Overview of Thermochemical Processes

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Alternate Pathways to Value

Untreated animal manure

Today - 98% land applied

Composting,
Storing & drying
Screening

Nutrients

Organic fertilizer,
Soil amendments,
Bio-char
Ash

Solid separation,
Chemical additions,
Filtration

Water Reuse

Flush water,
Irrigation,
Animal watering,
Parlor water

Torrefaction
Pyrolysis,
Gasification,
Combustion

Energy

Electricity,
Steam
Heating & cooling,
Heating oil, diesel
Fuel pellets

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Motivation for Thermal Processes

- Reduce the volume of land applied animal manure
- Concentrates the animal waste, (nutrients more transportable)
- Dry waste verses wet waste
- Provides options for managing odor
- Byproducts help farms generate revenue, becoming more sustainable
- On-farm energy can reduce farm's operating cost and energy dependence

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Manure has enough energy to be valuable

Feedstock	(Btus/lb) *	% Ash *	% Dry Matter
Chicken Litter	6,500	20	70
Swine feces	8,000	15	3
Dairy manure	8,000	10	1-15
Feedlot manure	4,500	30	70
Wood	8,000	3	50
Municipal sewage	4,000 – 8,000	15-60	<1-3
Coal, bituminous	12,000	22	80

* Values reported are based on dry matter basis

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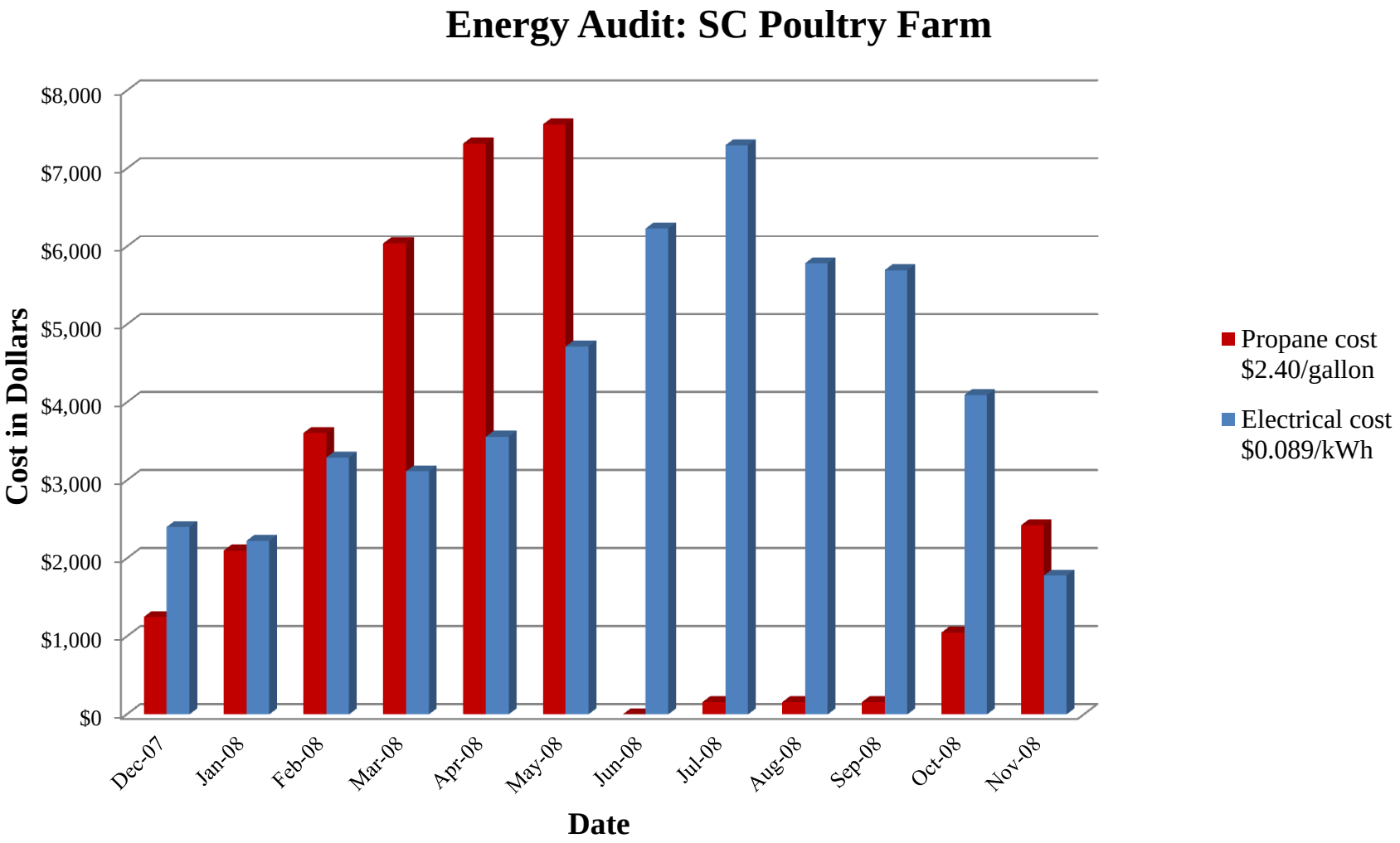
On Farm Energy Consumption



