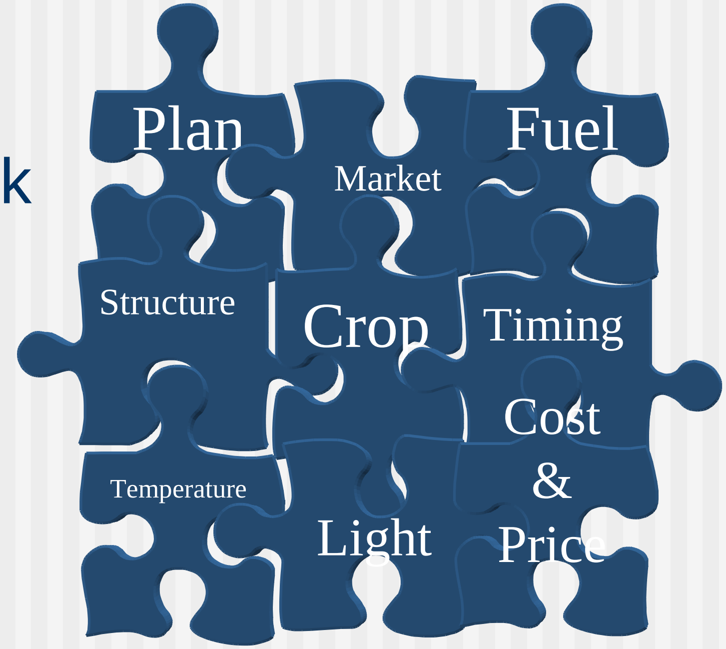
Greenhouse Energy Management, The 2008 Version

for the Western New York Greenhouse Programs



With suggestions from :
Neil Mattson
&
Lou Albright

Walter N Nelson, Horticulture Program Leader
Monroe & Ontario Counties

Agenda

- Structures you grow in?
- Age of structures?
- Tips & tricks
- Fuels you use?
- Cropping implications
- Budget implications

Heating Energy

- Fuel costs rising substantially since year 2000
- Suggestions for reduce energy consumption
  - Proper controls
  - Alter crop development plan
  - Improve space efficiency
  - Structural changes with some capital investment
  - Fuel selection
  - Result, return on investment can be significant, especially in New York

Controls

- Placement
- Check for temperature gradient
- Response lag?
- Set point offset?

Heat distribution

- Air unit heaters
  - Clean
  - Direct air stream down
  - HAF
- Pipes
  - Clean
  - Latex, oil, not aluminum paint on iron
  - Insulated to outside walls
  - Reflective metal between pipe and outside

Structure

- Air leaks? (w/ bee smoker)
- Insulate foundation walls, pipes
- Double glaze side & end walls
- Super insulate north walls

Structural Options

- Vertical curtains
- Retractable energy/shade curtain
  - 20-60% reduction in fuel use
- Improve insulation
  - gaps near fans, doors, roof, wherever
    - 20% waster, plug 'em and save 3-10%
  - Insulate north walls w/ reflector insulation
  - Sidewall insulation save 10%
  - Foundation insulation save 5%
  - Seal off exhaust fans, another 5%

HAF & Cycling

- Mix air
- Increase uniformity
- Your fan position?
- Dead band
  - Reduces cycling
- Set point
- Monitor average daily temperature, adjust to stay on schedule.

Lighting

- Reflectors
- Clean
- Directed to plants, not aisles

Plug Size

- Larger plug reduces final crop timing
- Finish stage, fewer plants per ft^2
  - (compared to plug stage)
- Heat and light costs *per plant* are lower
  - (higher density)
- Partial budget size & origin

Saving heat?

- Crop timing increases as temperature decreases
- Lower temperatures, begin earlier
- Result: start heating greenhouse earlier
- Energy consumption *per crop* grown in the spring can be higher w/ cool grown corps, heated longer

Cropping Strategies

- Not all plants respond to temperature the same way
- Separate cold-tolerant and cold-sensitive crops
  - vinca and celosia grow very slowly at 60F
  - ageratum, pansy and ivy geranium continue to grow moderately well at 60F
- Open up a full greenhouse

Temperature ABCs

- Temperature controls timing
- Plants respond differently to temperature
- Above their base plants grow faster and faster
  - Base temperatures differ
    - AKA petunia cooler, vinca warmer

Cold-tolerant/cold-sensitive

- Difference relates to crop's base temperature
- Low base temperature = "cold-tolerant"
- High base temperature = "cold-sensitive"
  - Cold-sensitive plants more sensitive to lower greenhouse temperature than cold-tolerant species
- Middle ground plants (base temperature between 39°F and 46°F)
- All plants respond to temperature during all development stages

