Energetics of Sustainable Agriculture

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4th Biophysical Economics Conference
University of Vermont
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Where are the Networks?

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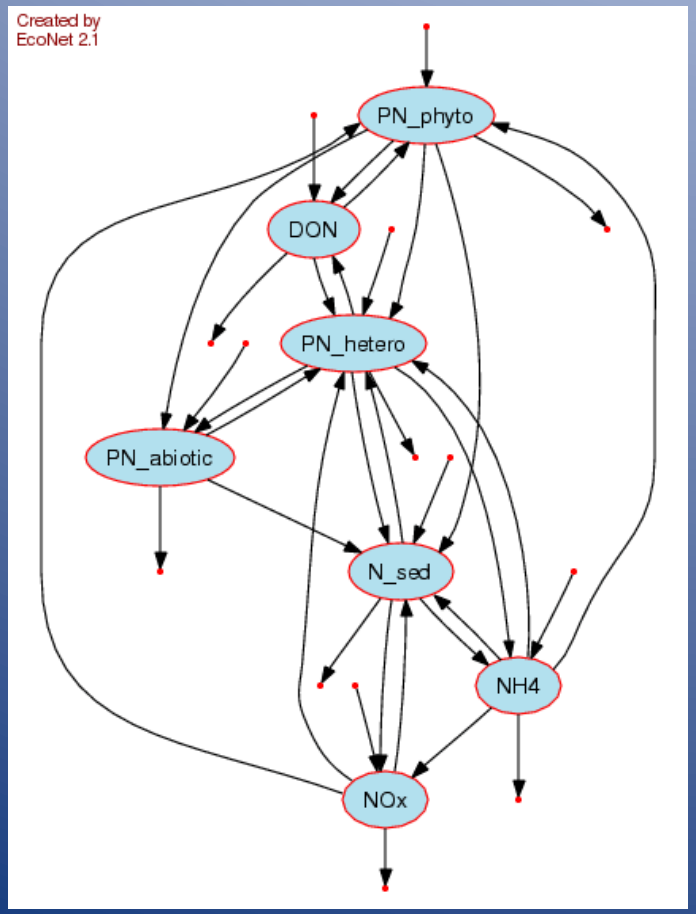
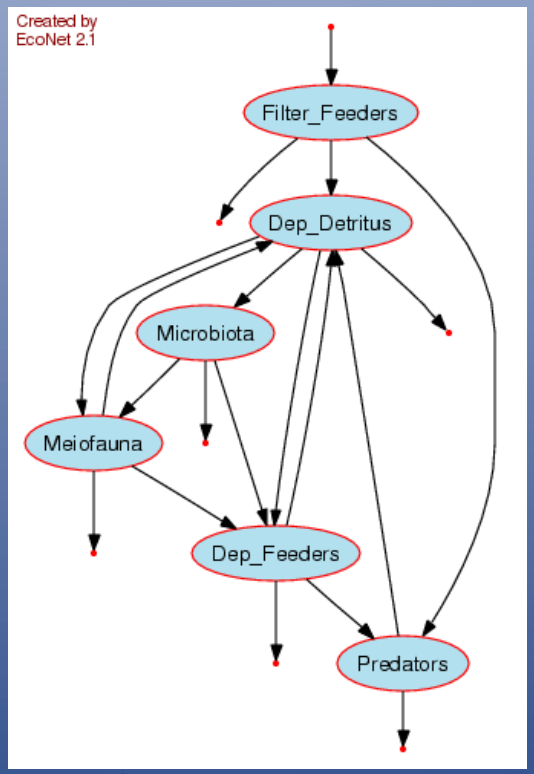
Examples, Mass & Energy Network Modeling

