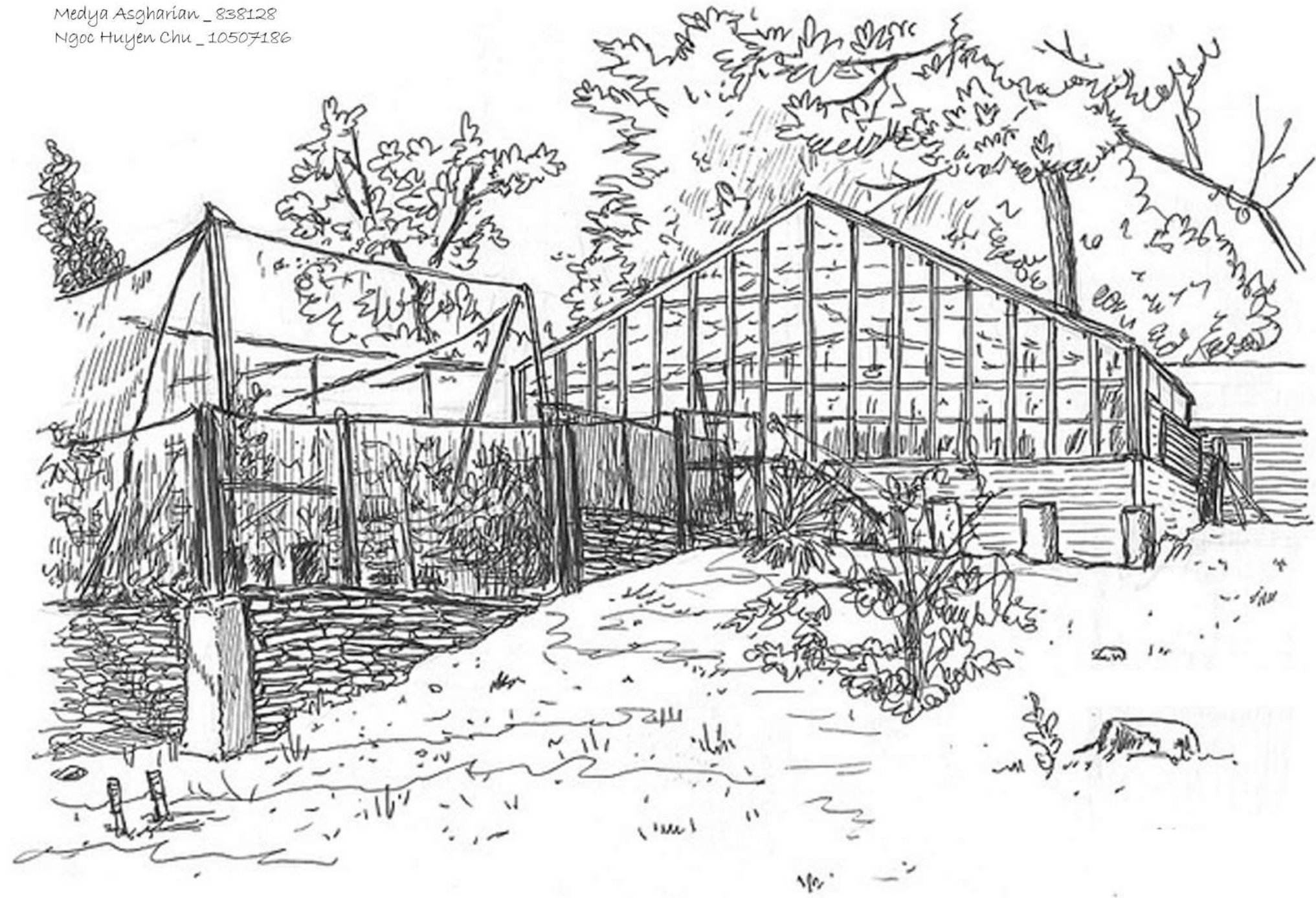


# greenhouse

architectural Design studio 2

Medya Asgharian \_ 838128  
Ngoc Huyen Chu \_ 10507186





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- 1. DEFINITION**
- 2. ADVANTAGES OF GREENHOUSE**
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## THERE IS SOMETHING GROWING IN THE BUILDING...

### 1\_GREEN HOUSES

A GREENHOUSE (ALSO CALLED A GLASSHOUSE, OR, IF WITH SUFFICIENT HEATING, A HOTHOUSE) IS A STRUCTURE WITH WALLS AND ROOF MADE CHIEFLY OF TRANSPARENT MATERIAL, SUCH AS GLASS, IN WHICH PLANTS REQUIRING REGULATED CLIMATIC CONDITIONS ARE GROWN. THESE STRUCTURES RANGE IN SIZE FROM SMALL SHEDS TO INDUSTRIAL-SIZED BUILDINGS. A MINIATURE GREENHOUSE IS KNOWN AS A COLD FRAME. THE INTERIOR OF A GREENHOUSE EXPOSED TO SUNLIGHT BECOMES SIGNIFICANTLY WARMER THAN THE EXTERNAL AMBIENT TEMPERATURE, PROTECTING ITS CONTENTS IN COLD WEATHER.





## 2\_ ARE THE GREEN HOUSES ARE USEFULL FOR US?

1

### ABSORBS RAINWATER

A ROOFTOP GREEN SPACE WILL ABSORB RAINWATER(UP TO 80%)AND REDUCE THE CHANGE OF FLOODING,ESPECIALLY IF YOUR GUTTERS OVER FLOW FROM RUNOFF.



### EXTENDS ROOF LIFE

IT DOUBLES OR SOMETIMES EVEN TROLES THE LIFE OF ROOF MATERIAL,WHICH GROWS BRITTLE AND CRACKS FROM EXTENSIVE SUNLIGHT.

2

3

### ABSOBS SUNLIGHT

BY SOAKING UP THE SUN'S RAYS,A GREEN ROOF CAN HELP KEEP YPUR HOME'S INTERIOR COOLER BY AS MUCH AS 6-8 F AND LOWER YOUR UTILITY BILLS.



### DECREASES OUTSIDE NOISES

GREENERY ON YOUR ROOF ACTS A SOUND BARRIER AND EXTERIOR NOISES ARE REDUCED BY AROUND EIGHT DECIBLES MORE THAN A TRADITIONAL ROOF.

4



5

KEEPS TEMPERATURES DOWN

IT HELPS THE ENVIRONMENT BY HELPING COUNTERACT THE URBAN HEAT ISLAND EFFECT, WHICH IS WHERE CITY BUILDINGS CAPTURE SUNLIGHT AND HEAT UP THE AREA.



INCREASE EFFICIENCY

GREEN ROOFS CAN INCREASE THE EFFICIENCY OF ROOFTOP SOLAR PANELS BY HELPING ABSORB HEAT AND MAKING THE PANELS MORE EFFECTIVE.

6

7

IMPROVES AIR QUALITY

A ROOFTOP GARDEN WILL CLEAN THE AIR OF POLLUTANTS HELPING REDUCE THE QUANTITY OF HAZARDOUS WASTE WE BREATHE IN.



FEEDS YOUR PETS

MAINTENANCE OF A GREEN ROOF IS EASY, YOU CAN EITHER HIRE SOMEONE TO CLIP IT OR JUST BUY A COUPLE OF GUINEA PIGS OR CHICKENS!

8



### 3 DIFFERENT TYPES OF SHAPE

1

#### LEAN-TO

PLACED AGAINST AN EXISTING WALL TYPICALLY FACING SOUTH COMMON FOR HOBBY GREEN HOUSES.EASY ACCESS FOR SMALLER AREA.



#### EVEN-SPAN

TWO SLOPES OF EQUAL PITCH AND WIDTH MOST COMMON CONFIGURATION



3

#### UNEVEN-SPAN

ROOFS OF UNEQUAL WIDTH AND PITCH AND ADPTABLE TO SLOPES GOOD FOR HIGH LATITUDE SITES



#### RIDGE AND FURROW

MULTIPLE A-FRAME SPANS CONNECTED ALONG THE EAVES GUTTERS PLACED AT JUNCTION OF EAVES ALSO TERMED GUTTER CONNECT

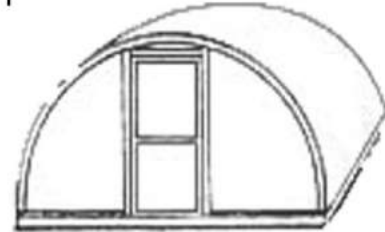




### 3\_DIFFERENT TYPES OF SHAPE

5

POLYTUNNEL GREENHOUSE  
QUONSET



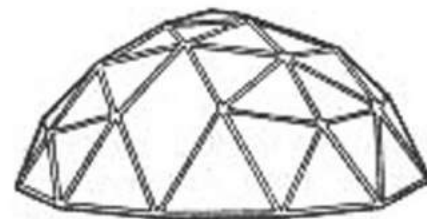
TWIN-WALL GREENHOUSE  
GOTHIC ARCH



6

7

GEO-DOME



GLASS HOUSE  
A-FRAME

8

MOST EFFICIENT GREENHOUSE DESIGN

| TYPE         | BUILD | COST | STRENGTH | LIGHT | HEAT | LIFESPAN | FLEXIBILITY |
|--------------|-------|------|----------|-------|------|----------|-------------|
| POLY-TUNNEL  | 1     | 1    | 3        | 1     | 3    | 3        | 4           |
| GLASS GREEN- | 4     | 4    | 4        | 3     | 4    | 1        | 3           |
| GEO-DOME     | 2     | 2    | 1        | 2     | 1    | 2        | 1           |
| TWIN-WALL    | 2     | 3    | 2        | 4     | 2    | 2        | 2           |

IN THE TABLE ABOVE COMPARE 4 DIFFERENT STYLES OF GREENHOUSE AND MARKED THEM IN ORDER OF EFFECTIVENESS IN EACH CATEGORY, THE BEST PERFORMER WITH 1 DOWN TO THE WORST WITH 4. HERE ARE THE SCORES, LOWEST SCORE MEANS BEST PERFORMANCE:

GEO-DOME (11) – NOTHING CAN BEAT A DOME FOR STRENGTH OR THERMAL EFFICIENCY. FLEXIBILITY IS ALSO EXCELLENT BECAUSE IT CAN BE REPURPOSED OR RECOVERED IN A DIFFERENT MATERIAL WHICH NONE OF THE OTHERS CAN BE.

