VrFarms Hydrogen Production from Biomass For Energy Storage to Charge Batteries to Power Micro-Grids

The Design Difference

Biomass to Grid Electric Power Plants and VrFarms Hydrogen Production

Hydrogen from Gasification of Biomass vs Steam to Cooling Towers to Grid Electricity
Deliver Compressed Hydrogen to Charge 2 Mwh Batteries to Power a 1 MW Micro-Grid
Deliver Compressed Hydrogen from Biomass for Off-Grid EV SuperCharging
Power Greenhouses rather than Cooling Towers

The Difference
We Power Micro-Grids with Hydrogen from Biomass and Grow Food
They Waste Energy

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VrFarms Hydrogen Production

The Design Difference

Most Grid Electric Power Plants burn Wood to
Boil Water To Produce Steam and have Cooling Towers

Most Biomass Power Plants operate at 20% Efficiency

These Cooling Towers waste up to 60% of the Energy going into the Power Plants

This makes the US Electric Grid ~ 40% Efficient

We use a Greenhouse as our Cooling Tower (Heat Sink)
Social Benefit – We Create New Indoor Farmers
We Grow Food – They Waste Energy

VrFarms – Hydrogen for SuperChargers for EV (with Zero CO2 Emissions)

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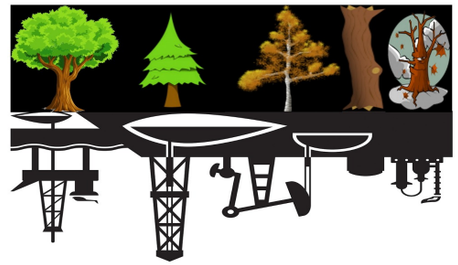


Trees – Upside Down Oil Wells

Water Gas Shift Reaction

CO + H2O □ CO2 + H2

https://en.wikipedia.org/wiki/Water-gas_shift_reaction

https://www.energy.gov/sites/prod/files/2015/01/f19/billion_ton_update_0.pdf

https://www.energy.gov/eere/fuelcells/hydrogen-production-biomass-gasification

Wood Gasifier

Input - 100 TPD Biomass @ 5000 BTU/# (1 billion btu/day)
Produces approx 5850 scfm @ 1400F = 41.6 MBTU/hr = 683333 btu/min

Wood Gas Composition

Carbon monoxide	27.0%
Hydrogen	14.0%
Carbon dioxide	4.5%
Methane	3.0%
Oxygen	0.6%
Nitrogen	50.9%

Hydrogen Capture + Water-Gas Shift CO to Hydrogen

2 Kg/min of H2 Captured into Metal Hydride (@ 16% by vol of H2)

+

Flue Gas Heat Recovery from 1400F to 200F = 126360 BTU/min

Hydrogen at just 16% of Gasifier Flue Gas produces 2 Kg/min or 66 kWh of Hydrogen per minute

H2 Capture into MH TES H2 – GHV = 325 BTU/scf 1 Kg of H2 = 423.4 SCF
5850 scfm capturing H2 into MH TES MgH2 = 71100 BTU/Kg

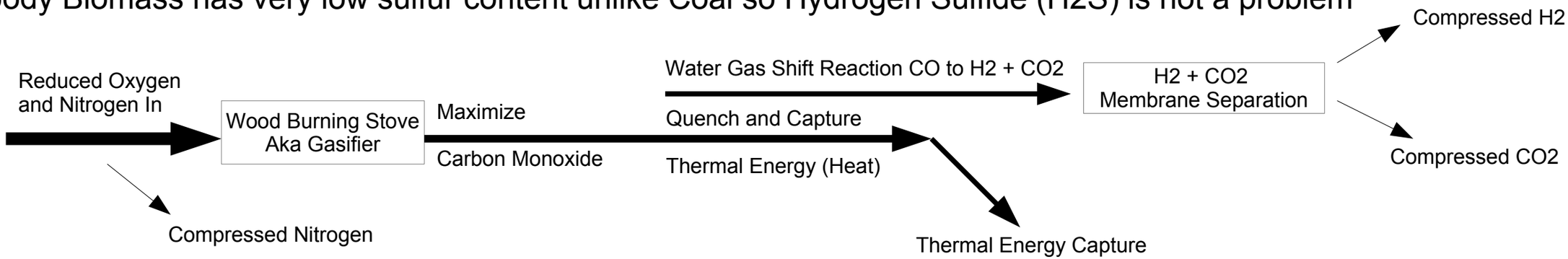
12% - 702 scfm / 423.4 scf/Kg = 1.65 Kg/min H2 at 12% = 117315 BTU/min
20% - 1170 scfm / 423.4 scf/Kg = 2.76 Kg/min H2 at 20% = 196236 BTU/min
30% - 1755 scfm / 423.4 scf/Kg = 4.15 Kg/min H2 at 30% = 294710 BTU/min
40% - 2340 scfm / 423.4 scf/Kg = 5.57 Kg/min H2 at 40% = 392947 BTU/min

Hydrogen from Biomass

Use a Wood Gasifier with a controlled Air Input Mixture on Woody Biomass to Maximize Carbon Monoxide.