Salvia 'Vista Red'

- 288-cell trays

Temperature	Weeks to Finish
57F	6.5
79F	4

- Under low light, transplant to first flowering 12 days longer at 63°F than at 73°F

Effect of Temperature on Impatiens, Petunia & Pansy

Cultivar	54°F	61°F	68°F	75°F	delay in flowering if 24-h temp is reduced 1°F (days)
Super Elfin Lipstick		72	54	47	1.8
Avalanche Pink	88	74	47	39	2.5
Dreams Rose	84	67	46	37	2.3
Purple Wave	112	88	57	45	3.3
Colossus Yellow Blotch	95	82	63	58	1.9
Crystal Bowl Supreme Yellow	72	63	51	46	1.3
Delta Pure White	88	71	61	53	1.6
Sorbet Blackberry Cream	68	60	50	45	1.1

Quality & Temperature

- For most crops, quality increases as temperature decreases
  - thicker stems
  - greater branching
  - more roots
  - more, larger flowers
- Exceptions, heat loving plants
  - AKA hibiscus
- Benefit of growing cool = overall plant quality improves, although delayed
- Watch for chilling injury

Lights

- Provide long days to long-day plants
  - Many annuals and perennials long-day plants
    - Flower earlier when grown under a long photoperiod
    - Examples: ageratum, blue salvia, dianthus, pansy, petunia, Rudbeckia, snaps, and tuberous begonia
    - Spring photoperiod short until April
    - Flowering of early long-day crops delayed without artificial long days
- Supplemental lighting
  - Pack energy to plugs or seedlings

Photoperiod

- Accelerate flowering of long-days plants with LD
- Extended days or night break
- ‘Wave’ petunias
- Retard flowering of short-day plants with LD
- Extended days or night break
- *Cosmos* and *Zinnia*

Photo Energy

- High quality light (daily light integral, or DLI)
- Early flower development, fewer leaves
- Higher plant temperature accelerating growth

Lights

- DLI is an inve$tment
- High pressure sodium
- Photoperiod lighting , less so
  - Incandescent or high-pressure sodium
  - ~10 foot-candles

Media ^oF *fx* of air ^oF

- Cooler air = cooler media
- Nutrition *fx* of ^oF
- Water uptake *fx* of ^oF
- Smaller plants > impact (plugs)
- Optimum 60-65 ^oF
- Media ~ < 10 ^oF with overhead heat
  - > when growing on ground
  - > with cold water
  - Evaporation cools soil
- *What is your media temperature?*

Media Temperature Remediation

- Warm irrigation water
- Grow off the ground, only pallet height?
- Air circulation, open benching vs flood
- Propagate with tent versus mist or fog

Tips for Growing Cooler

- Separate crops by thermal demand
- Cool crops w/ established root systems
- Grow off the floor (unless floor heated)

Nutrition

- Phosphorus (P) deficiency symptoms
  - Stunting, purpling of stems, leaf petioles and undersides of leaves
- cold media
- Low $^{\circ}$F influences water (other nutrients) uptake
- Inactive roots = water uptake = wilting
- AND…
- Low temperatures = higher Rh
- Calcium (Ca) moves with water uptake
- Lacking root action = Ca

Nitrogen

- Ammonium Nitrogen (NH_4) converts to Nitrate Nitrogen (NO_3^-) by bacterial action
- @ < 60 ^oF ~~action~~
- Result = NH_4 toxic build up
- Remedy = use NO_3^- fertilizer

Oxygen

- Low temperatures = low H_2O use =oxygen starvation
- Remedy… well drained media, large pore space
- Prepare to adjust water practice when changing media composition

Insects & Growing Degree Days (GDD)