POLY TUNNEL (16) – TOP IN THE BUILD, COST AND LIGHT CATEGORIES. MODERN POLY TUNNELS HAVE HI TECH COVERS THAT MAXIMIZE LIGHT TRANSMISSION AND THERE ARE FEWER SPARS TO CAST SHADOWS.

TWIN-WALL GREENHOUSE (17) – TWIN-WALL POLYCARBONATE ONLY LETS ABOUT 66% OF THE OUTSIDE LIGHT THROUGH.

GLASS GREENHOUSE (23) – LAST PLACE FOR THE GLASS GREENHOUSE FOR EASE OF CONSTRUCTION, COST, THERMAL EFFICIENCY AND STRENGTH, BUT WINNING THE LIFESPAN CATEGORY. WE COULD IMPROVE SOME OF THESE SCORES BY USING TOUGHENED GLASS, IT WOULD THEN BEAT A POLY TUNNEL FOR STRENGTH BUT IT MAKES MORE SENSE TO TRY AND IMPROVE THE BEST PERFORMER.



### 3 DIFFERENT TYPES OF MATERIAL

# 1

## GLASS

GLASS WAS THE ONLY CHOICE UNTIL THE 1950S

- ADVANTAGES
  - GREATER LIGHT INTENSITY OVER PLASTIC PANELS AND FILM PLASTIC
  - MORE AIR EXCHANGES WITH GLASS
  - LONGEVITY
- DISADVANTAGES
  - LOWER RELATIVE HUMIDITY
  - FRAGILE AND LESS FORGIVING TO KNOCKS
  - POOR THERMAL EFFICIENCY (3MM GLASS  $R=0.95$  AND 4MM GLASS  $R=1.0$ )
  - POTENTIAL TO BURN PLANTS DUE TO THE LEVEL OF CLARITY



# 2

## PLASTIC FILM

- ADVANTAGES
  - LOW COST PER SQUARE METER
  - TAKES THE KNOCKS
  - DIFFUSED LIGHT - PREVENTS BURNING AND AIDS PHOTOSYNTHESIS
- DISADVANTAGES
  - RELATIVELY SHORT LIFESPAN AND REQUIRES REPLACEMENT
  - PRONE TO RIPS AND TEARS
  - POOR THERMAL EFFICIENCY ( $R=0.83$ ), UNLESS DOUBLE SKINNED



# 3

## POLYCARBONATE

- ADVANTAGES
  - GOOD THERMAL EFFICIENCY (6MM TWINWALL  $R=1.54$ ). KEEPS THE WARMTH IN LONGER INTO THE NIGHT AND OFFERS BETTER FROST PROTECTION
  - VERY TOUGH AND DURABLE
  - GOOD LONGEVITY (PROVIDED IT IS A PREMIUM GRADE POLYCARBONATE)
  - PRODUCES A SLIGHTLY DIFFUSED LIGHT WHICH HELPS PREVENT - BURNING/SCORCHING THE PLANTS
- PRONE TO SCRATCHING
  - THE FLUTES IN THE TWIN-WALL CAN ATTRACT MOISTURE, MOULD AND BUGS - IF - NOT SEALED SUFFICIENTLY IN THE FRAME. (WINTER GARDENZ GREENHOUSE FLUTES ARE ALL SEALED WITH RUBBER BEADING)
- POOR THERMAL EFFICIENCY (3MM GLASS  $R=0.95$  AND 4MM GLASS  $R=1.0$ )







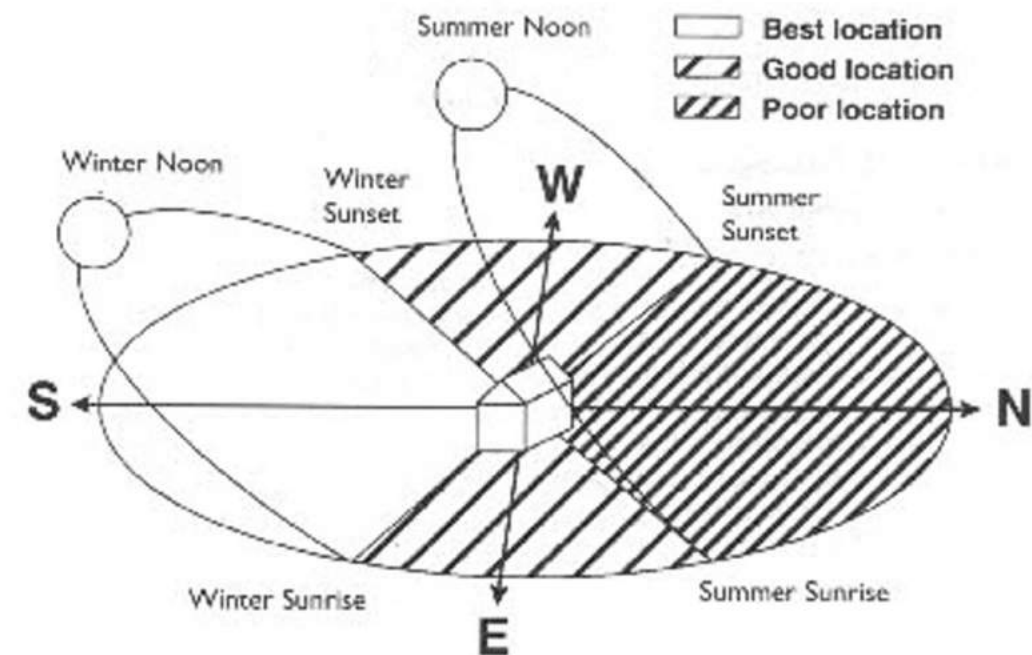
## 4\_LOCATION OF GREEN HOUSE

THE LENGTH OF THE GREENHOUSE (LONGER DIMENSION) SHOULD FACE SOUTH AS THIS IS WHERE THE MAJORITY OF LIGHT COMES FROM IN THE NORTHERN HEMISPHERE.

WHAT IF IT CAN'T FACE DIRECTLY SOUTH?

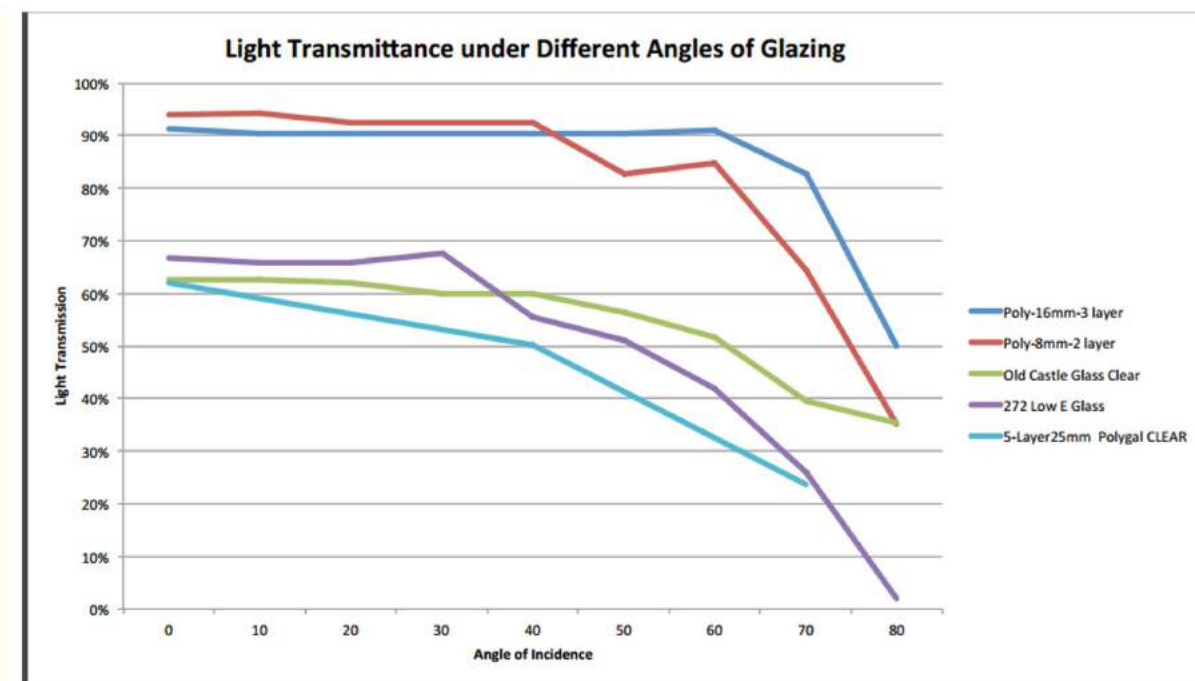
MOSTLY SOUTH IS THE GOAL, BUT IN CASES WHERE THAT IS NOT POSSIBLE A, SOUTH-WEST OR SOUTH-EAST FACING GREENHOUSE IS DOABLE.

