Green Houses

By Maarten Lubbers & Steve “O” Edmonds
<table>
<thead>
<tr>
<th>Colour Code</th>
<th>Colour Name</th>
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<tbody>
<tr>
<td>410E-1</td>
<td>Frostwork</td>
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<tr>
<td>410A-1</td>
<td>Green Shimmer</td>
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<tr>
<td>410C-1</td>
<td>Highlight</td>
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<tr>
<td>410E-7</td>
<td>Hemlock Bud</td>
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<td>430A-1</td>
<td>Mint Hint</td>
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<td>410E-2</td>
<td>Celery Ice</td>
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<tr>
<td>420A-2</td>
<td>Spirit Whisper</td>
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<td>420C-2</td>
<td>Water Sprout</td>
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<tr>
<td>420E-2</td>
<td>Palm Breeze</td>
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<tr>
<td>430A-2</td>
<td>Seafoam Spray</td>
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<td>410E-3</td>
<td>Rejuvenate</td>
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<td>420A-3</td>
<td>Key Lime</td>
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<tr>
<td>420C-3</td>
<td>Celery Bunch</td>
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<tr>
<td>420E-3</td>
<td>Spring Hill</td>
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<tr>
<td>430A-3</td>
<td>Fairway Mist</td>
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<tr>
<td>410F-4</td>
<td>Mother Nature</td>
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<tr>
<td>420B-4</td>
<td>Tart Apple</td>
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<tr>
<td>420D-4</td>
<td>Marsh Fern</td>
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<tr>
<td>420F-4</td>
<td>Sagey</td>
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<td>430B-4</td>
<td>Peas In A Pod</td>
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<td>410F-5</td>
<td>Boston Fern</td>
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<tr>
<td>420B-5</td>
<td>Sweet Midori</td>
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<tr>
<td>420D-5</td>
<td>Herbal Garden</td>
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<tr>
<td>420F-5</td>
<td>Olivine</td>
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<td>430B-5</td>
<td>Apple Orchard</td>
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<td>410F-6</td>
<td>Grape Vine</td>
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<td>420B-6</td>
<td>New Green</td>
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<tr>
<td>420D-6</td>
<td>Thyme Green</td>
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<td>420F-6</td>
<td>Egyptian Nile</td>
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<td>430B-6</td>
<td>Caterpillar</td>
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<td>410F-7</td>
<td>Fiddle Leaf</td>
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<td>420B-7</td>
<td>Pepper Grass</td>
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<td>420D-7</td>
<td>Dill Pickle</td>
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<td>420F-7</td>
<td>Forest Ridge</td>
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<tr>
<td>430B-7</td>
<td>Cress Green</td>
</tr>
</tbody>
</table>
Costa del Polythene: A Sea of Plastic

- 40,000~Hectares
- 2.7 M Tonnes of Produce
- €1.2 billion
The Eden Project
World's largest greenhouse botanical garden

Each “Biome” replicates a different climate

Super Sized Vents
Understanding Plants

Plants need:
Light, CO2, Water & Minerals

Plants produce:
O2, water, biomass, Produce & flowers

Transpiration: As the plant absorbs energy it exhausts latent heat in the form of evaporated water.
Commercial: Uses

- Produce
- Cut and Potted Plants
- Medicinal
- Exhibition
Hobby Greenhouses

Lean to Style
Home heat can heat greenhouse

Stand Alone: Hobby Kit
Plenty of space for a plant enthusiast

Do it yourself
Plant Considerations

-Maintain the Levels of: (varies according to plant)

- Light
- Temperature
- Humidity
- CO$_2$
- Fertilizer and water
Coverings

Translucent covers allow the maximum penetration of solar energy

They have low R values, Hot to cold really fast.

With increasing energy costs improvements in covering materials have allowed for better control.
More Coverings

Layers of polyethylene film inflated by a fan is the #1 choice of commercial growers

It's cheap & offers decent insulation, light diffusion & penetration

- 52' roll

A nice unbroken air barrier

Double walled construction
Plants prefer their light diffused

Direct sunlight causes shadowing.

Diffuse the light and it bounces in from every angle.

Plants absorb energy everywhere, not just from the top.

Results in healthier plants.
1. Install inflation mount firmly to horizontal or vertical greenhouse frame member (fasteners supplied only for mounting to roll-form rails; fasteners for other applications not provided).

2. To attach the inflation mount to roll-form rails, use stop tabs, 5/16" lock washers, and 5/16" hex nuts as shown in diagram above.

3. Place (1) air transfer gasket on the poly to be inflated. Cut out the poly (ONE layer of plastic only) from the gasket to allow air to pass. Note: Only cut through ONE layer of plastic.

4. Place a second air transfer gasket on the inside of the roof poly. Be sure to align the two gaskets prior to pressing the two together. Staple the 2 gaskets together using an ordinary office stapler.