Use Water Gas Shift Reaction to Convert Carbon Monoxide to Hydrogen and Carbon Dioxide

Woody Biomass has very low sulfur content unlike Coal so Hydrogen Sulfide (H2S) is not a problem

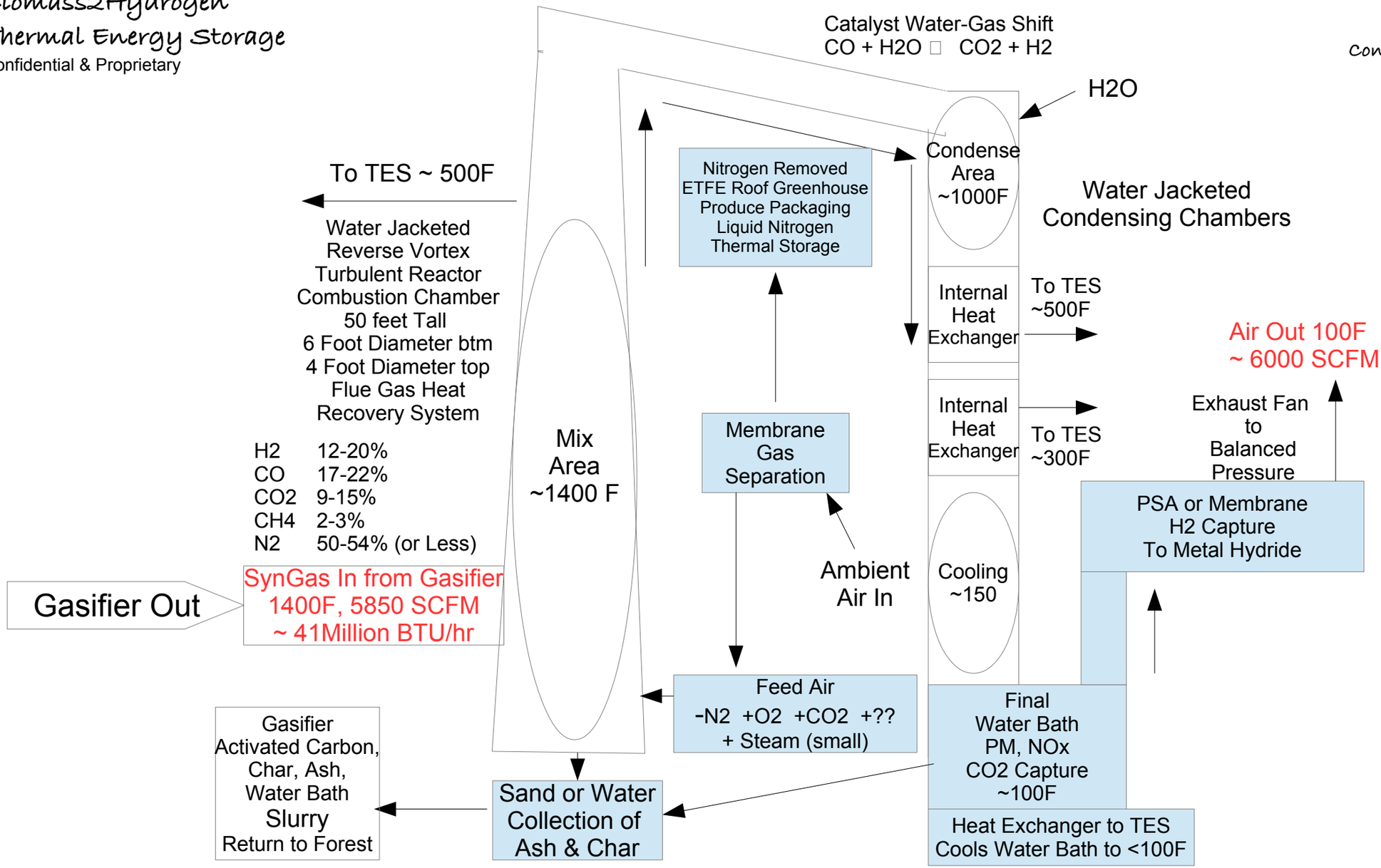


From Wikipedia https://en.wikipedia.org/wiki/Water-gas_shift_reaction

The water-gas shift reaction (WGSR) describes the reaction of carbon monoxide and water vapor to form carbon dioxide and hydrogen:
CO + H2O □ CO2 + H2 – The water gas shift reaction was discovered by Italian physicist Felice Fontana in 1780.