SOUTH EAST IS PREFERABLE TO SOUTH WEST BECAUSE IT WILL GET THE MORNING SUN, WHICH HELPS HEAT UP THE GREENHOUSE AFTER IT'S GOTTEN COOLER OVERNIGHT. SOUTH-WEST OR COMPLETELY WEST FACING GREENHOUSE, THE AFTERNOON CAN BE THE HOTTEST PART OF THE DAY AND ADDITIONAL SUN AT THIS TIME CAN OVERHEAT THE GREENHOUSE. COOL-WEATHER, LOW-LIGHT CROPS WILL DO BETTER IN EAST-FACING GREENHOUSES. HEAT-LOVING CROPS LIKE TOMATOES AND PEPPERS WILL DO BETTER WEST-FACING GREENHOUSES



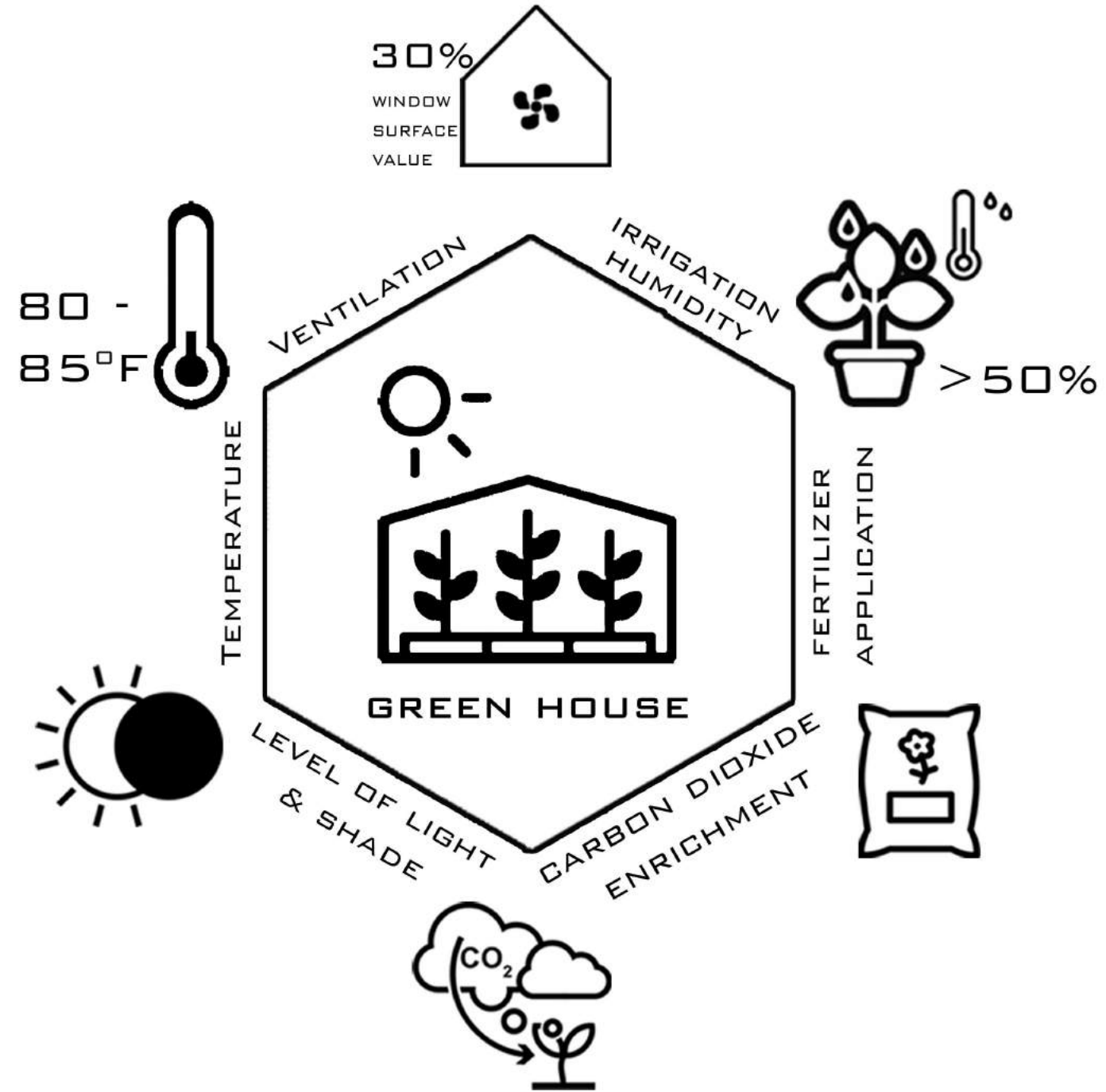
| Greenhouse Covering              | R - Value | U - Value |
|----------------------------------|-----------|-----------|
| Polyethylene film , single layer | 0.83      | 1.20      |
| Single Pane Glass, 3mm           | 0.95      | 1.05      |
| 4mm Double Wall Polycarbonate    | 1.43      | 0.70      |
| 6mm Double Wall Polycarbonate    | 1.54      | 0.65      |
| 8mm Double Wall Polycarbonate    | 1.60      | 0.63      |
| 10mm Double Wall Polycarbonate   | 1.89      | 0.53      |
| Double Pane Storm Windows        | 2.00      | 0.50      |
| 8mm Triple Wall Polycarbonate    | 2.00      | 0.50      |
| 3.5mm Twin-Wall Polyethylene     | 2.10      | 0.48      |
| 5mm Twin-Wall Polyethylene       | 2.30      | 0.43      |

R-Value - the measurement of 'insulating ability' of the material. Higher R-Value refers to higher insulation value.  
U-Value - the measurement of 'heat loss' through the material. The lower the U-Value the less heat is escaping.



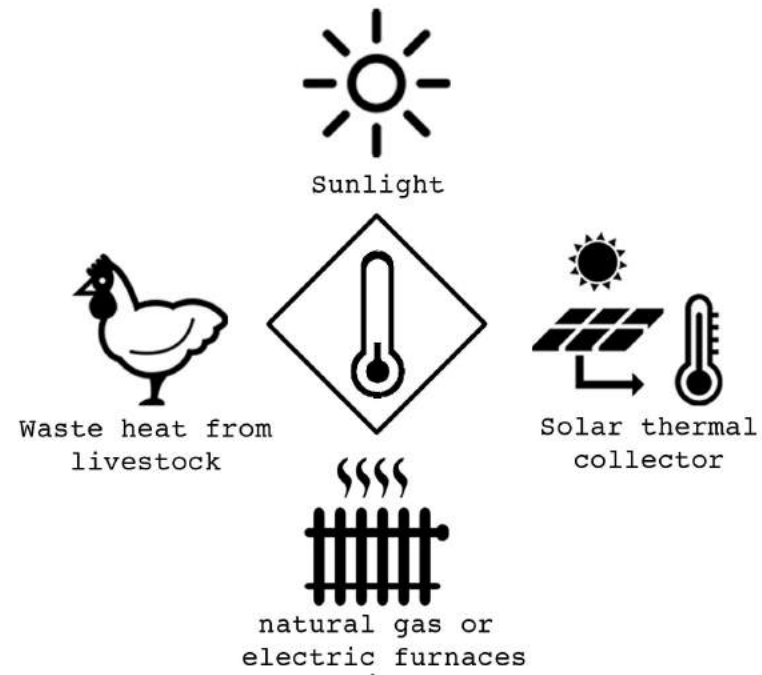


5\_ WHAT FACTORS SHOULD BE CONSIDERED INSIDE THE GREENHOUSE?





## DIFFERENT HEAT RESOURCES



Biomass , heating with wood

SUSTAINABLE  
CO2-NEUTRAL  
ECONOMICAL  
HIGH-TECH AND RELIABLE  
LOCAL AND INDEPENDENT  
TYPE OF WOOD: PELLETS,  
SAWDUST, WOODCHIPS,  
MIXED WOODS



forcas pipe

- THIN WALL STEEL TUBE IDEALLY SUITED FOR HEATING SYSTEMS IN GREENHOUSES
- BRINGS HEAT DIRECTLY TO THE CROP WHERE IT IS MOST EFFECTIVE
- LIGHTWEIGHT AND PRACTICAL APPLICATION
- REDUCES VOLUME OF WATER NEEDED
- PROVIDES QUICK AND ENERGY EFFICIENT HEATING
- HOT-DIPPED WITH A GALVANIZED COATING TO PROTECT AGAINST CORROSION



in-floor heating

HEATING ZONES CAN BE SEPARATED FOR INDIVIDUAL CLIMATE CONTROL FOR DIFFERENT CROPS  
BEST FOR PROVIDING UNIFORM HEATING TO THE ENTIRE CROP  
HEATED CONCRETE FLOOR CUTS DOWN ON CONDENSATE ON POLY ROOF, THIS ALLOWS MORE SOLAR ENERGY TO PASS THROUGH POLY, CONSERVING ENERGY  
MAXIMIZES GROWING AREA BY ELIMINATING NEED FOR WALKWAYS, MORE PLANTS PER SQUARE FOOT



overhead heating

OVERHEAD HEATING IS IMPORTANT IN AREAS THAT GET SEASONS WITH COLD NIGHT TIME TEMPERATURES. IT PROVIDES THE SUPPLEMENTARY HEATING REQUIRED TO COMBAT THESE COOLER TEMPERATURES.



perimeter heating

PERIMETER HEATING SYSTEMS SHOULD ALWAYS BE USED IN COLD WEATHER CLIMATES IN ORDER TO PROTECT PLANTS GROWING NEAR SIDE AND END WALLS. A WELL DESIGNED PERIMETER HEATING SYSTEMS PROVIDES SUPPLEMENTAL HEAT ALONG THE SIDEWALLS CONTRIBUTING TO A UNIFORM THERMAL ENVIRONMENT THROUGHOUT THE GREENHOUSE.