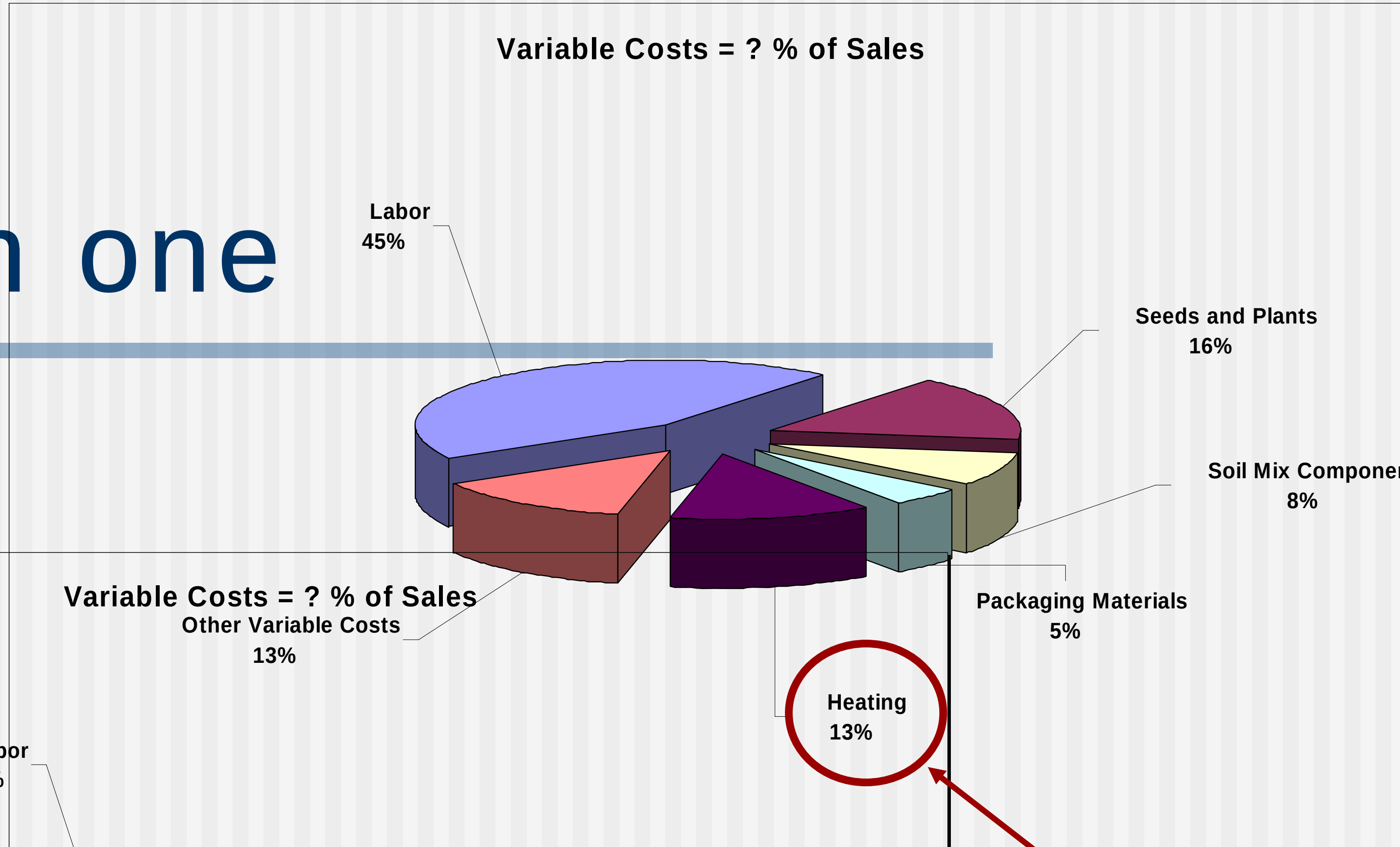
- Two spotted spider mite 50° F
  - Optimum development 85° F and 95° F
- Western flower thrips 50° F
  - At 78-82° F life-cycle from egg to adult 12 - 14 days (cooler = slower)
- Whitefly 47° F
  - Greenhouse vs. silverleaf = 7 days @ 70° F
- Green peach Aphid 39° F
  - Proportional development with temperature
- *Cool Temps = Aphids!*