Manure is a Challenging Feedstock

- Material handling systems are not mature
  - Waste can be heterogeneous, variable
  - Tendency to bridge
  - Foreign materials
- Feedstock preparation
  - Moisture
  - Fractionation
- No "off -the-shelf" system for manure-to-energy
  - Byproducts not fully characterized nor market ready
  - Scale (smaller farm-scale electrical technologies just now emerging)

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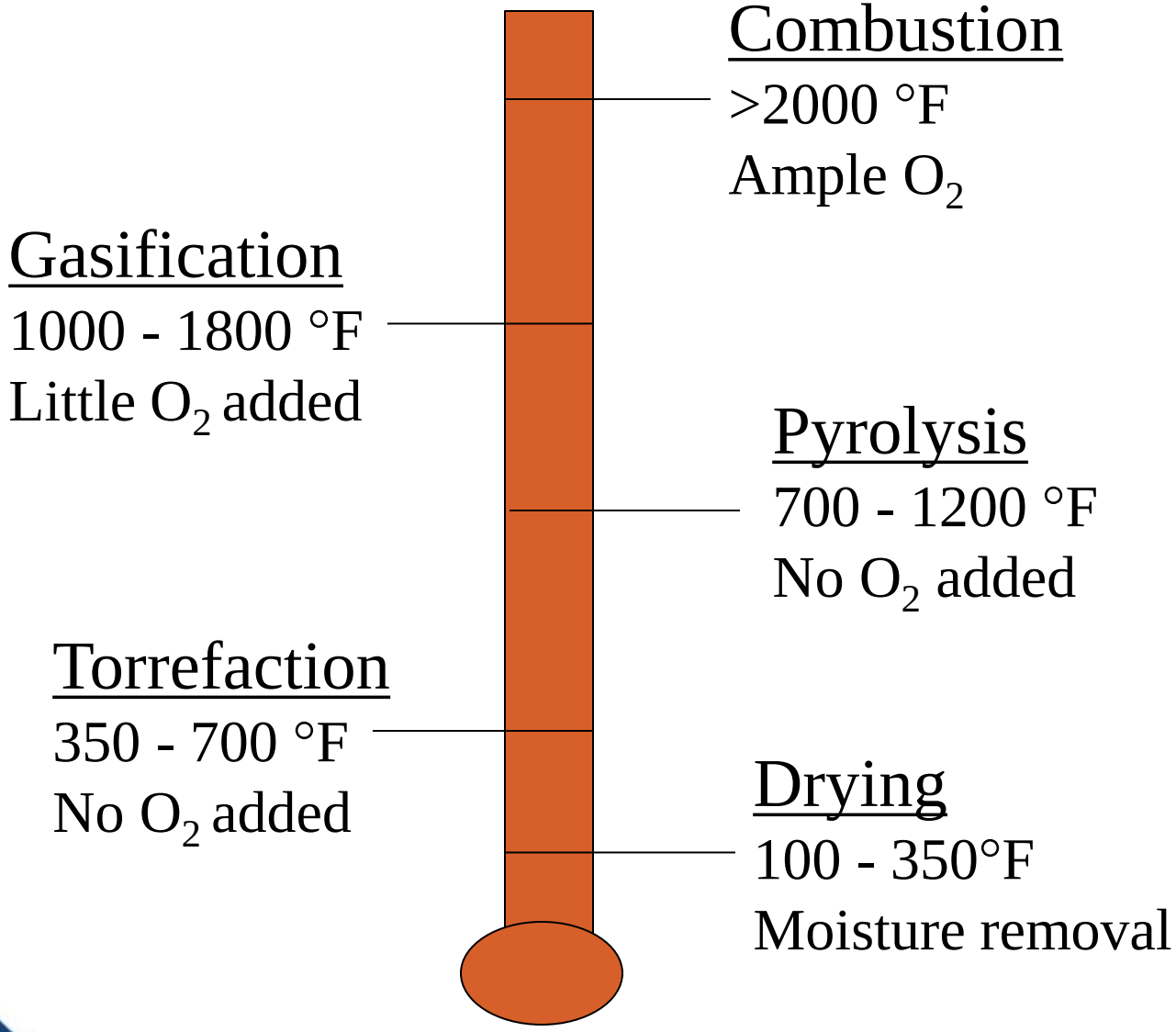
Thermochemical Processes