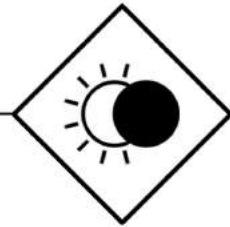


under bench heating

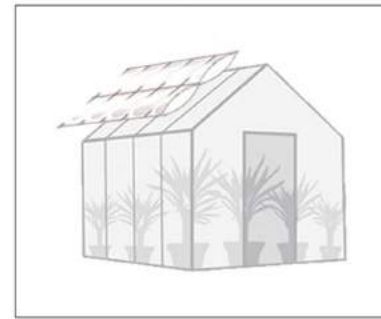
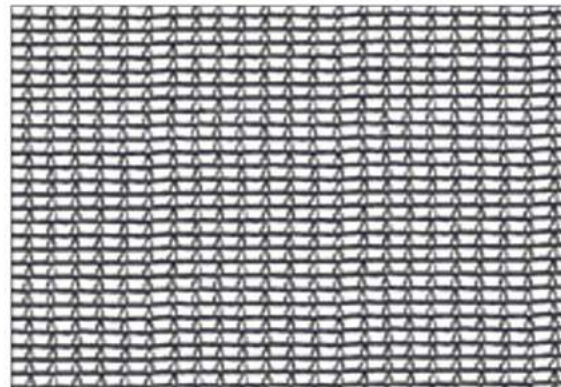
AN UNDER BENCH HEATING SYSTEM CAN REDUCE FUEL COSTS 10 PERCENT OR MORE. AIR TEMPERATURE IN THE GREENHOUSE CAN BE 5 TO 10 DEGREES LOWER THAN THE GROWING MEDIUM TEMPERATURE AND STILL ACHIEVE EXCELLENT GROWTH. THIS LOWER AIR TEMPERATURE MEANS THAT THE HEAT LOSS BETWEEN THE INSIDE OF THE GREENHOUSE AND OUTSIDE WILL BE LESS.



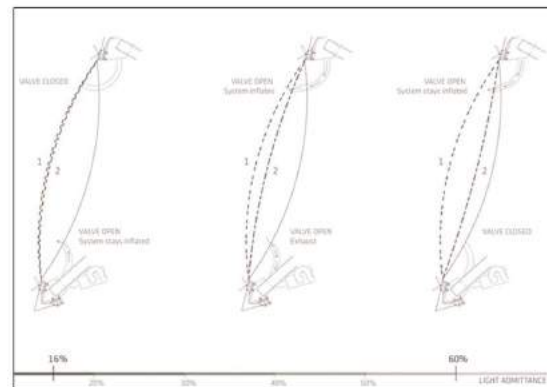
## DIFFERENT TECHNIQUE FOR LIGHTING AND SHADING



green or other dark-colored shade cloth



ETFE cushion with pattern



### BENEFITS OF ETFE

- EXCEPTIONAL LIGHT TRANSMISSION – ETFE FILMS CAN BE HIGHLY TRANSPARENT (FROM 90% TO 95%) AND ALLOW FOR THE PASSING OF UVS WHICH ARE RESPONSIBLE FOR THE PROMOTION OF PHOTOSYNTHESIS THUS FACILITATING PLANT GROWTH.
- SOLAR CONTROL/SHADING – ETFE FILM SYSTEMS CAN INCORPORATE A NUMBER OF FRIT PATTERNS ON ONE OR MULTIPLE LAYERS TO ALTER THEIR SOLAR PERFORMANCE. THE FOIL IS PRINTED WITH VARIOUS STANDARD OR CUSTOM PATTERNS.
- ELASTICITY – WHILE ETFE FILMS ARE VERY ELASTIC (UP TO 600% AT BREAKING POINT), THEY ARE STILL STRUCTURALLY RESISTANT. THE TENSILE STRENGTH AT THE LIMIT OF ELASTICITY/PLASTICITY IS 21-23 N/MM<sup>2</sup> BUT TENSILE STRENGTH TO BREAKING POINT IS 52/NMM<sup>2</sup>. FOR STRUCTURAL CALCULATION A LIMIT OF 15 N/MM<sup>2</sup> IS CONSERVATIVELY USUALLY TAKEN.
- LONG LASTING/LONGEVITY – ETFE FILM HAS APPROXIMATELY 70% ACOUSTIC TRANSMISSION
- SUSTAINABLE/ENERGY EFFICIENT –
- COST EFFECTIVE – DUE TO THE LIGHTWEIGHT NATURE OF ETFE, SUBSTRUCTURE SUPPORT SYSTEMS AND CONCRETE FOUNDATIONS CAN BE DESIGNED MORE EFFICIENTLY. ETFE SYSTEMS ALSO PROVIDE AMPLE NATURAL DAYLIGHTING, THUS MINIMIZING ENERGY COSTS BY LOWERING THE DEMAND FOR INDOOR LIGHTING.
- RECYCLABLE – EASILY RECYCLABLE, WASTE FROM THE MANUFACTURING PROCESS OR EVEN OLD ETFE ELEMENTS CAN BE REMOLDED INTO NEW ETFE PRODUCTS SUCH AS TUBING COMPONENTS, WIRES OR CASTINGS.





### AQUAPONICS

AQUAPONICS , REFERS TO ANY SYSTEM THAT COMBINES CONVENTIONAL AQUACULTURE (RAISING AQUATIC ANIMALS SUCH AS SNAILS, FISH, CRAYFISH OR PRAWNS IN TANKS) WITH HYDROPONICS (CULTIVATING PLANTS IN WATER) IN A SYMBIOTIC ENVIRONMENT.

AQUAPONICS CONSISTS OF TWO MAIN PARTS, WITH THE AQUACULTURE PART FOR RAISING AQUATIC ANIMALS AND THE HYDROPONICS PART FOR GROWING PLANTS. AQUATIC EFFLUENTS, RESULTING FROM UNEATEN FEED OR RAISING ANIMTALS LIKE FISH, ACCUMULATE IN WATER DUE TO THE CLOSED-SYSTEM RECIRCULATION OF MOST AQUACULTURE SYSTEMS. THE EFFLUENT-RICH WATER BECOMES TOXIC TO THE AQUATIC ANIMAL IN HIGH CONCENTRATIONS BUT THIS CONTAIN NUTRIENTS ESSENTIAL FOR PLANT GROWTH. TYPICAL COMPONENTS INCLUDE:

REARING TANK: THE TANKS FOR RAISING AND FEEDING THE FISH;

SETTLING BASIN: A UNIT FOR CATCHING UNEATEN FOOD AND DETACHED BIOFILMS, AND FOR SETTLING OUT FINE PARTICULATES;

BIOFILTER: A PLACE WHERE THE NITRIFICATION BACTERIA CAN GROW AND CONVERT AMMONIA INTO NITRATES, WHICH ARE USABLE BY THE PLANTS;

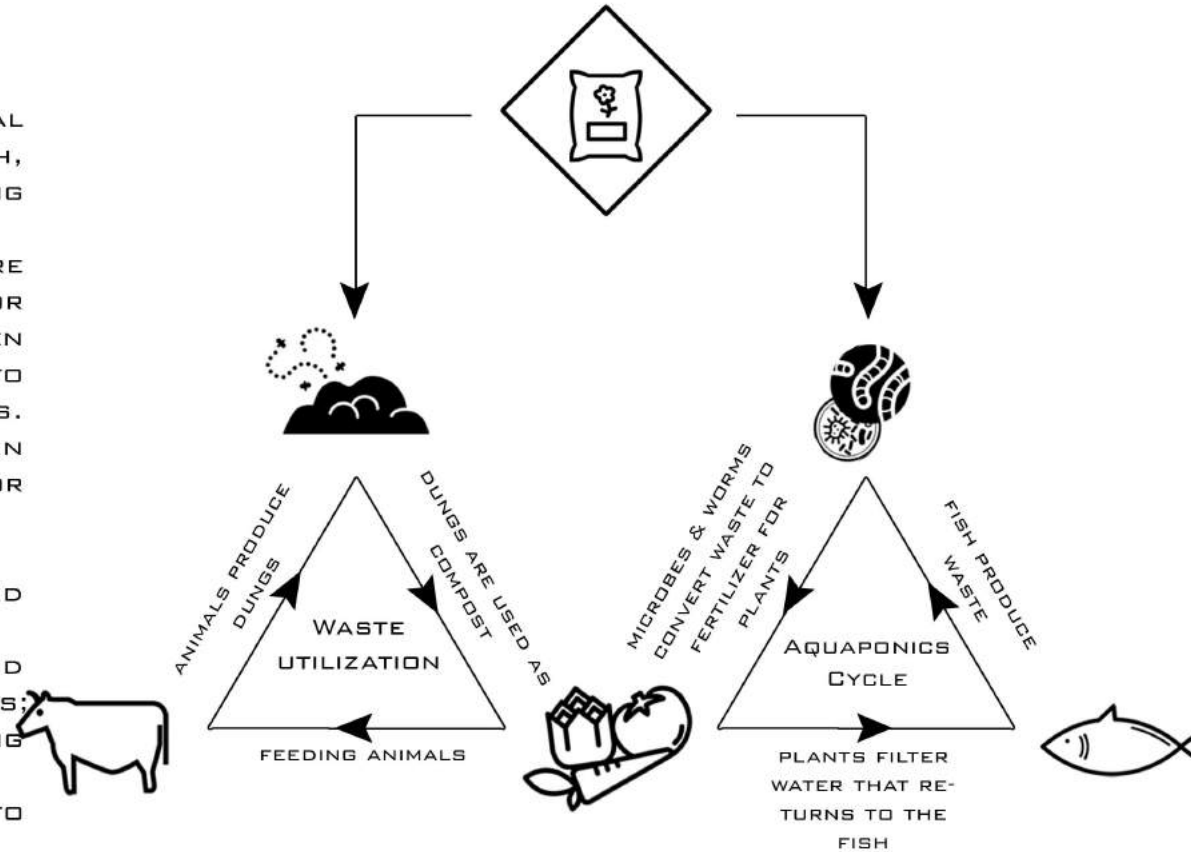
HYDROPONICS SUBSYSTEM: WHERE PLANTS ARE GROWN BY ABSORBING EXCESS NUTRIENTS FROM THE WATER;

SUMP: THE LOWEST POINT IN THE SYSTEM WHERE THE WATER FLOWS TO AND FROM WHICH IT IS PUMPED BACK TO THE REARING TANKS.