Neuse River Nitrogen
Mass Model
Finn Cycling = 89%



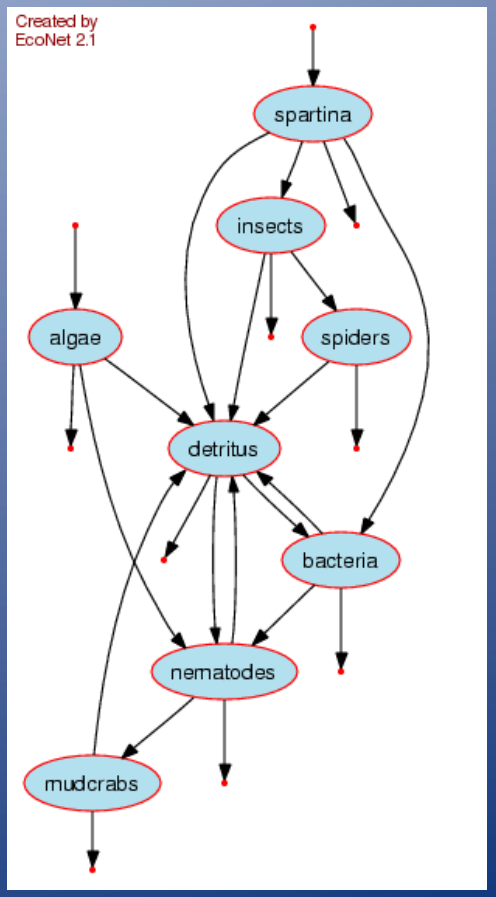
Christian and Thomas 2003

Oyster Reef
Energy Model
Finn Cycling = 11%



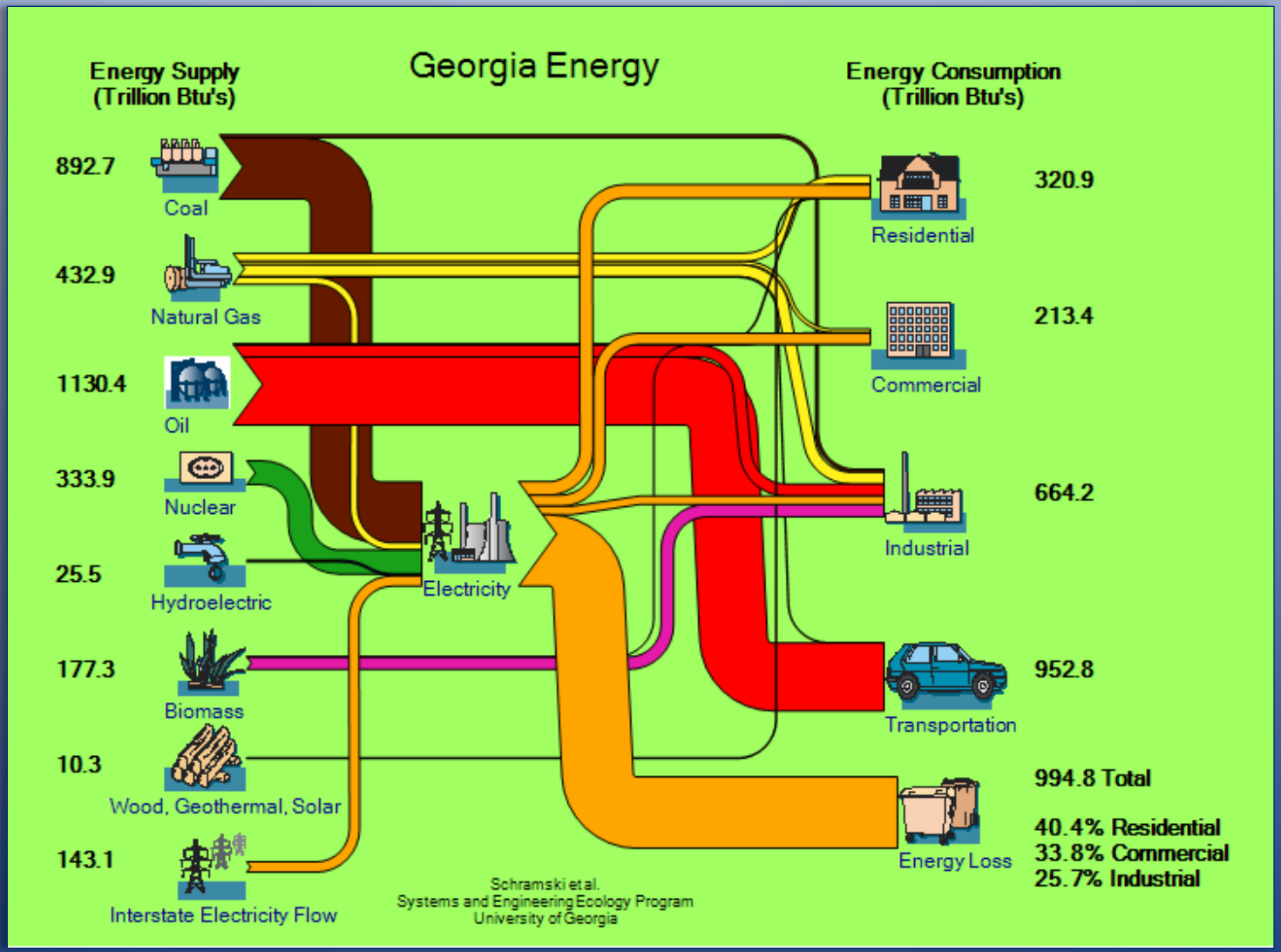
Dame and Patten 1981

Georgia Salt Marsh