Cool = slower development

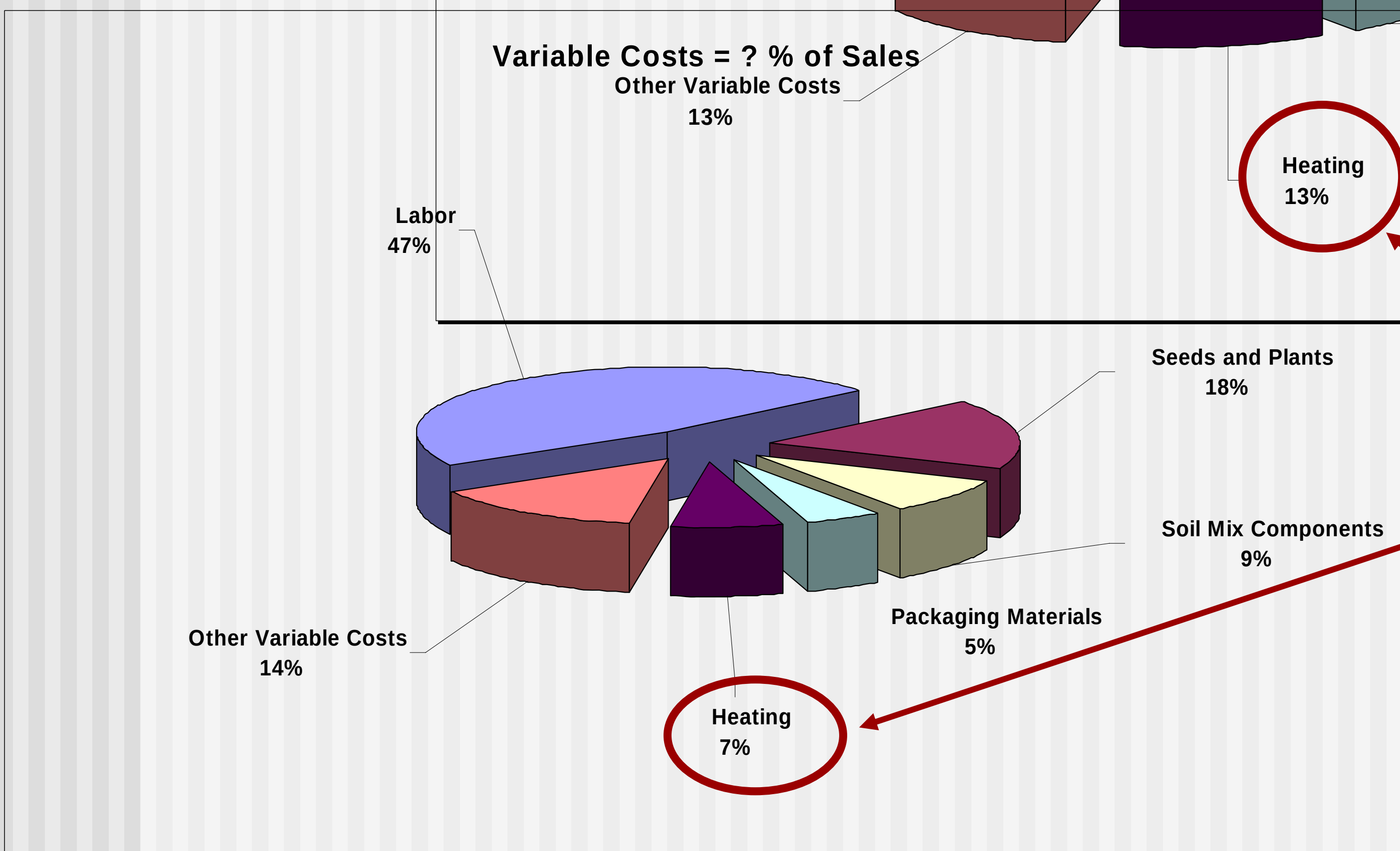
Diseases

- *Botrytis cinerea* higher Rh favors development
- Sanitation is prime management tool
- Decree (brown residue)
- Chipco 26019
- Daconil 2787 (& others containing chlorothalonil)
- Compass
- Medallion (pricey, some plants injured)

Firm one



Variable Costs = ? % of Sales
Labor 45%
Seeds and Plants 16%
Soil Mix Components 8%
Packaging Materials 5%
Heating 13%
Other Variable Costs 13%



Variable Costs = ? % of Sales
Labor 47%
Seeds and Plants 18%
Soil Mix Components 9%
Packaging Materials 5%
Heating 7%
Other Variable Costs 14%

Firm one

- Gross ~$750,000
  - Scenario 1:
    - Fuel nearly doubles, no other changes
    - Result: profit 5% to –0.19%
    - Net Income ~$35K to -$1,350
  - Scenario 2:
    - 2X fuel & Sales up 5%
    - Result: Π now 9.6%
  - Scenario 3:
    - 2X fuel & Sales up 1%
    - Result: Π now 0.9%

Firm Two

- Gross ~$160,000
  - Scenario 1
    - Double fuel, no other changes
    - Result Π 5.64% to –1.7%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result: Π now 2.9%
  - Scenario 3
    - 2X fuel & Sales up 1%
    - Result: Π now –0.61%

Firm Three

- Gross ~$550,000
  - Scenario 1
    - Double fuel, no other changes
    - Result Π 20.8% to 15%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result Π now 19%
  - Scenario 3
    - 2X fuel & sales up 1%
    - Result Π now 15.8%