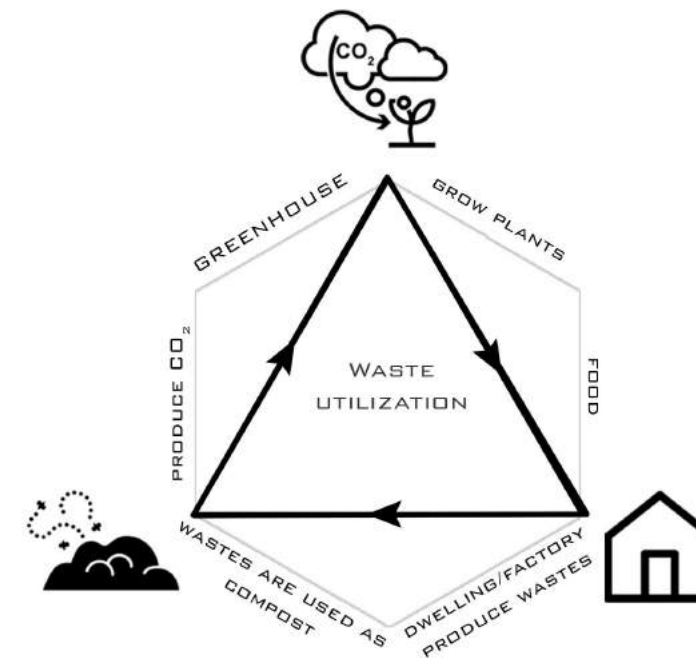
### CO2 ENRICHMENT

THE POSSIBILITY OF USING CARBON DIOXIDE ENRICHMENT IN GREENHOUSE CULTIVATION TO ENHANCE PLANT GROWTH HAS BEEN KNOWN FOR NEARLY 100 YEARS. AFTER THE DEVELOPMENT OF EQUIPMENT FOR THE CONTROLLED SERIAL ENRICHMENT OF CARBON DIOXIDE, THE TECHNIQUE WAS ESTABLISHED ON A BROAD SCALE IN THE NETHERLANDS. SECONDARY METABOLITES, E.G., CARDIAC GLYCOSIDES IN DIGITALIS LANATA, ARE PRODUCED IN HIGHER AMOUNTS BY GREENHOUSE CULTIVATION AT ENHANCED TEMPERATURE AND AT ENHANCED CARBON DIOXIDE CONCENTRATION. COMMERCIAL GREENHOUSES ARE NOW FREQUENTLY LOCATED NEAR APPROPRIATE INDUSTRIAL FACILITIES FOR MUTUAL BENEFIT. FOR EXAMPLE, CORNERWAYS NURSERY IN THE UK IS STRATEGICALLY PLACED NEAR A MAJOR SUGAR REFINERY, CONSUMING BOTH WASTE HEAT AND CO2 FROM THE REFINERY WHICH WOULD OTHERWISE BE VENTED TO ATMOSPHERE. THE REFINERY REDUCES ITS CARBON EMISSIONS, WHILST THE NURSERY ENJOYS BOOSTED TOMATO YIELDS AND DOES NOT NEED TO PROVIDE ITS OWN GREENHOUSE HEATING.

### FERTILIZATION

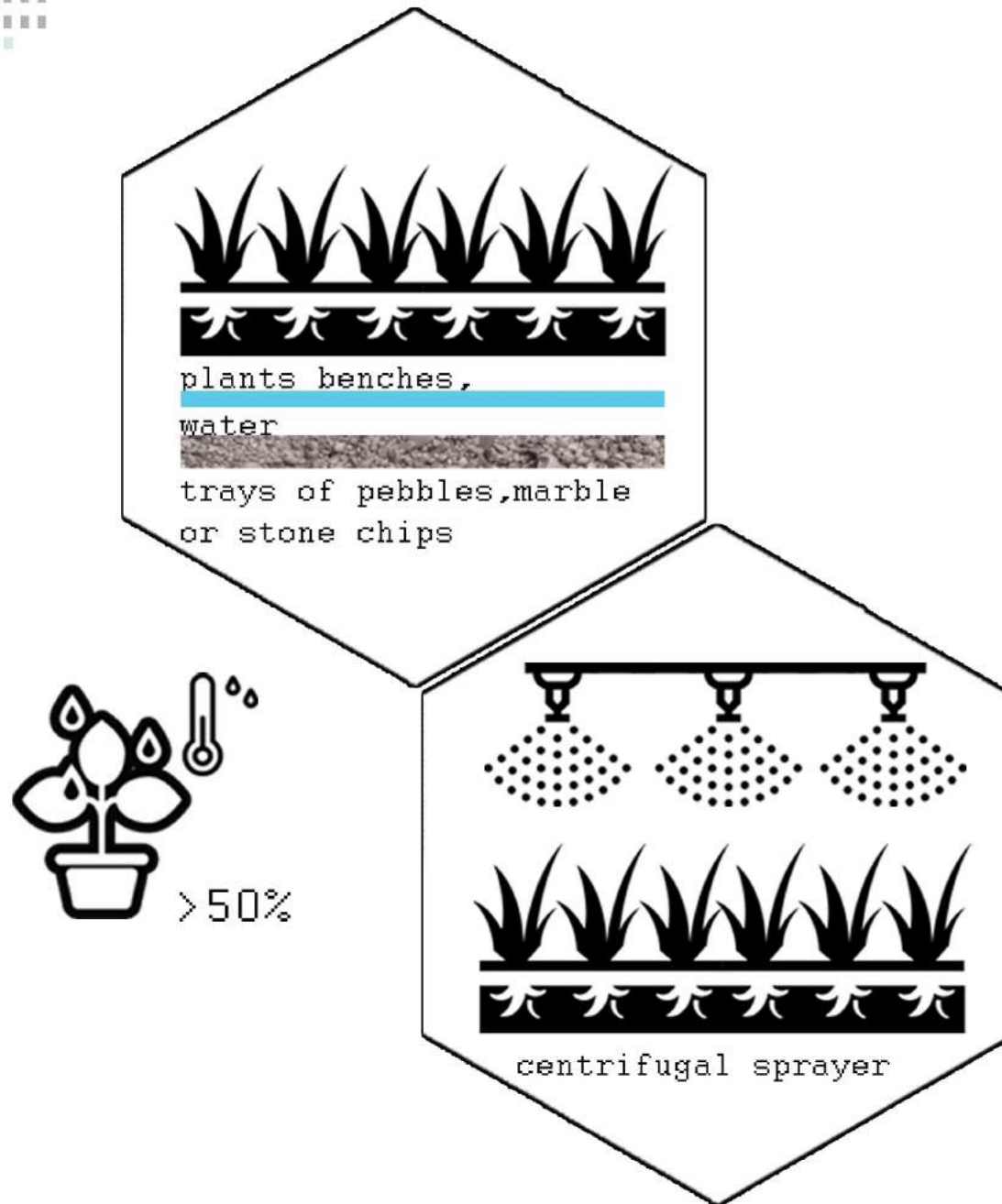


### CO2 ENRICHMENT





## IRRIGATION AND HUMIDITY CONTROL SOLUTION



### HUMIDITY

HUMIDITY OFFERS MANY BENEFITS, PARTICULARLY TO TROPICAL PLANTS. UNLESS YOU'RE RAISING CACTI, KEEP THE GREENHOUSE ON THE HUMID SIDE, AT LEAST 50 PERCENT OR HIGHER.

TO ADD HUMIDITY TO THE AIR:

PLACE TRAYS OF PEBBLES UNDERNEATH THE PLANTS. FILL THE TRAYS WITH WATER SO IT COVERS THE PEBBLES. AS THE WATER EVAPORATES, IT WILL ADD HUMIDITY NEAR THE PLANTS. ALTERNATIVELY, PUT MARBLE OR STONE CHIPS ON THE FLOOR UNDER THE PLANT BENCHES OR TABLES. THESE CAN ALSO HELP CREATE HUMIDITY IF THEY'RE DAMPENED DOWN ON A DRY DAY.

### HUMIDITY

THE PRIMARY NURSERY AND GREENHOUSE IRRIGATION SYSTEMS ARE OVERHEAD SPRINKLER, MICROIRRIGATION OR TRICKLE AND SUBIRRIGATION SYSTEMS.