Energy Model
Finn Cycling = 8%

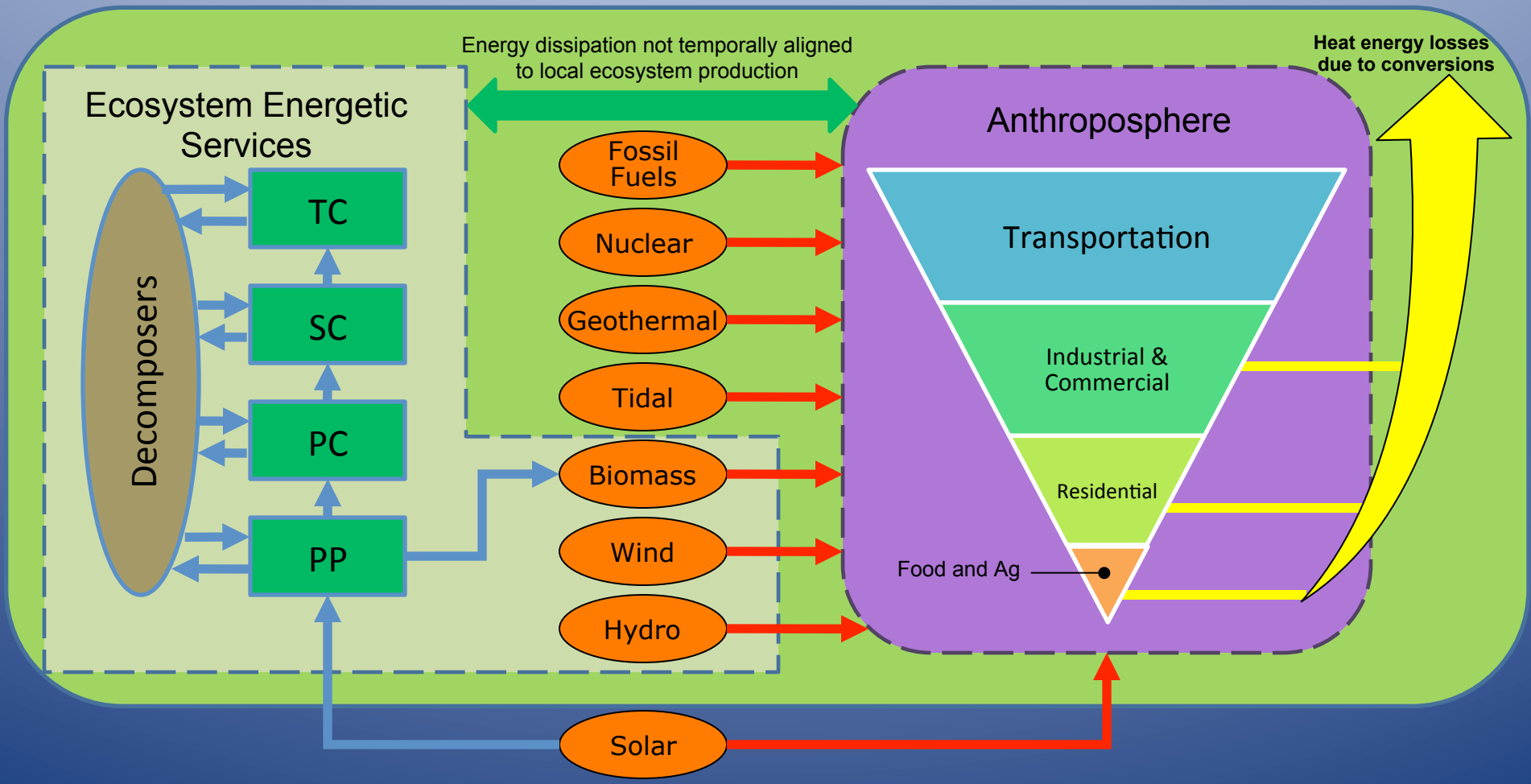


Teal 1962, Small 2006

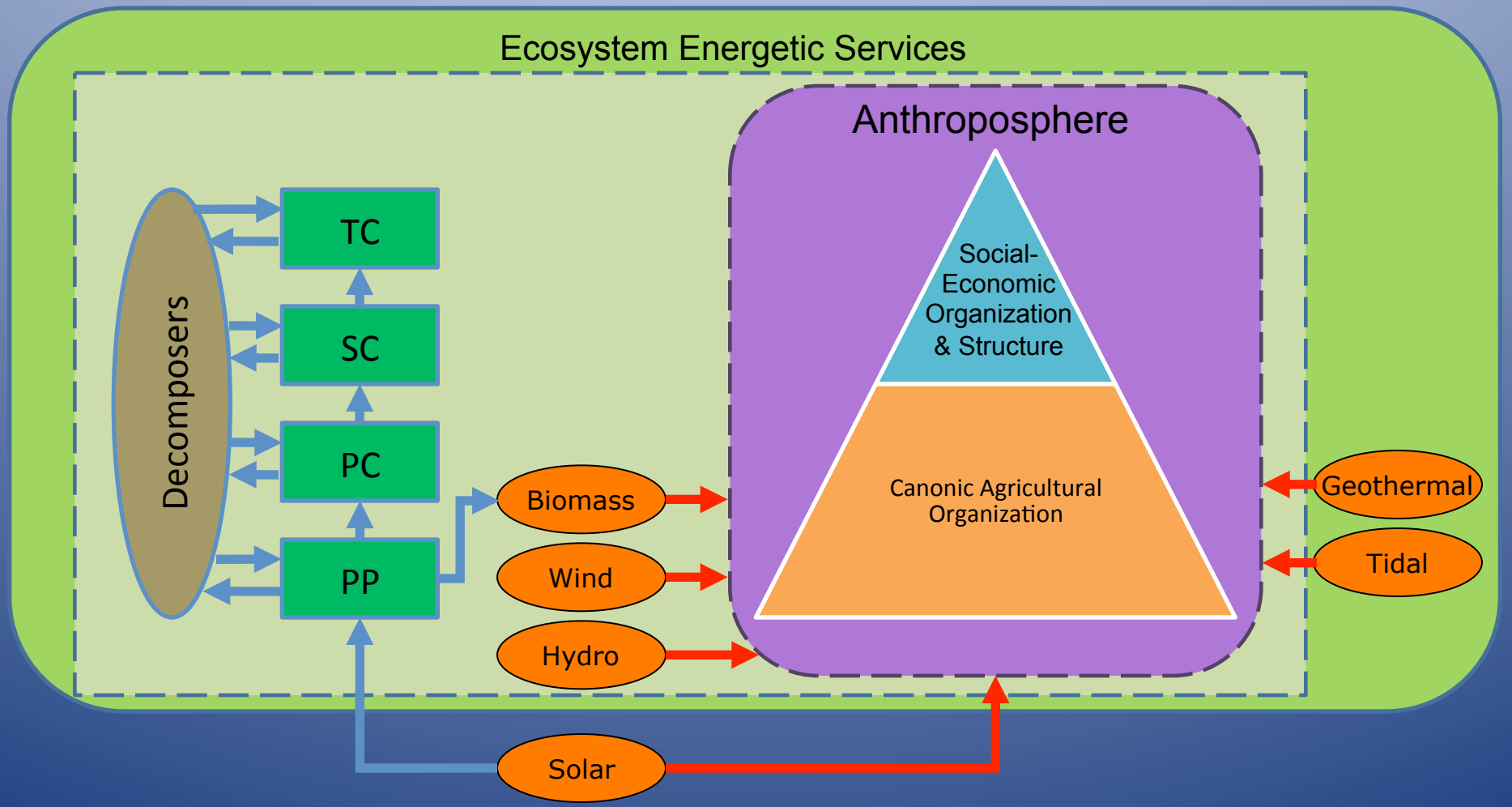
Urban Energy Systems



Biosphere


Energy dissipation not temporally aligned to local ecosystem production
Heat energy losses due to conversions
Ecosystem Energetic Services
Decomposers
TC
SC
PC
PP
Fossil Fuels
Nuclear
Geothermal
Tidal
Biomass
Wind
Hydro
Solar
Anthroposphere
Transportation
Industrial & Commercial
Residential
Food and Ag