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Thermochemical Processes

Drying

Dry product

Torrefaction

No added O_2
Bio-char

Pyrolysis

No added O_2
Bio-char
Bio-oil
Syngas

Gasification

Little or No O_2
Thermal energy
Syngas
Ash

Combustion

Ample O_2
Thermal energy
Ash

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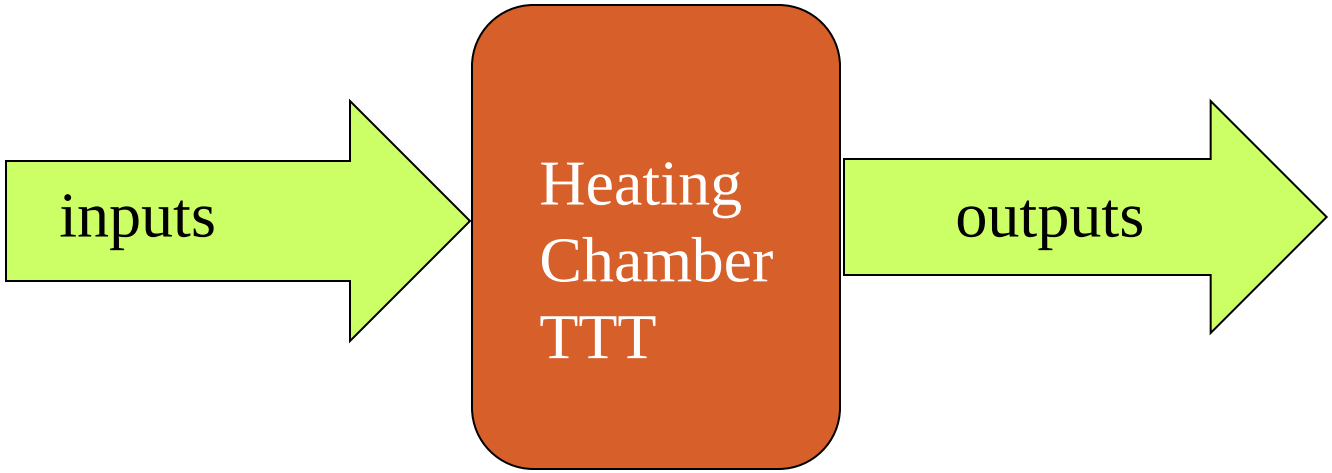
Analysis of thermochemical conversion



