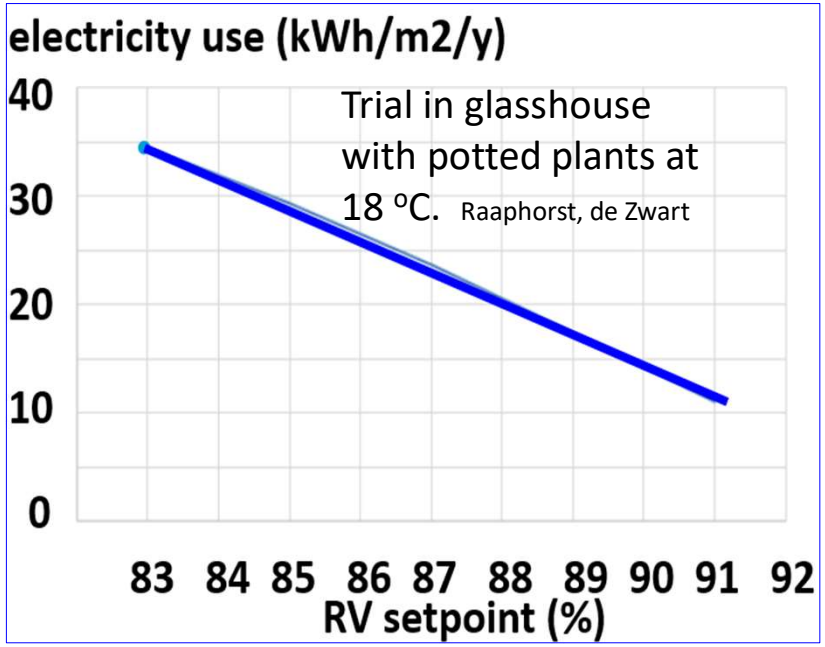
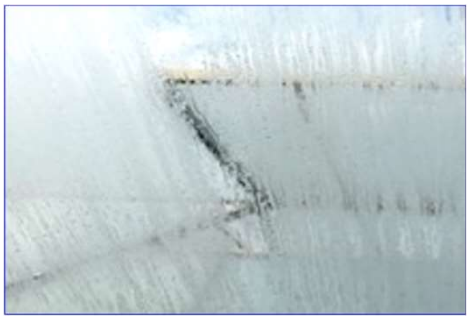
SAVING ENERGY BY ALLOWING A HIGHER RV (as we all know)

- Striving for a very low humidity requires a lot of energy
- Accepting higher RV (eg 91%) requires *far less* heating than pursuing 83%
- However, risk of condensation on cold spots
- Remedy: create even temperature



HUMIDITY CONTROL / DEHUMIDIFYING / DRYING METHODS



1. Minimum pipe temperature + venting *WASTING HEAT, LATENT HEAT & CO2*
2. Minimum ventilation (+ gap in screen) + heating *SAME*
3. Fans for vertical and/or horizontal airflow *GOOD, REDUCES CONDENSATION ON PLANTS*
4. Mechanical ventilation (draw-in dry outside air) + heating *ENERGY EFFICIENT*
5. **ATU**: mech. vent + dehumidifying + recovering heat + heating *VERY EFFICIENT*
6. Same with heat storage for a day *EVEN BETTER*
7. Same with heat storage for a season *SUSTAINABLE*

SUSTAINABLE

CO2 & OTHER

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CO2 FOR ENRICHMENT

Growers want CO2 for boosting the production.

But no CO2 from:
- geothermal heat
- waste heat (CO2 supplied separately)
- hydrogen, - electric, - solar, - wind
- heat from storage

CO2 is available from ….

Industries:	yes, in NL via pipeline
Natural gas burner:	yes, incl. from CHP, but not in future
Wood burning:	yes, some working examples
Biomass digestion:	yes, 35-50% of biogas is CO2
Biomass other:	being researched
Outside air:	CO2 capturing is being trialled

Making CO2 available is part of the fuel transition in NL

OTHER NEW DEVELOPMENTS RELATED TO ENERGY

Thermal screens (2 or even 3), and using them in an optimal way

Cooling by adsorption (cooling with heat as input)

Capturing CO2 from the air - possible, but expensive

Heat pump for air to water, improving efficiency

LED lighting (lots of options and opportunities!)

CO2 production and pipeline network

New roof cladding materials (low energy loss, high light penetration)

Improved control, better sensors, 'autonomous' growing (with AI)

Energy transition & decarbonisation in greenhouses - update from the Netherlands

Thank you!

Tomatoes NZ, Vegetables NZ, EECA

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Christchurch – 2 Aug 2023