Modelling a Trophically Balanced Thermodynamic Economy



Developing the Network Mathematics of Urban Energy Systems

Humans

$$\dot{e}_{21} = \dot{e}_{10} + \dot{e}_{12} + W_{12} + W_{13} + Q_{10}$$

Cultivated Natural

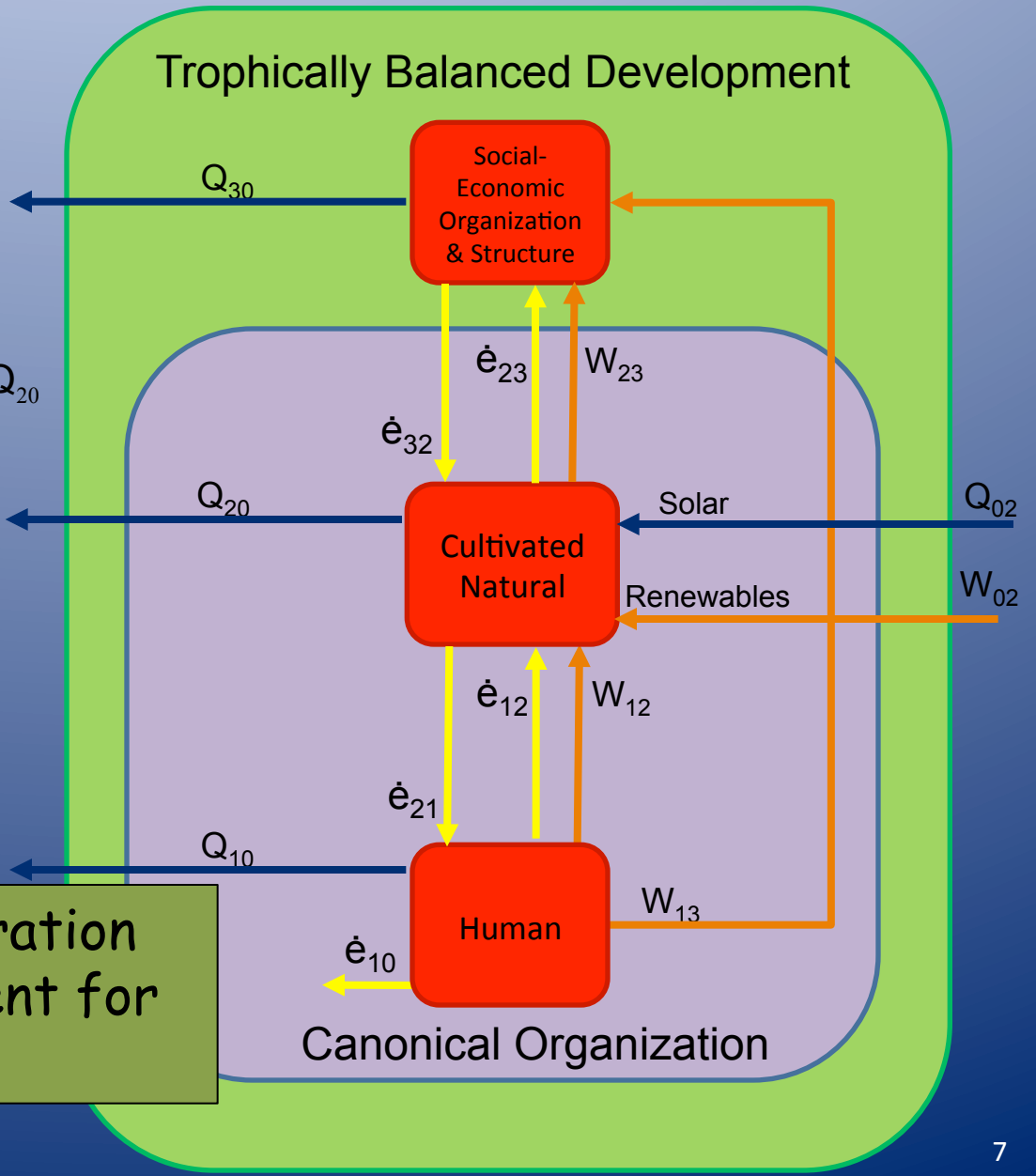
$$W_{02} + Q_{02} + W_{12} + \dot{e}_{12} + \dot{e}_{32} = \dot{e}_{21} + \dot{e}_{23} + W_{23} + Q_{20}$$