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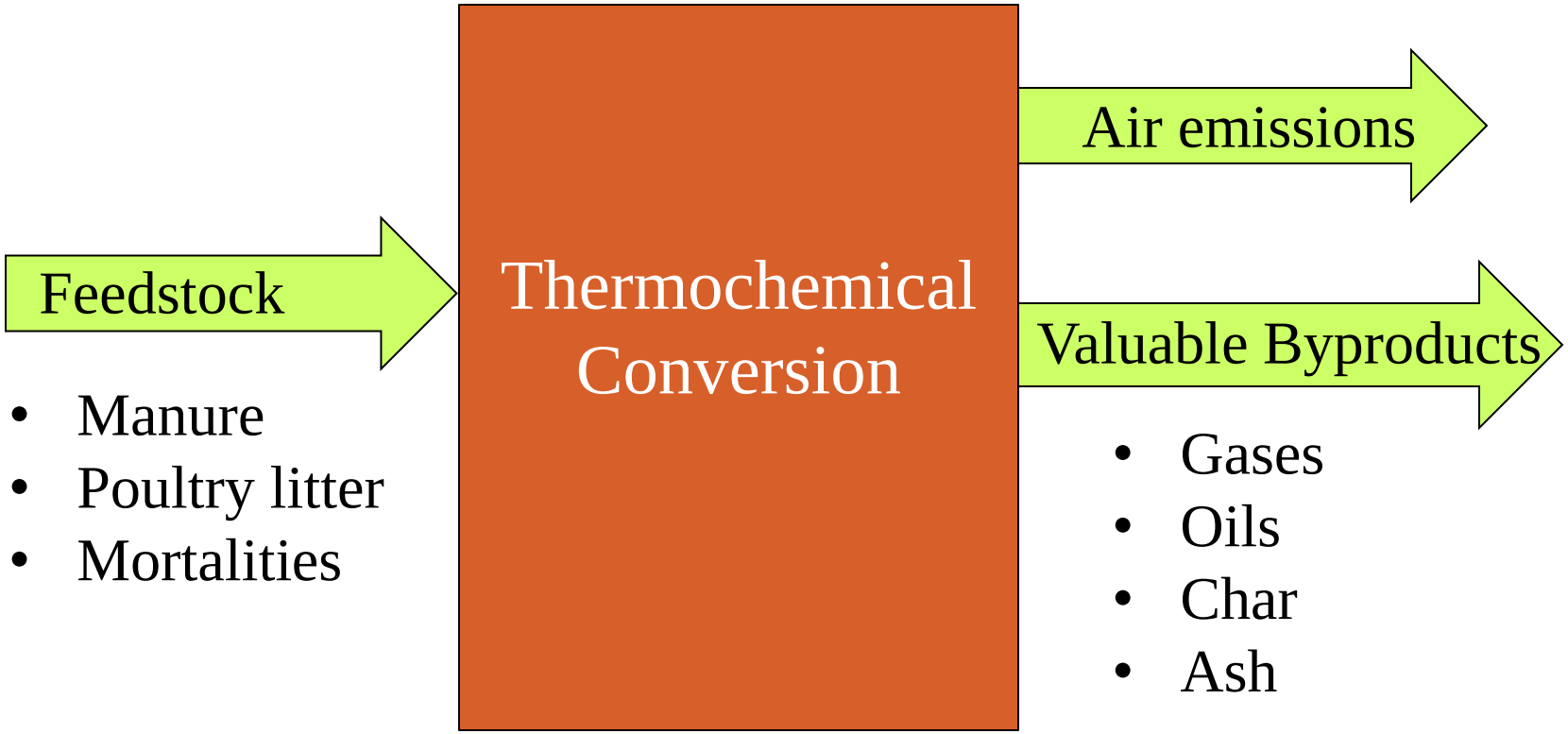
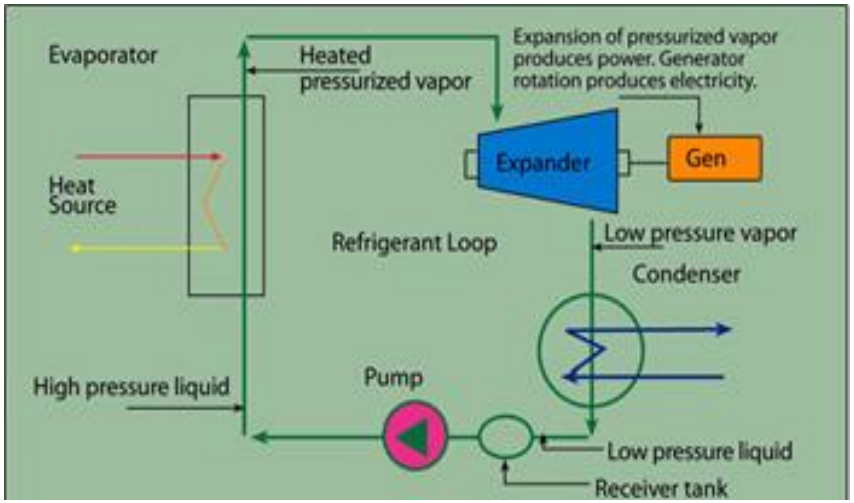
All of the N,P,K can be accounted for in a nutrient mass balance