THERE ARE MANY DIFFERENT TYPES AND SIZES OF SPRINKLERS AND THE SAME IS TRUE OF ALL THE EMISSION DEVICES AVAILABLE UNDER THE CATEGORY OF MICROIRRIGATION. IN THIS SECTION SOME OF THESE EMISSION DEVICES WILL BE DISCUSSED IN REFERENCE TO THE APPLICATIONS IN THE NURSERY OR GREENHOUSE CROP AREAS.



OVERHEAD WATERING (SPRAY/MIST)



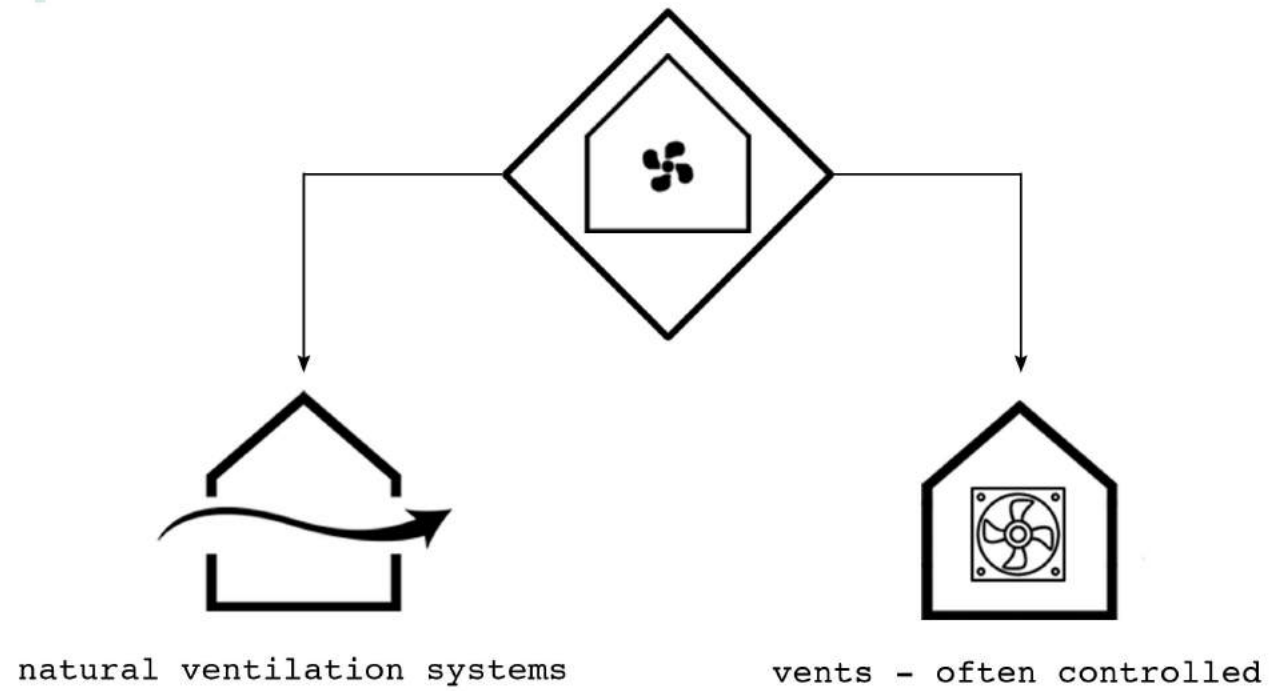
CONTAINER WATERING (DRIP/SPRAY)



GREENHOUSE TIMERS (BATTERY/ELECTRIC)



## VENTILATION SOLUTION



### HOW MUCH VENTILATION DO I NEED?

LIKE MANY DESIGN CHOICES, THIS DEPENDS ON CLIMATE AND GREENHOUSE DESIGN. HERE ARE SOME GENERAL RULES OF THUMB:

IF USING PASSIVE VENTS AND / OR OPERABLE WINDOWS (NO FANS), THE TOTAL OPENING AREA SHOULD BE 20-40% OF THE GREENHOUSE FOOTPRINT. THIS IS A LARGE RANGE AS IT GREATLY DEPENDS ON YOUR CLIMATE AND THE GLAZING AREA OF THE GREENHOUSE.

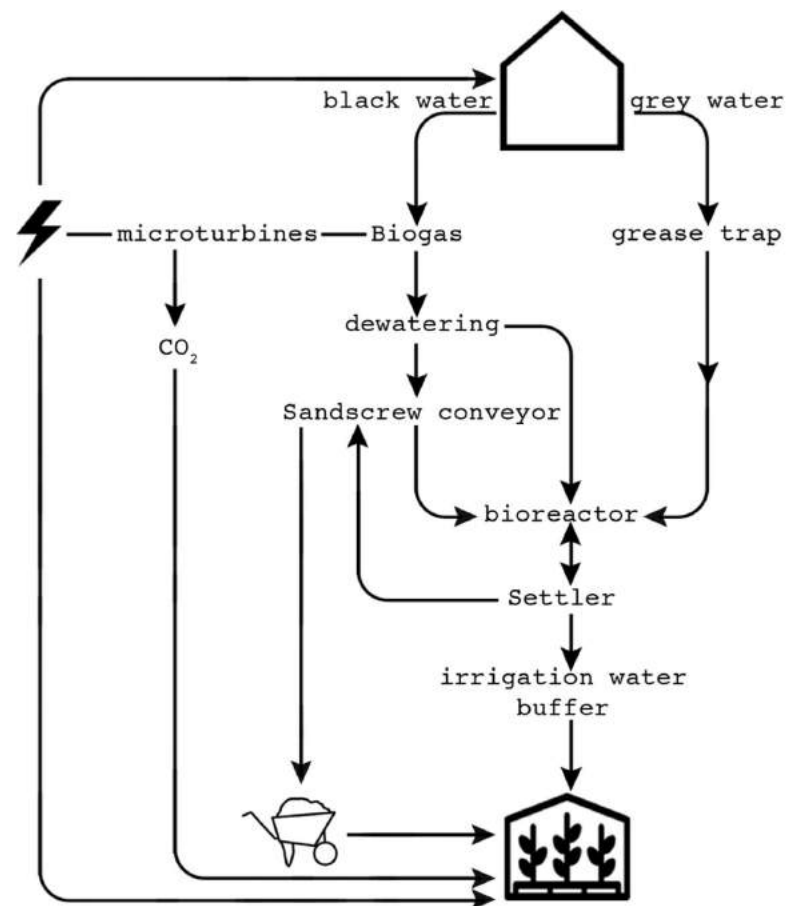
IF USING EXHAUST FANS, A COMMON RULE OF THUMB IS SIZING THE FAN TO PROVIDE 1-3 FULL AIR EXCHANGES PER HOUR. AT CERES, WE USE A GROUND TO AIR HEAT TRANSFER (GAHT) SYSTEM TO PROVIDE SOME AIR CIRCULATION AND COOLING, AND THUS RELY ON SMALLER FANS.



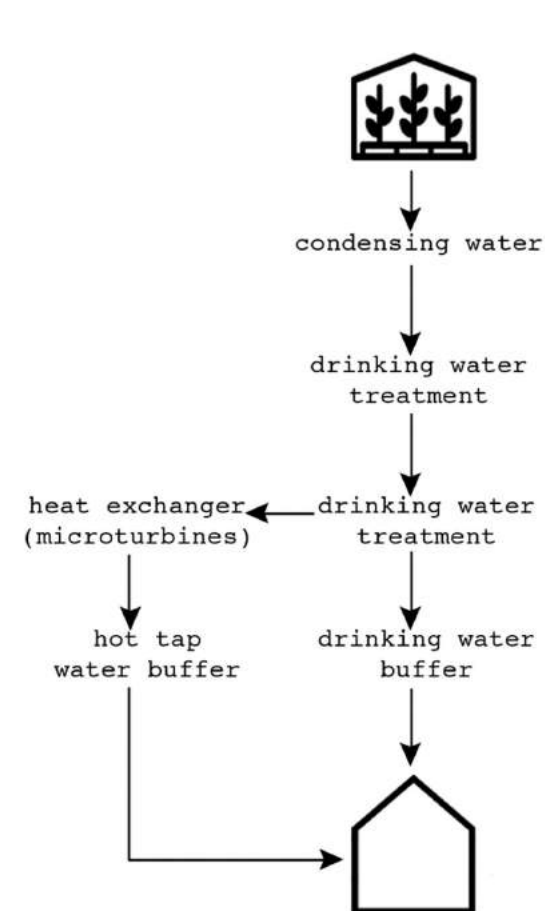
## 6 HOW IT WORKS : LINK THE RESOURCE FLOWS OF GREENHOUSES AND HOUSEHOLD

AND LEISURE POSSIBILITIES. THUS RESIDENTIAL UNITS BECOME A) DIRECT USERS FOR ENERGY STREAMS (WITH OR WITHOUT STORAGE) AND WATER PRODUCED IN THE GREENHOUSE, AND B) PROVIDE BIOGAS, RECOVERED NUTRIENTS AND ORGANICS VIA SOURCE-SEPARATED SANITATION CONCEPTS FOR THE OPERATION OF THE GREENHOUSE.