Social-Economic Development

$$W_{13} + W_{23} + \dot{e}_{23} = Q_{30} + \dot{e}_{32}$$

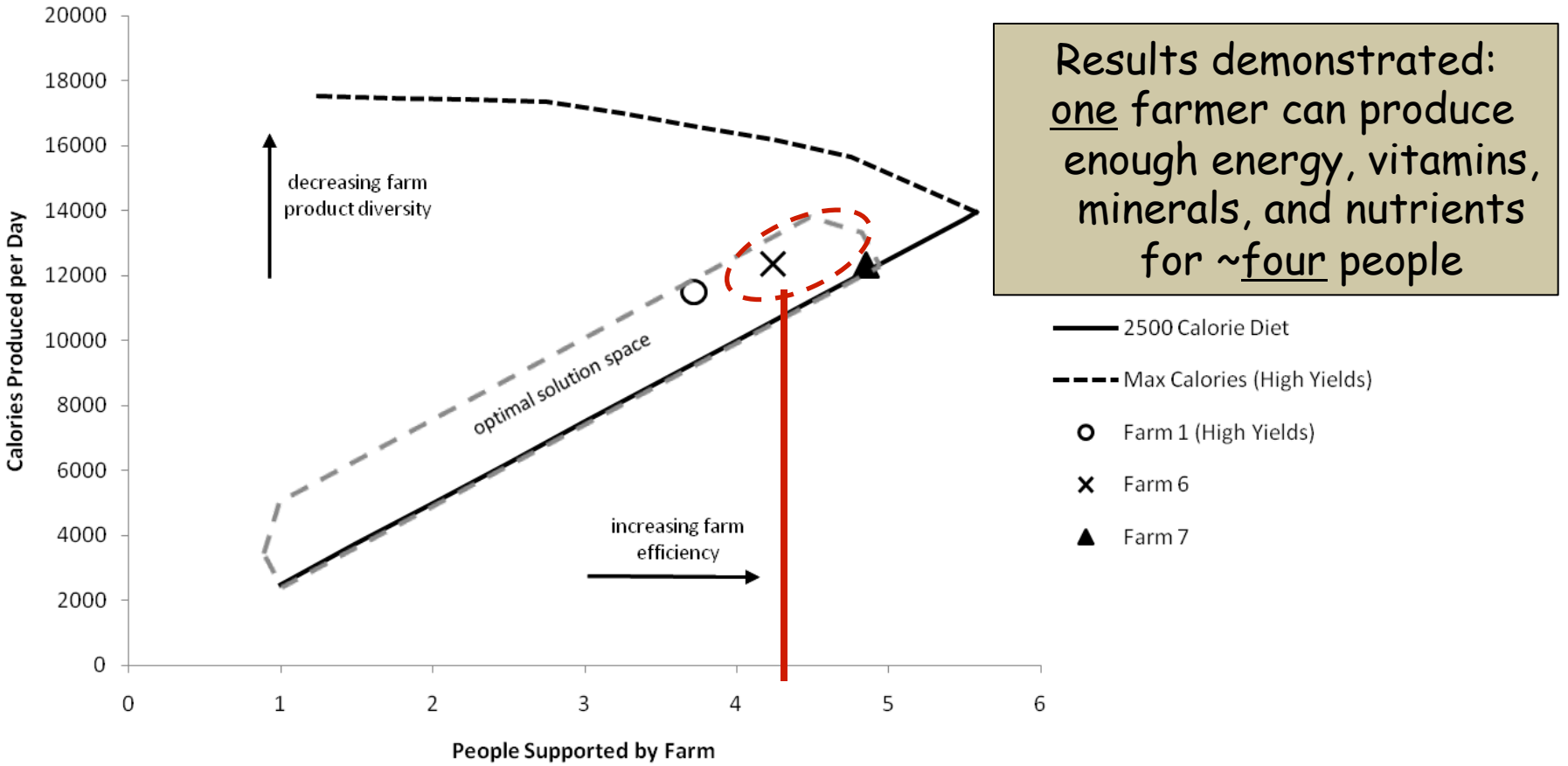
Total System

$$W_{02} + Q_{02} = Q_{10} + Q_{20} + Q_{30}$$



Essentially, network generation becomes the threshold event for true sustainability