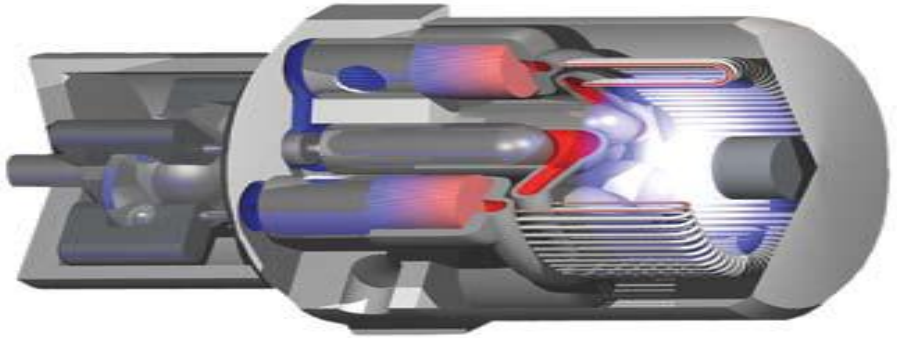


Conversion Technology: Heat to Electricity

- Organic Rankine Cycle;
  10-100 kwe



- Stirling Engine;
  30 kwe



- Steam Turbine; >500kwe

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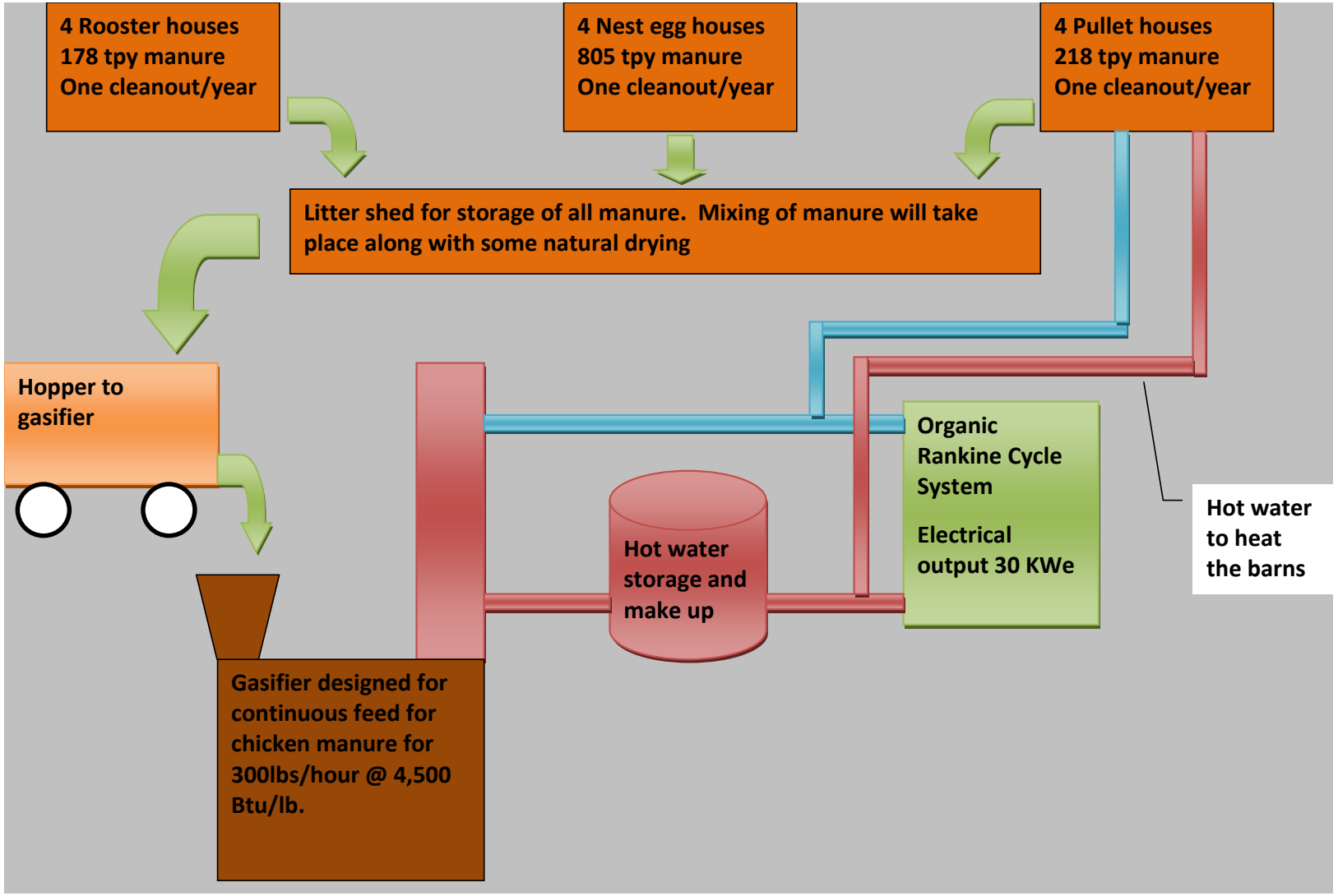
Process Flow for a Poultry Farm Project