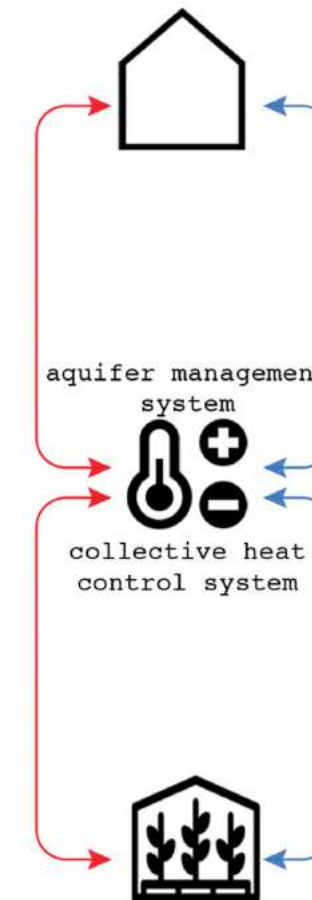
CORE TECHNICAL ELEMENTS OF THE GREENHOUSE SYSTEM ARE A) AN AQUIFER THERMAL ENERGY STORAGE SYSTEM FOR HEAT AND COLD STORAGE AND SUPPLY IN COMBINATION WITH A HIGHLY EFFICIENT HEAT EXCHANGER AND B) SOURCE-SEPARATED SANITATION CONCEPTS WITH RESOURCE RECOVERY (NEW SANITATION).



SEPARATE COLLECTION AND TREATMENT OF BLACK AND GREY WATER IN GREENHOUSE VILLAGE



CLIMATE CONTROL SYSTEM OF THE GREENHOUSE AND THE HOUSING BLOCK







## 6\_ HOW IT WORKES: WATER EFFICIENT ZERO EMISSION GLASSHOUSE

### IMPORTANCE OF DRAIN WATER RECYCLING & IMPACT ON WATER QUALITY

#### THEORETICAL EMISSION OF NITROGEN (KG/HA/YEAR)

| STRATEGY  | NITROGEN EMISSION |
|---|-------------------|
| 1. 100% RUN-TO-WASTE  | 945 KG/HA         |
| 2. CURRENT BEST PRACTICE*:<br>30% DRAIN & 85% REUSE                         | 142 KG/HA         |
| 3. RE-USING DRAIN WATER FROM START CULTIVATION (COLLECTION & REUSE OF FIRST | 75 KG/HA          |



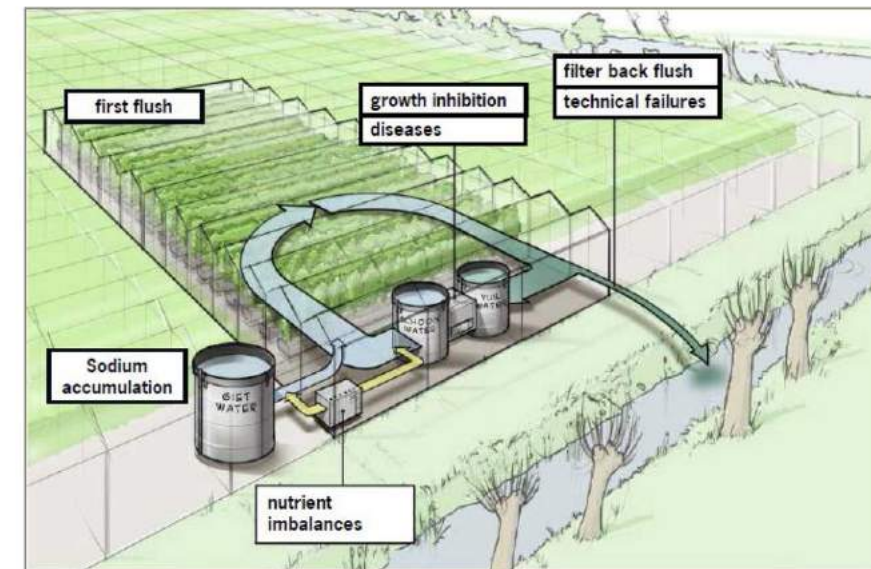
### REASONS TO DISCHARGE WATER FROM THE GREENHOUSE

#### SODIUM ACCUMULATION

- PRIMARY WATER QUALITY
- SUBSTRATE CHOICE
- FILTER RINSE WATER
- UNBALANCED NUTRIENT SOLUTION

#### DURING GROWTH

- "FEELING THAT RE-USE LOWERS PRODUCTION"
- FIRST FLUSH
- & RIGHT NOW "JUST BECAUSE WE CAN"





HOW WE CAN MAKE GREEN HOUSE SIMPLY?



HARDWARE FENCING HOOP HOUSE



SALVAGED WINDOW



CUT BOTTLE MINI GREENHOUSES



BOTTLE GREENHOUSES



CEDAR BRANCH HOOP HOUSE



SIMPLE COLD FRAME



STRAW BALE COLD FRAME



© bepa's garden



GD CASE GREENHOUSE

Mega-Crafty



## 7\_CASE STUDIES - EDEN PROJECT

THE EDEN PROJECT: THE BIOMES  
 CORNWALL, UK  
 SIZE: 23,000 SQ M  
 COMPLETION DATE: 2001

### GREEN FEATURES

#### SUPER INSULATION

THE HEXAGONAL CUSHIONS ON THE STEEL STRUCTURE TRAP AIR BETWEEN TWO LAYERS OF ETFE WHICH ACT AS A THERMAL BLANKET.

#### ENERGY GENERATION

##### 1. REDUCE ENERGY CONSUMPTION

###### - SUSTAINABLE CONSTRUCTION

SUPER INSULATION AND NATURAL LIGHTING AND VENTILATION.

###### - BUILDING MANAGEMENT SYSTEM (BMS)

LIKE A GIANT TV REMOTE ALLOWING FOR VERY TIGHT CONTROL OF HEATING AND ELECTRICAL SYSTEMS.

###### - HIGH-EFFICIENCY BOILERS

SMALLER, HIGHLY-EFFICIENT BOILERS HAVE BEEN FITTED AT THE EDEN PROJECT ITSELF.

###### - ENERGY-EFFICIENT LIGHTING

FITTING LED LIGHTS ACROSS SITE

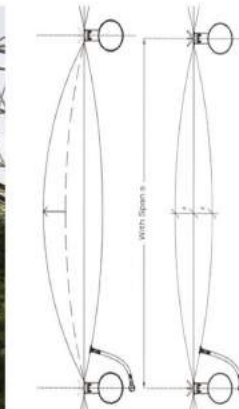
##### 2. GENERATE POWER

###### - GEOTHERMAL

PLANNING PERMISSION FOR A 3-4MW GEOTHERMAL POWER PLANT ON THE EDEN PROJECT SITE, TAKING ENERGY FROM THE HEAT IN UNDERGROUND GRANITE ROCKS.

###### - SOLAR

THE PHOTOVOLTAIC PANELS ON THE ROOF OF THE CORE, OUR EDUCATION BUILDING, HAVE A 30KW CAPACITY.



###### - WIND

A 5kW WIND TURBINE UP NEAR OUR CAR PARKS FEEDS INTO OUR OVERALL POWER SUPPLY.

###### - HYDRO

THEY INVESTIGATED HARNESSING THE ENERGY OF AN ANCIENT WATERCOURSE FROM THE TIN MINING ERA, WHICH RUNS THROUGH EDEN AND DOWN TO THE COAST.

###### - REDUCING CARBON EMISSIONS EVEN MORE

+ PLANTED MILLIONS OF PLANTS AT THE EDEN PROJECT THAT CAPTURE CARBON EVERY DAY.

+ SOURCE LOCAL, SEASONAL AND VEGETARIAN FOOD, WHICH ALL PLAY A PART IN REDUCING GREENHOUSE GAS EMISSIONS.

+ OPERATE A GREEN TRAVEL PLAN

+ SOURCE ELECTRICITY FROM GOOD ENERGY.



## 7\_CASE STUDIES - EDEN PROJECT

### - WATER HARVESTING

+ AS WELL AS REDUCING OUR WATER USE IN THE FIRST PLACE, BY INSTALLING LOW-FLUSH TOILETS, AND TAPS WHICH TURN THEMSELVES OFF, WE HARVEST OUR OWN WATER TO FLUSH THE LOOS AND WATER THE PLANTS.

+ UNDERGROUND DRAINAGE SYSTEM COLLECTS ALL THE WATER COMING ON TO THE SITE, WHICH WE USE TO IRRIGATE PLANTS AND FLUSH LOOS. RAINWATER THAT FALLS ON THE BIOMES IS HARVESTED TO IRRIGATE THE PLANTS INSIDE, TOP UP THE RAINFOREST WATERFALL AND MAINTAIN THE HIGH HUMIDITY INSIDE.

+ TO AVOID USING TOO MUCH MAINS WATER AT EDEN:

USE RAIN AND GROUND WATER WHEREVER POSSIBLE

MONITOR WATER USE VIA A METER, EVEN ON WATERING HOSES

HAVE INVESTED IN THE BEST WATER-EFFICIENT PRODUCTS, INCLUDING LOW-FLUSH TOILETS AND TAPS WHICH TURN THEMSELVES OFF.

### - NATURAL LIGHT

DESIGNING BUILDINGS THAT LET IN LOTS OF NATURAL LIGHT CAN MEAN ELECTRICITY SAVINGS (IF THE WINDOWS ARE WELL INSULATED) AS WELL AS HAPPIER, MORE ALERT PEOPLE.

### - SUSTAINABLY SOURCED MATERIALS

THERE'S A LOT TO THINK ABOUT WHEN CHOOSING CONSTRUCTION MATERIALS – HOW THEY'RE MADE, HOW FAR THEY HAVE TO TRAVEL, HOW LONG THEY'LL LAST.