Firm Four

- Gross $500,000
  - Scenario 1
    - Double fuel, no other changes
    - Result Π 24% to 9%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result Π now 14%
  - Scenario 3
    - 2X fuel & Sales up 1%
    - Result Π now 10%

Fuel	$/unit	1,000 BTU/$1	Efficiency %	Yield 1,000/BTU/$1
Wood pellet	120/T 240/T	141 70.5	60 60	
Nat. gas	7.4/D-Therm	116.25	90	
#2 corn*	3.50/bu.	108.8	75	
Rice coal	190/T	131.6	70	
Grass pellet	120/T	87.3	60	
#2	2.70/gal.	41.4	85	
LP	2.50/gal.	36.6	85	
electric	0.124/KWh	27.5	100	

Fuel	$/unit	1,000 BTU/$1	Efficiency %	Yield 1,000/BTU/$1
Wood pellet	120/T 240/T	141 70.5	60 60	84.6 42.3
Nat. gas	7.4/D-Therm	116.25	90	104.63
#2 corn*	3.50/bu.	108.8	75	81.6
Rice coal	190/T	131.6	70	92.1
Grass pellet	120/T	87.3	60	52.38
#2	2.70/gal.	41.4	85	35.19
LP	2.50/gal.	36.6	85	31.1
electric	0.124/KWh	27.5	100	27.5