From NETL / DOE https://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/water-gas-shift

The shift reaction will operate with a variety of catalysts between 400°F and 900°F. The reaction does not change molar totals and therefore the effect of pressure on the reaction is minimal. However, the equilibrium for H2 production is favored by high moisture content and low temperature for the exothermic reaction. A conventional low temperature (LT) sweet shift, typically used to reduce residual CO content to below 1%, operates between 400°F to 500°F and uses a copper-zinc-aluminum catalyst.

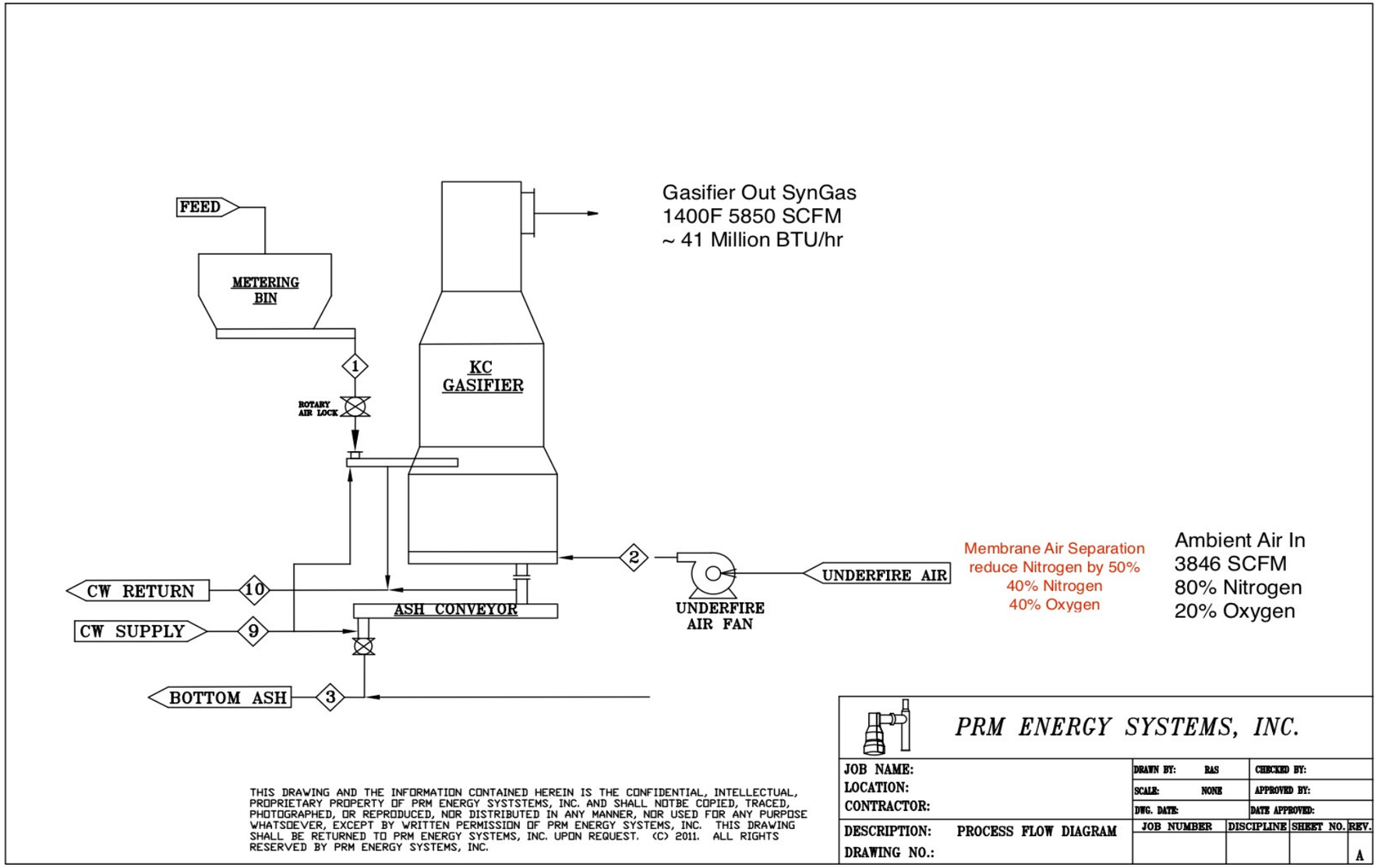

Catalyst Water-Gas Shift
CO + H2O CO2 + H2
H2O
Condense Area ~1000F
Water Jacketed Condensing Chambers
To TES ~ 500F
Water Jacketed
Reverse Vortex
Turbulent Reactor
Combustion Chamber
50 feet Tall
6 Foot Diameter btm
4 Foot Diameter top
Flue Gas Heat
Recovery System
H2 12-20%
CO 17-22%
CO2 9-15%
CH4 2-3%
N2 50-54% (or Less)
Nitrogen Removed
ETFE Roof Greenhouse
Produce Packaging
Liquid Nitrogen
Thermal Storage
Mix Area ~1400 F
Internal Heat Exchanger
To TES ~500F
Air Out 100F
~ 6000 SCFM
Exhaust Fan to Balanced Pressure
Membrane Gas Separation
Internal Heat Exchanger
To TES ~300F
PSA or Membrane
H2 Capture
To Metal Hydride
Gasifier Out
SynGas In from Gasifier
1400F, 5850 SCFM
~ 41Million BTU/hr
Ambient Air In
Cooling ~150
Feed Air
-N2 +O2 +CO2 +??
+ Steam (small)
Final
Water Bath
PM, NOx
CO2 Capture
~100F
Gasifier
Activated Carbon,
Char, Ash,
Water Bath
Slurry
Return to Forest
Sand or Water
Collection of
Ash & Char
Heat Exchanger to TES
Cools Water Bath to <100F

VrFarms
Biomass2Hydrogen
Thermal Energy Storage
Confidential & Proprietary

Standard Wood Gasifier

PRM Energy Systems Inc.
Hot Springs, Arkansas
501 767-2100

http://www.prmenergy.com/