### - RECYCLED MATERIALS

+ RESPONSIBLE MANUFACTURERS

+ LOW-WASTE MANUFACTURING

+ FEWER MATERIALS

THE BIOMES' HEXAGONS COPY NATURE'S HONEYCOMBS: MAXIMUM STRENGTH USING MINIMUM MATERIALS.

### - LOWER-CARBON PRODUCTS





## 7 CASE STUDIES - LUFA FARM



### WATER CONSERVATION

USE HYDROPONIC CULTIVATION METHODS, WHICH ALLOW TO GROW USING BETWEEN 50% AND 90% LESS WATER THAN A COMPARABLE FARM NOT PRACTICING RECIRCULATION. RECIRCULATE 100% OF IRRIGATION WATER.

A LARGE BUFFER SYSTEM IS CREATED AROUND THE GREENHOUSE. THIS SLOWS THE RATE AT WHICH UNCOLLECTED RAINWATER FLOWS INTO CITY SEWERS.

### PEST CONTROL

LADYBUGS, FOR INSTANCE, ARE INTRODUCED INTO THE GREENHOUSE TO HELP CONTROL APHIDS THAT DAMAGE PLANTS BY FEEDING ON THEIR SAP. A WIDE RANGE OF INSECTS IS USED TO COMBAT PESTS, AND BIOCONTROL SOFTWARE IS DEVELOPED SO THAT CAN ENSURE HEALTHY, GREAT-TASTING PRODUCE.

### WHY ON A ROOF?

FARMING ON ROOFTOPS IS WAY TO TAKE BACK ARABLE LAND LOST TO DEVELOPMENT. PROTOTYPE 31,000 SQUARE FOOT FARM FEEDS APPROXIMATELY 2000 PEOPLE AND PROVIDES THEM WITH AN EXCELLENT SELECTION OF FRESH AND NUTRITIOUS PRODUCE

### SAVING ENERGY

- THE HEATING DEMANDS OF .

### GREENHOUSES OCCUR ALMOST

EXCLUSIVELY DURING THE NIGHT  
 - EMPLOY ENERGY CURTAINS. HELP INSULATE THE GREENHOUSE AND REDUCE HEAT LOSS AT NIGHT.  
 - CUSTOMERS ARE URBAN RESIDENTS WHO LIVE AND WORK CLOSE TO GREENHOUSES.  
 - GREENHOUSE LOWERS THE ENERGY NEEDED TO COOL THE BUILDING UNDERNEATH OUR GREENHOUSES DURING HOT SUMMER DAYS.

### COMPOSTING

ORGANIC WASTE IS COMPOSTED ON-SITE USING AN IN-VESSEL ROTATING DRUM LOCATED IN THE BASEMENT OF OUR BUILDING. HIGH QUALITY FINISHED COMPOST IS NOW AVAILABLE FOR SALE TO CUSTOMERS IN A 100% COMPOSTABLE BAG.

CURRENTLY, THE COMPANY HARVESTS 1,000 TO 1,500 POUNDS OF FOOD DAILY AND DELIVERS MORE THAN 2,500 BASKETS OF PRODUCE PER WEEK TO DROP-OFF POINTS ALL OVER THE METROPOLITAN AREA YEAR-ROUND

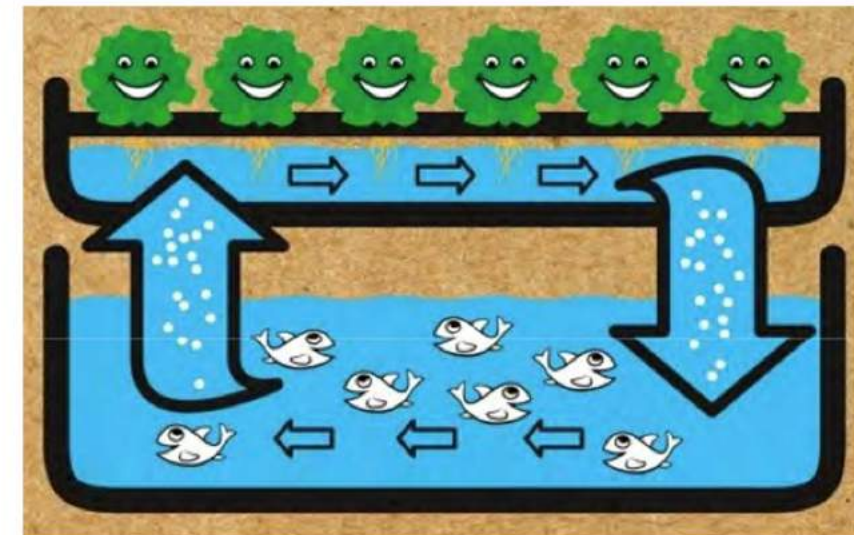
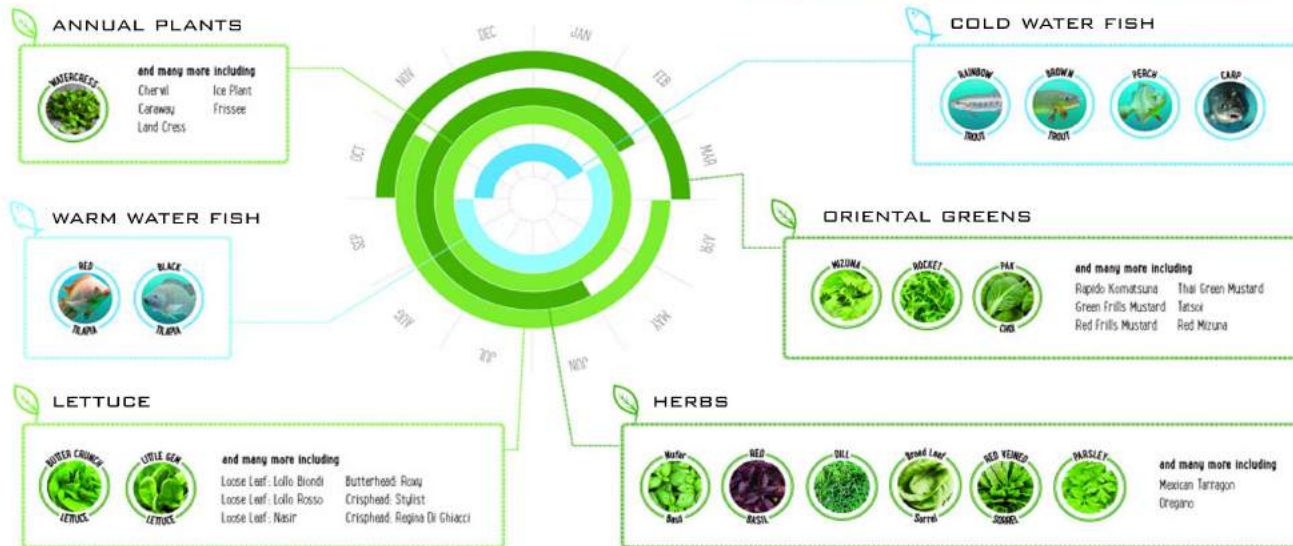
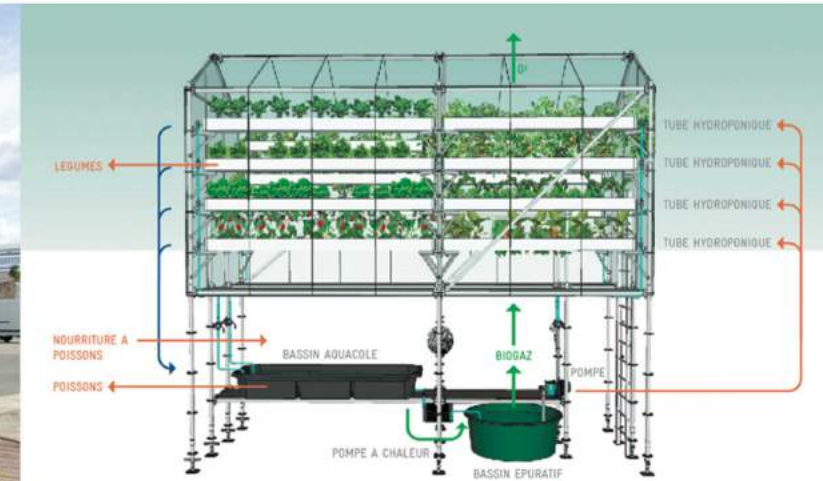




## 7\_CASE STUDIES - UF BOX

THE UFBOX USES AQUAPONIC TECHNOLOGY DEVELOPED BY THE ZURICH UNIVERSITY OF APPLIED SCIENCES (ZHAW) AND ALLOWS FOR ULTRA-LOCAL, ULTRA-FRESH VEGETABLE AND FISH PRODUCTION WITHOUT THE USE OF HERBICIDES OR PESTICIDES. THE BOX IS PERFECT FOR SCHOOLS AND SMALL ENTERPRISES AS A TEACHING TOOL.

- SIZE 18M2
- PRODUCTION 60KG FISH 120KG VEGETABLES
- SPECS MOBILE AND TRANSPORTABLE
- LOCATION SCHOOLS, PARKING LOTS, BACKYARDS AND OTHER PUBLIC PLACES



## 8\_REFERENCES

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- [GREENHOUSEVILLAGE-CANWELINKTHERESOURCELOWSOFGREENHOUSESANDHOUSEHOLDS?/DR. IR. INGOLEUSBROCK/PROF. DR. IR. GRIETJE ZEEMAN](http://GREENHOUSEVILLAGE-CANWELINKTHERESOURCELOWSOFGREENHOUSESANDHOUSEHOLDS?/DR_IR_INGOLEUSBROCK/PROF_DR_IR_GRIETJE_ZEEMAN)
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