5. Insert the 3" x 5'-0" flex tubing through the air transfer gaskets. Make sure approximately 1" of flex tubing passes through gaskets to ensure a tight fit. Make sure the sharp wire is not exposed to puncture the outer layer of poly.
<table>
<thead>
<tr>
<th>Covering</th>
<th>R Value</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycarbonate 6mm quad wall</td>
<td>1.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polycarbonate 8mm quad wall</td>
<td>2.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polycarbonate 16mm triple wall</td>
<td>2.5</td>
<td>Long Life, Strong, Good diffusion</td>
<td>Uv Degradable</td>
</tr>
<tr>
<td>Polycarbonate 8mm triple wall</td>
<td>2.0-2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polycarbonate 8mm double wall</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylic double wall</td>
<td>1.82</td>
<td>Most resistant plastic to UV, long life</td>
<td></td>
</tr>
<tr>
<td>Glass double layer</td>
<td>1.5 - 2.0</td>
<td></td>
<td>Expensive, requires</td>
</tr>
<tr>
<td>Glass double layer low-e</td>
<td>2.5</td>
<td>Indefinite life, traditional, excellent</td>
<td>strong structure</td>
</tr>
<tr>
<td>Glass triple layer 1/4 &quot; (0.6 cm) air space</td>
<td>2.13</td>
<td>light transmission with treated glass.</td>
<td></td>
</tr>
<tr>
<td>Fiberglass glazing- single layer</td>
<td>0.83</td>
<td>Lightweight, strong, shatterproof</td>
<td>Uv Degradable</td>
</tr>
<tr>
<td>Polyethylene Double 5mil film</td>
<td>1.5</td>
<td>Structural costs low, low cost</td>
<td>Short life</td>
</tr>
<tr>
<td>Polyethylene Double 6mil film</td>
<td>1.7</td>
<td>covering, easy to install</td>
<td></td>
</tr>
<tr>
<td>Polyethylene single film</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 inches (15 cm) of fiberglass bat insulation</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polystyrene (styrofoam) 1 inch (2.5 cm) thick</td>
<td>4.0</td>
<td></td>
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</tbody>
</table>

Similar products may vary vastly in terms of quality, these figures are only estimates.
## COST

<table>
<thead>
<tr>
<th>Covering</th>
<th>cost/sqft</th>
<th>uv warranty</th>
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<tbody>
<tr>
<td>Polycarbonate 6mm double wall</td>
<td>1.63</td>
<td>10 year</td>
</tr>
<tr>
<td>Acrylic 8mm double wall</td>
<td>3.35</td>
<td>30 year</td>
</tr>
<tr>
<td>Glass double layer</td>
<td>$$$$$$$</td>
<td>forever</td>
</tr>
<tr>
<td>Two layers of Poly Film 6mm</td>
<td>0.25</td>
<td>4 years</td>
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</table>
Soap bubbles blown through the air gap between two layers of poly would increase the R value. Washing soap bubbles away would increase light penetration.
Typical Cross-Section of the Green House
WINTER SOLAR PROCESS

NORTH ROOF
Insulated night and day during the winter to reflect low angle sunlight into the greenhouse

EXTERIOR MEMBRANE

COOL RESERVOIR
SUNKEN PATHWAYS
GROWING BEDS
FOOTING
WARM RESERVOIR

SOUTH ROOF

The North facing Bubblegenerator fills the north cavity with insulating bubbles

Liquid cooling during the winter day for solar heat capture which is stored in the warmer thermal mass on the south side of the greenhouse

FLOW-THROUGH BACKUP HEATING SYSTEM

END WALL SLIDING DOOR 4"x7"
COLUMNS
Performance on Coldest Night

ARGON
Max temp: 24.3°C
Min temp: −6.1°C

BUBBLE
Max temp: 21.4°C
Min temp: −9.7°C

NO INSULATION
Max temp: 20.3°C
Min temp: −13.3°C

OUTDOORS
Max temp: −26.4°C
Min temp: −41.4°C
Max solar radiation: 445.6 W/m²
Wenkai Greenhouse

Supplemental heating costs 20% of a convention greenhouse 13°C min temp
**Results**

**Figure 2.** Hourly temperatures recorded inside and outside the greenhouse on February 19, 2005.

**Figure 3.** Average temperatures recorded in conventional and solar greenhouses during the month of March, 2005.
Solar Gain
Solar Gain and Absorption

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>VALUE BTU/Sq. Ft./degree F.</th>
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<tbody>
<tr>
<td>Brick</td>
<td>24</td>
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<tr>
<td>Concrete</td>
<td>35</td>
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<tr>
<td>Earth</td>
<td>20</td>
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<tr>
<td>Sand</td>
<td>22</td>
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<tr>
<td>Steel</td>
<td>59</td>
</tr>
<tr>
<td>Stone</td>
<td>35</td>
</tr>
<tr>
<td>Water</td>
<td>63</td>
</tr>
<tr>
<td>Wood</td>
<td>10.6</td>
</tr>
</tbody>
</table>