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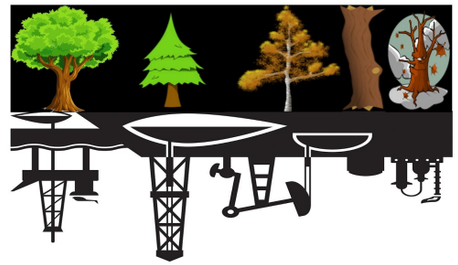


Trees – Upside Down Oil Wells

Available Biomass Energy (Dead Trees) in California

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd582598.pdf

Total Acres at Risk
159170
Average Dead Trees per Acre - 20
Total Dead Trees - 3183400
At 1000 pounds per tree
3,183,400,000 pounds or 1,591,700 Tons
Converting 100 TPD per site
15,917 days or 43 Years
10 – 100 TPD Sites makes it 4.3 years and powers 30 acres of Hydroponic Greenhouses

Energy in Dead Trees Converted to Usable Clean Renewable Energy by My Project
100 Tons per Day Wood Pyrolysis ~ Gasification Thermal Energy Conversion
100 Tons x 2000 #/Ton x 5000 BTU/# = 1,000,000,000 BTU per Day per Site
Replaces this per Day per Site - 300 Sites 10M Tons/Year Dead Trees
= 10,948 gal Propane = 3,284,400 gal Propane
= 7,246 gal Fuel Oil = 2,173,800 gal Fuel Oil
= 964,320 CF Natural Gas = 289,296,000 CF Natural Gas

Existing Similar Greenhouses

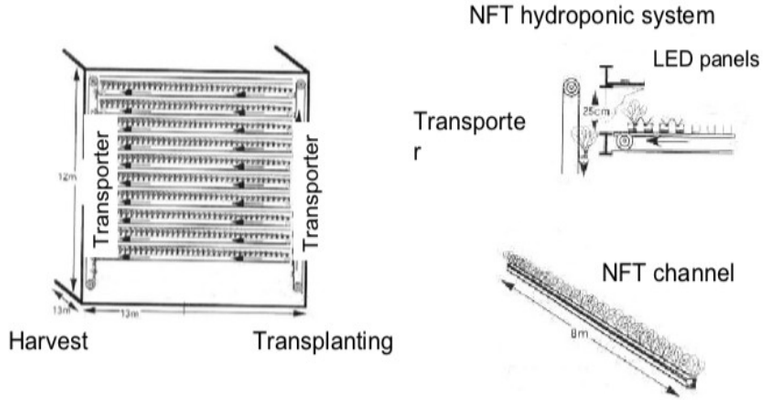
Angel Farm Fukui, Japan, Built 2008,

31,000sf, 3 million heads per year, 46 employees
http://www.meti.go.jp/english/policy/sme_chiiki/plantfactory/exam/exam_1.html
http://www.meti.go.jp/english/policy/sme_chiiki/plantfactory/exam/exam_4.html

Cosmo Factory Farm, 2008

6415sf, 830,000 Heads/year,
7 Employees

Cosmo Plant Growth System



Cultivation area: 800 m² in 169 m² building
Production capacity: 150 million lettuce heads per year

(Source: Watanabe, 2001)

New Greenhouse Design

2 – 200ft dia x 50ft tall Domes, 2 Floors, 3 Acres, Matched to 100TPD Pyrolysis
ETFE Pillow Covered, 25 year Lifetime Sealed, Insulated, LED Lit, Vertical Farming, Co-Gen Heated & Cooled, Climate Controlled Environment
Vertical Farming, Domes are More Stable in Bad Weather