PENNSTATE

College of Agricultural Sciences • Cooperative Extension

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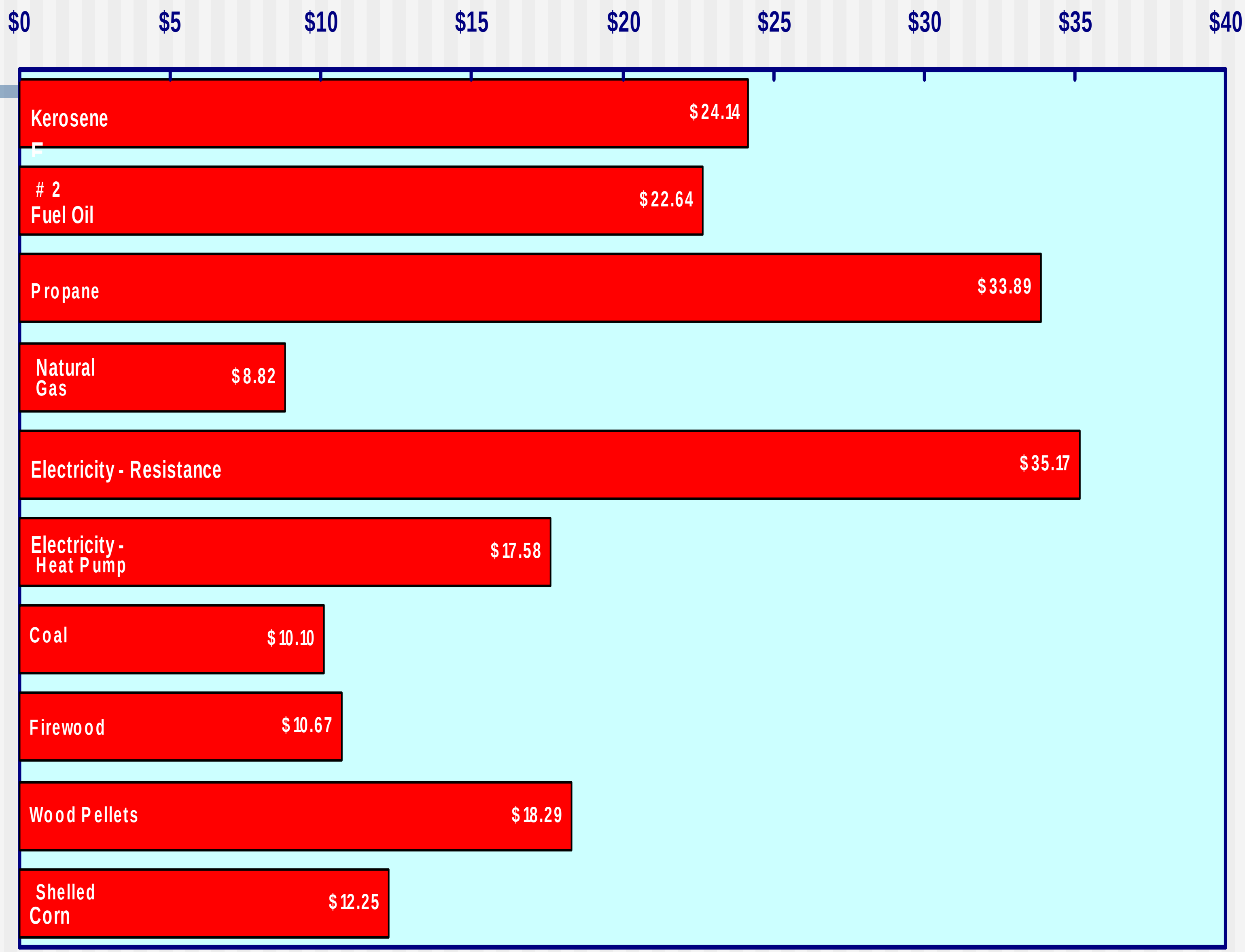