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- Characteristics of ash: Contains oxides and carbonates of minerals excreted with manure; P, K, Ca, Mg
  - Except for N, Cl, and S
- Collaborators: FPPC, NRCS, local poultry farmer, Virginia Tech
- Location: DELMARVA Peninsula
- Problems: untreated manure not suitable for vegetable crops
- Utilizing ash for fertilizer substitute
  - Phosphorus rich
  - No pathogens
  - Concentrated
  - Pelletize to reduce dust
  - Applied to vegetable crops to replace synthetic fertilizers
- Other uses: feed additive, construction
- New P standards will make continued land application more difficult

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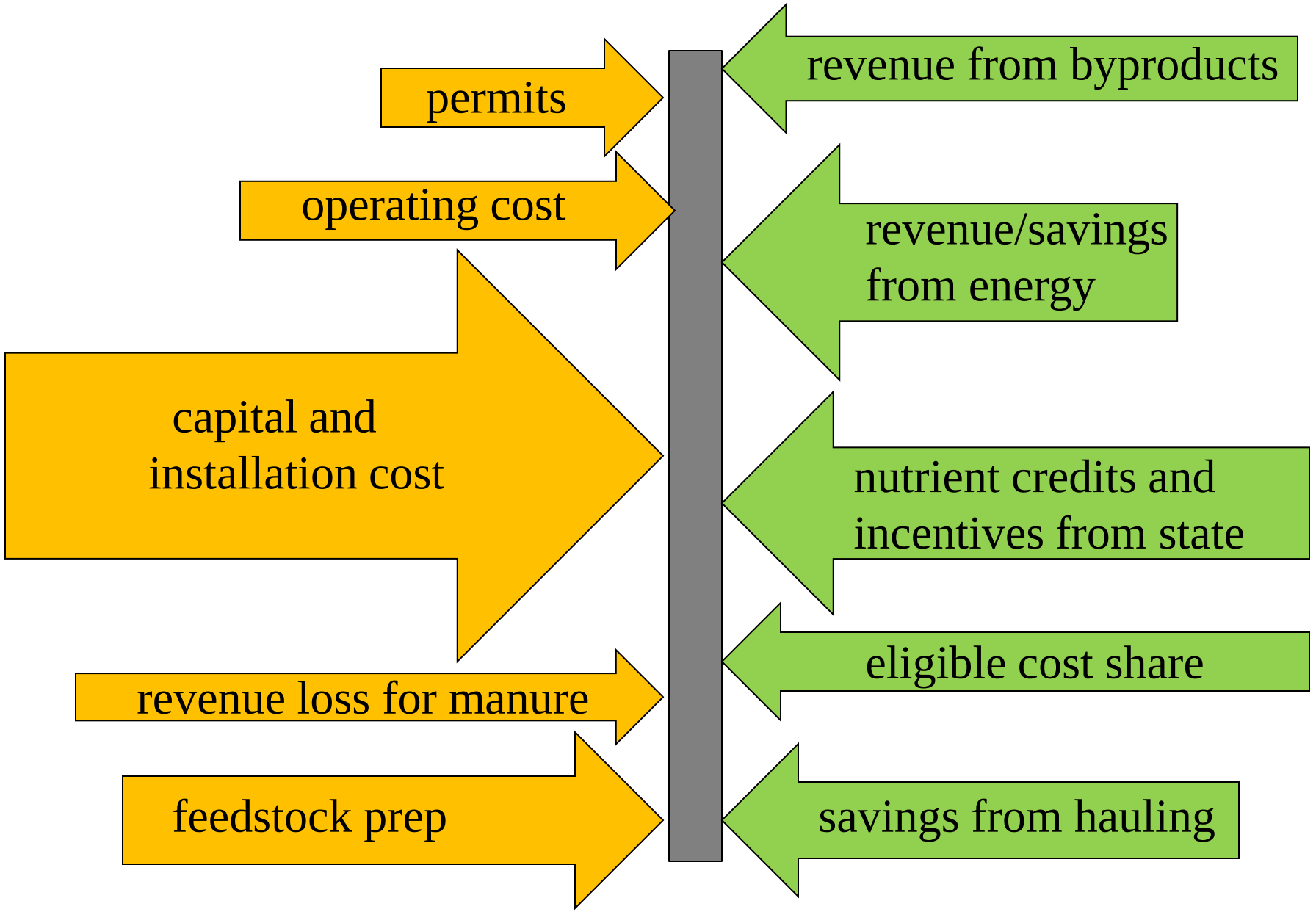
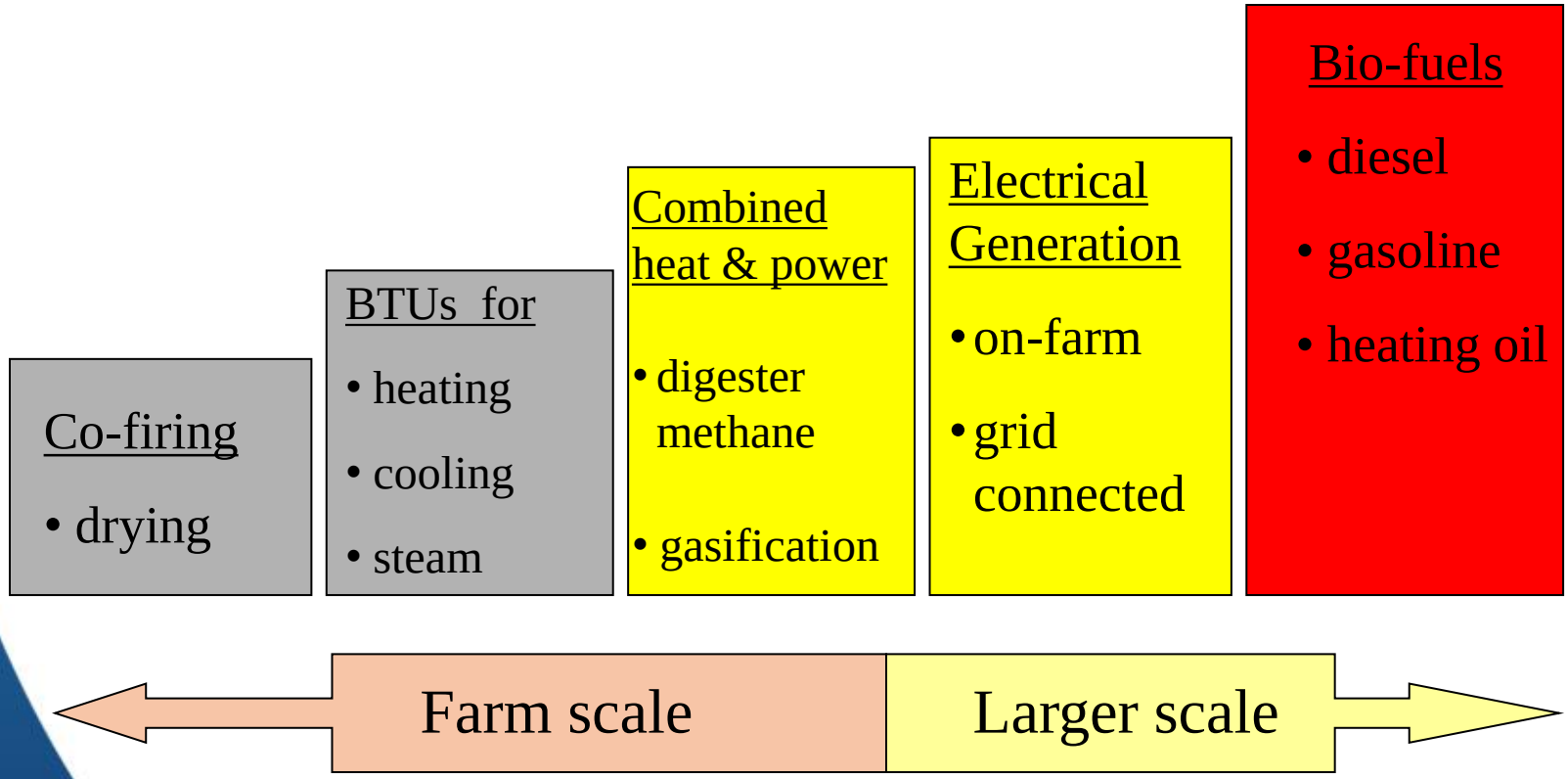
Generating payback - Economic Analysis