- Night time thermal release
- Sun heats a thermal mass water, gravel, stone
- Need for supplemental heat night/ winter/ cloudy
Easy Hobby Greenhouse

- Insulated Shutter
- Hinge
- Reflective Surface
- Triple Glazed Window
- Insulated Walls
- 1 Gal Milk Jug
- Growing Soil
Heating Systems

Energy Sources
- Oil
- Bunker C
- Coal
- Electric
- Gas

Concerns
- Oil is dirty, risk of spillage
- Gas is good, but not always available rurally
- COST
- Non Renewable sources

Heating represents 15-35% of operating cost in Ontario.
Experimental Bio Thermal Heating
HOT SHIT

Composting organisms require four equally important things to work effectively:

- **Carbon** — for energy; the microbial oxidation of carbon produces the heat.
  - High carbon materials tend to be brown and dry.

- **Nitrogen** — to grow and reproduce more organisms to oxidize the carbon.
  - High nitrogen materials tend to be green (or colorful, like fruits and vegetables) and wet.[4]

- **Oxygen** — for oxidizing the carbon, the decomposition process.

- **Water** — in the right amounts to maintain activity without causing anaerobic conditions.
Compost Coil Heat Exchangers

Coils to be covered in compost. Heat from compost will transfer to the coils.

The heat exchanger, which will be buried inside the larger heap.
Research on Biothermal Energy

• Greenhouses scattered throughout Europe have been heated and enriched by composting.

• PVC tubes in large compost piles through which water was pumped delivered radiant heat to a greenhouse.

• Schuchardt reports recovery rates of 111 kilowatt-hours per cubic meter (496,000 Btus/yd3 or 4.00 x 108 J/m3) over a six month period; water temperatures were maintained between 30 and 40 degrees C (86 - 1040 F).

• Pain and Pain report that a 50-metric-ton (110,000-lb) pile of wood chips can heat water from 10 degrees C (50 F) to 60 degrees C (1220 F) at a rate of four litres/minute (1.1 gal per min) for up to 6 months.

• White (1982b) reports that from 0.6 to 2.2 square meters (6 - 24 ft2) of greenhouse space can be heated/ton of externally located compost, using EPDM synthetic rubber heat-exchange mats.

• Cons: Labour intensive, Piles need regular replenishment
Bio Mass or Burt’s Burner

- They went from oil to wood
- ¼ of the price
- Heating is till the largest expense
- Heat is delivered by a main pipeline buried 6 feet under in an insulated pipe
Radiant in Floor Heating

Heated floors promote healthy roots and root stratification
Water to Air Heat Exchanger

Air distributed within greenhouse via polyethylene tubing. Just like in the HVAC shop.
Burt’s Piles of Recycled Wood Chips

Auger feeds conveyor belt which brings chips to the burner.

600 tons used per season

Problems with wood... quality... moisture, fiber size, presence of pollutants
How it Burns…

78%-83% Efficiency

Cost: $180,000
~ 5 Years to pay back

$75000 dollars saved vs. Oil / year

First stage (gasification) is based on control of air under the fuel and the grate speed (Lambda <1)
Second Stage (combustion) refers to the complete oxidation of the gases from the first stage gasification.
Cornelius Nurseries: Oregon

Massive Solar Thermal

- 300 000 gallons of water
- Up to 200°F
- 54000 sqft radiant floor heating
- 50% tax incentive
- 5-8 years payback
Cooling

• Shade Clothes

Misting

Ventilation

Evaporative cooling

CFM = Length x Width x 12
Ventilation

Ventilation of a greenhouse has several functions such as:

1. Temperature control (cooling)
2. Humidity control
3. CO2 control

Types

Power vented or natural draft
Manual louvers
Thermostatically controlled louvers
Air bladder fan inflated
Cooling and Ventilation

None

+ 95 Deg. F.
+ 140 Deg. F.

Natural Draft

+ 95 Deg. F.
+ 115 Deg. F.

Fan & Shutter

+ 95 Deg. F.
+ 105 Deg. F.

Evaporative Cooling

+ 95 Deg. F.

Fan and Pad Evaporative Cooling

+ 80 Deg. F.

Evaporative Cooler

+ 80 Deg. F.

Fan, Shutter and Cloth

+ 95 Deg. F.
This Commercial design becomes completely open in under 4 minutes.

Common Commercial thermostatically controlled louver.

Handles like these allow roll up sides of covering increasing natural vent.
R&D on Greenhouses:

DR. Zhang, Langrell, Boris; University of Manitoba funded and Manitoba Hydro.
http://www.hydro.mb.ca/your_business/farm/solar_energy_greenhouses_results.pdf
Thanks to Brain Burt of Burt’s Greenhouses for an informative tour of their greenhouse facilities

… thanks for being green too!

Open for business May 1\textsuperscript{st}

- They have a giant blue flame burner, it burns so clean, you can’t get it plants any greener.

Selling Quality Plants

Since 1981