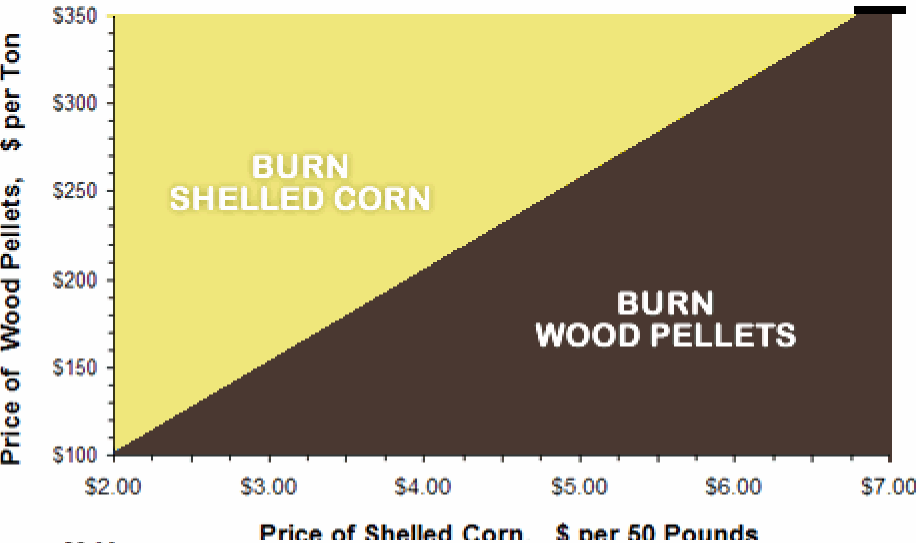
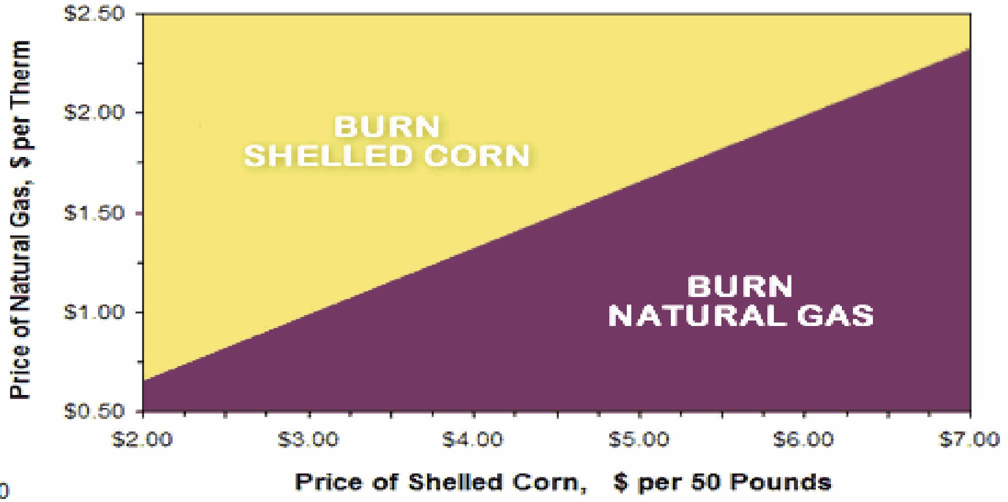
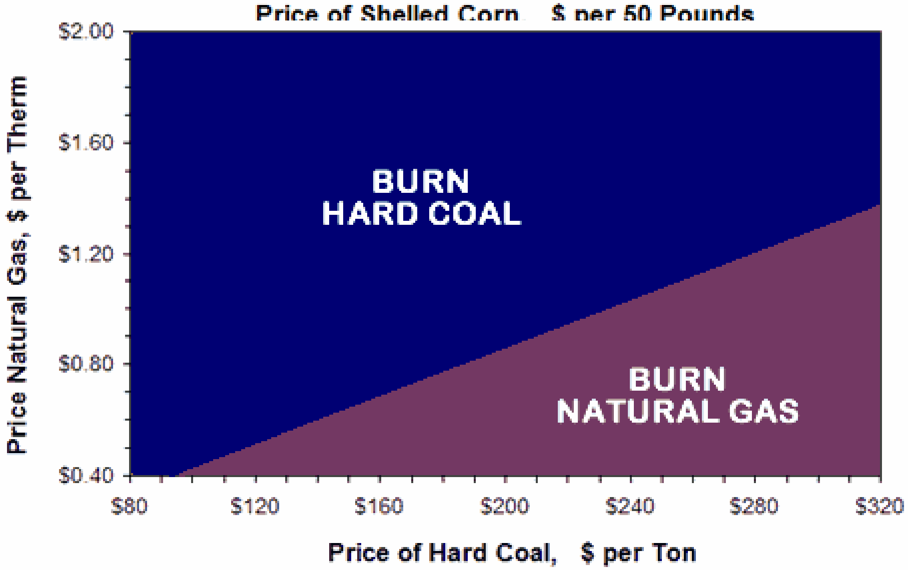
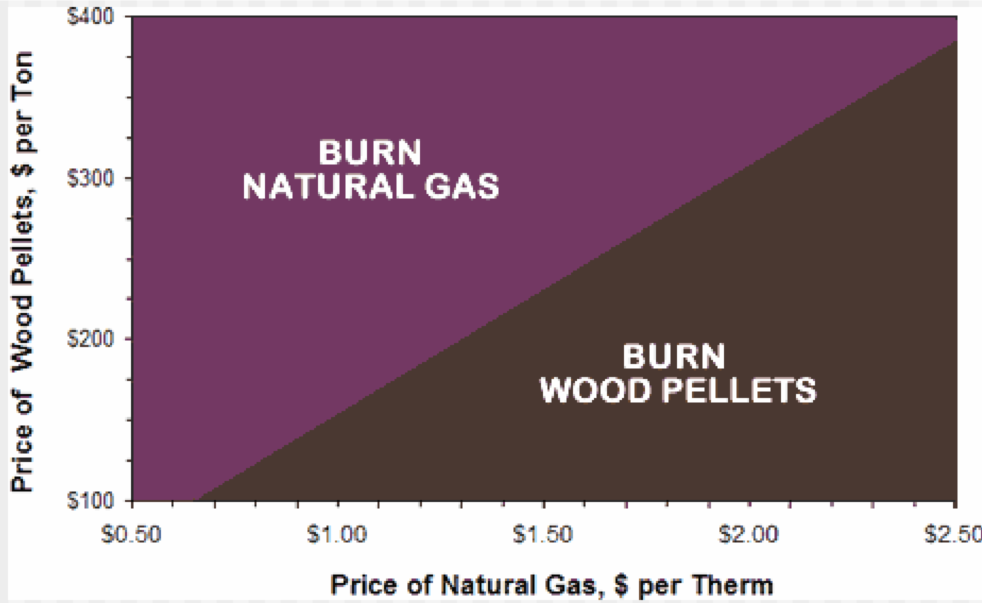
ENERGY COST COMPARISONS, $/Million BTU