Complexity and Cost Will Change Depending On System Benefits Targeted



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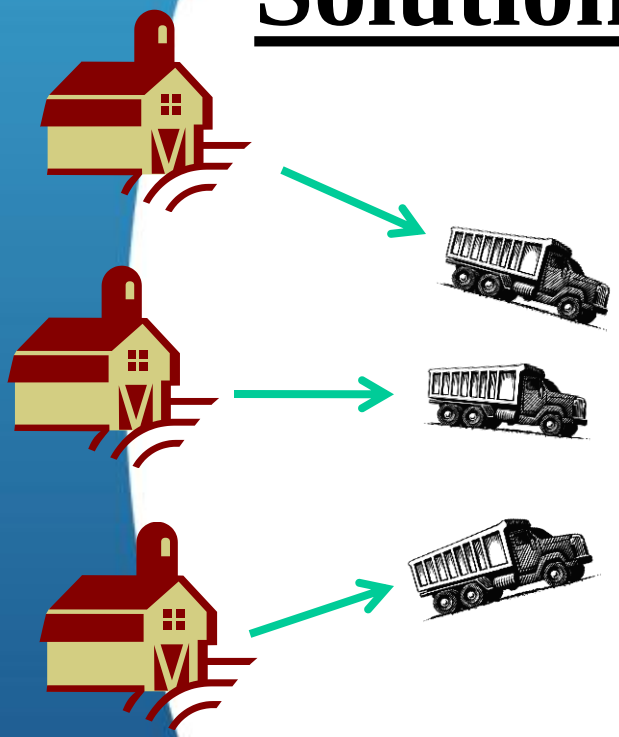
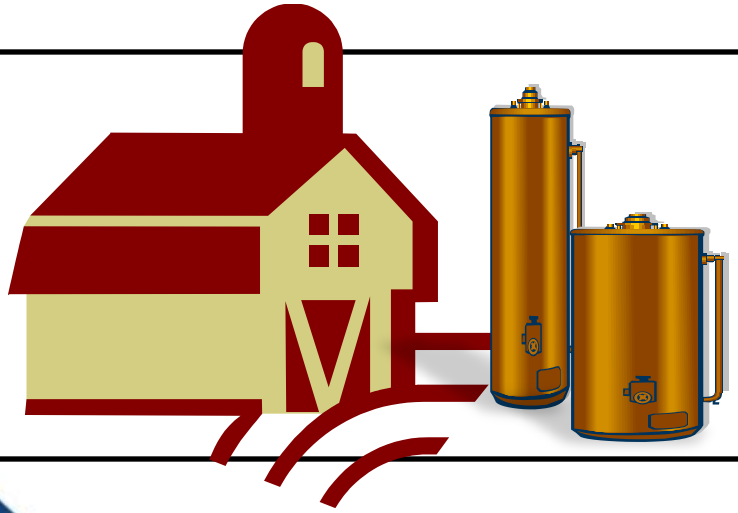
Solutions must fit size of operation



Hauling dry waste to a shared, centralized facility may offer a better solution for small farms, clustered nearby



Larger farms, remotely located may be better served with on-site treatment facilities

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Conclusions

- Farm energy audits encouraged
- Feedstock/Process/Products must be engineered as a complete system
  - Net energy out ≥ Net energy in
  - Feedstock preparation is important
- Economically viable solutions will require markets for by-products

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