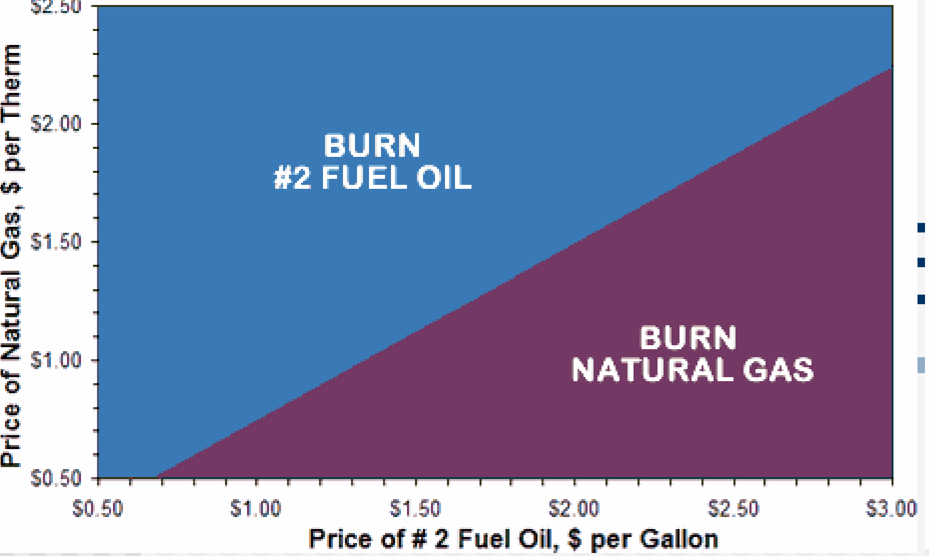


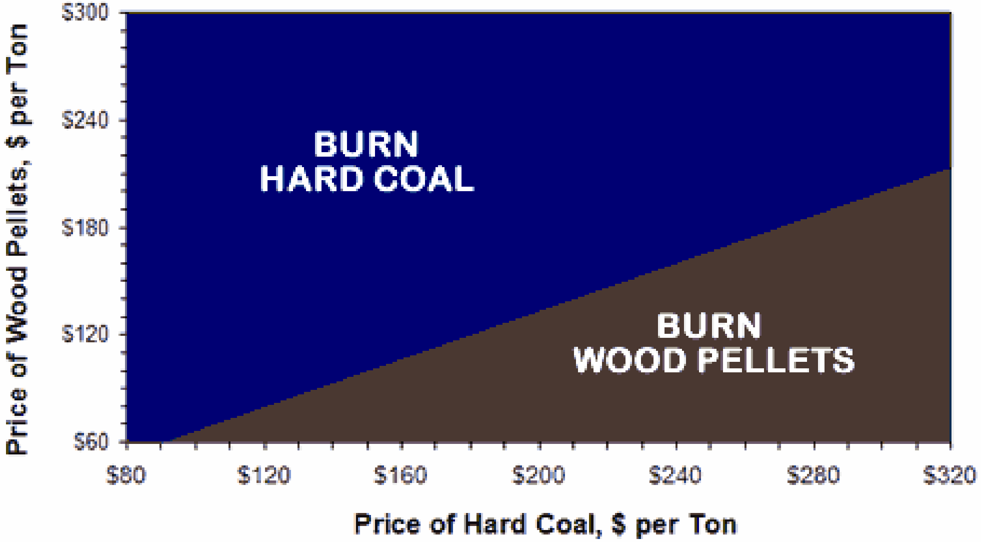

$350
$300
$250
$200
$150
$100
Price of Wood Pellets, $ per Ton
BURN
SHELLED CORN
BURN
WOOD PELLETS
$2.00
$3.00
$4.00
$5.00
$6.00
$7.00
Price of Shelled Corn $ per 50 Pounds


$2.50
$2.00
$1.50
$1.00
$0.50
Price of Natural Gas, $ per Therm
BURN
SHELLED CORN
BURN
NATURAL GAS
$2.00
$3.00
$4.00
$5.00
$6.00
$7.00
Price of Shelled Corn, $ per 50 Pounds


$2.00
$1.60
$1.20
$0.80
$0.40
Price Natural Gas, $ per Therm
BURN
HARD COAL
BURN
NATURAL GAS
$80
$120
$160
$200
$240
$280
$320
Price of Hard Coal, $ per Ton


$400
$300
$200
$100
Price of Wood Pellets, $ per Ton
BURN
NATURAL GAS
BURN
WOOD PELLETS
$0.50
$1.00
$1.50
$2.00
$2.50
Price of Natural Gas, $ per Therm


BURN
#2 FUEL OIL
BURN
NATURAL GAS
Price of Natural Gas, $ per Therm
$2.50
$2.00
$1.50
$1.00
$0.50
$0.50
$1.00
$1.50
$2.00
$2.50
$3.00
Price of # 2 Fuel Oil, $ per Gallon


BURN
HARD COAL
BURN
WOOD PELLETS
Price of Wood Pellets, $ per Ton
$300
$240
$180
$120
$60
$80
$120
$160
$200
$240
$280
$320
Price of Hard Coal, $ per Ton

More Information

- MSU GH Energy Fact Sheet
  - http://msucares.com/pubs/infosheets/is1618.html
- U Mass GH Energy Fact Sheets
  - www..umass.edu/umext/floriculture/fact_sheets
- Penn State web site
  - http://energy.cas.psu.edu/
- *Energy Conservation for Commercial Greenhouse*
  - NRAES-3 www.nraes.org or 607-255-7654

In Closing...

- What's new?...Nothing!
- Sweat the small stuff, for energy savings
- Labor is the largest cost

- Questions?
- Comments

Walter N Nelson, Horticulture Program Leader
Monroe & Ontario Counties