Theoretical Modelling of Trophically Balanced Agriculture

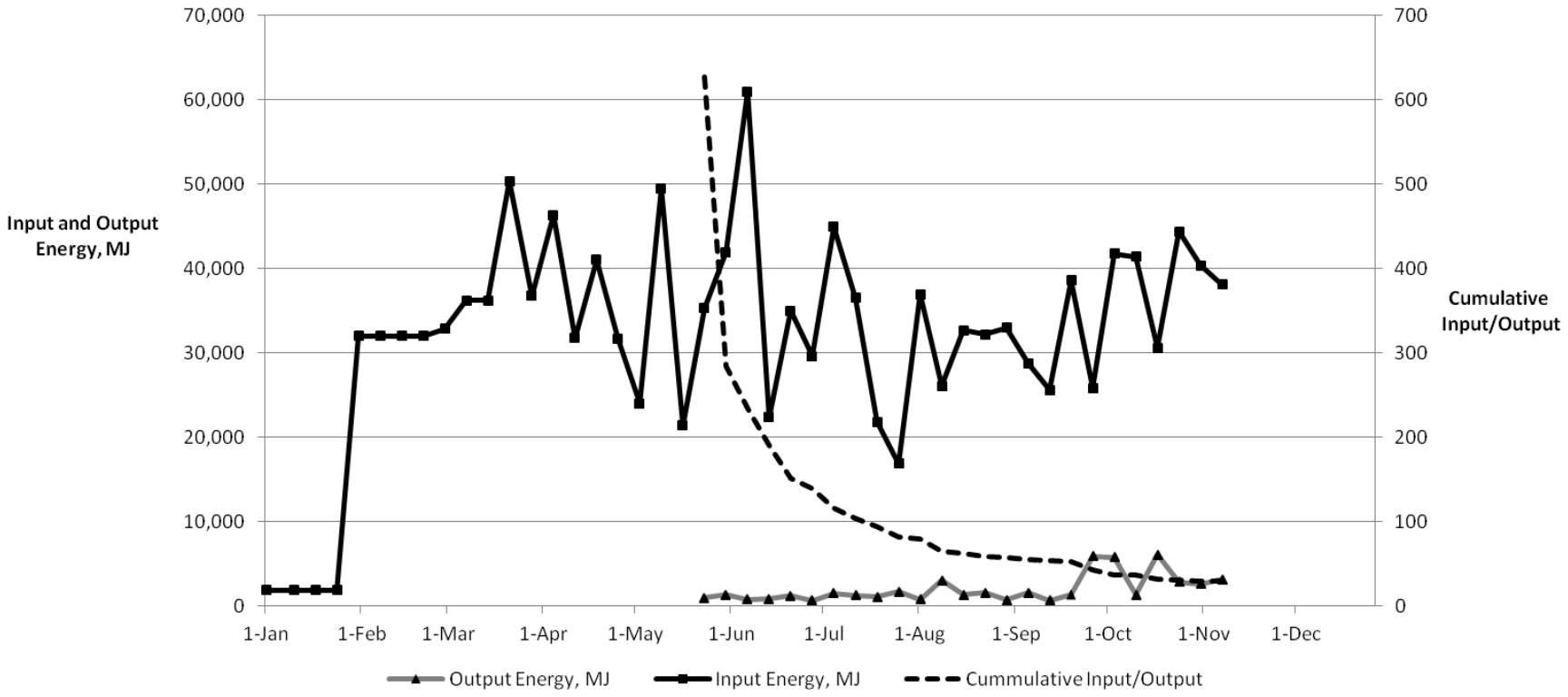


Results demonstrated: one farmer can produce enough energy, vitamins, minerals, and nutrients for ~four people

Schramski JR, Rutz, Z, Gattie, DG, Li K. 2011. Trophically balanced sustainable agriculture. *Ecological Economics*, 72-88-96.

2011 YTD Energy Totals for Kentucky USA Organic Farm

EROI = output/input = 0.025
input/output = 40



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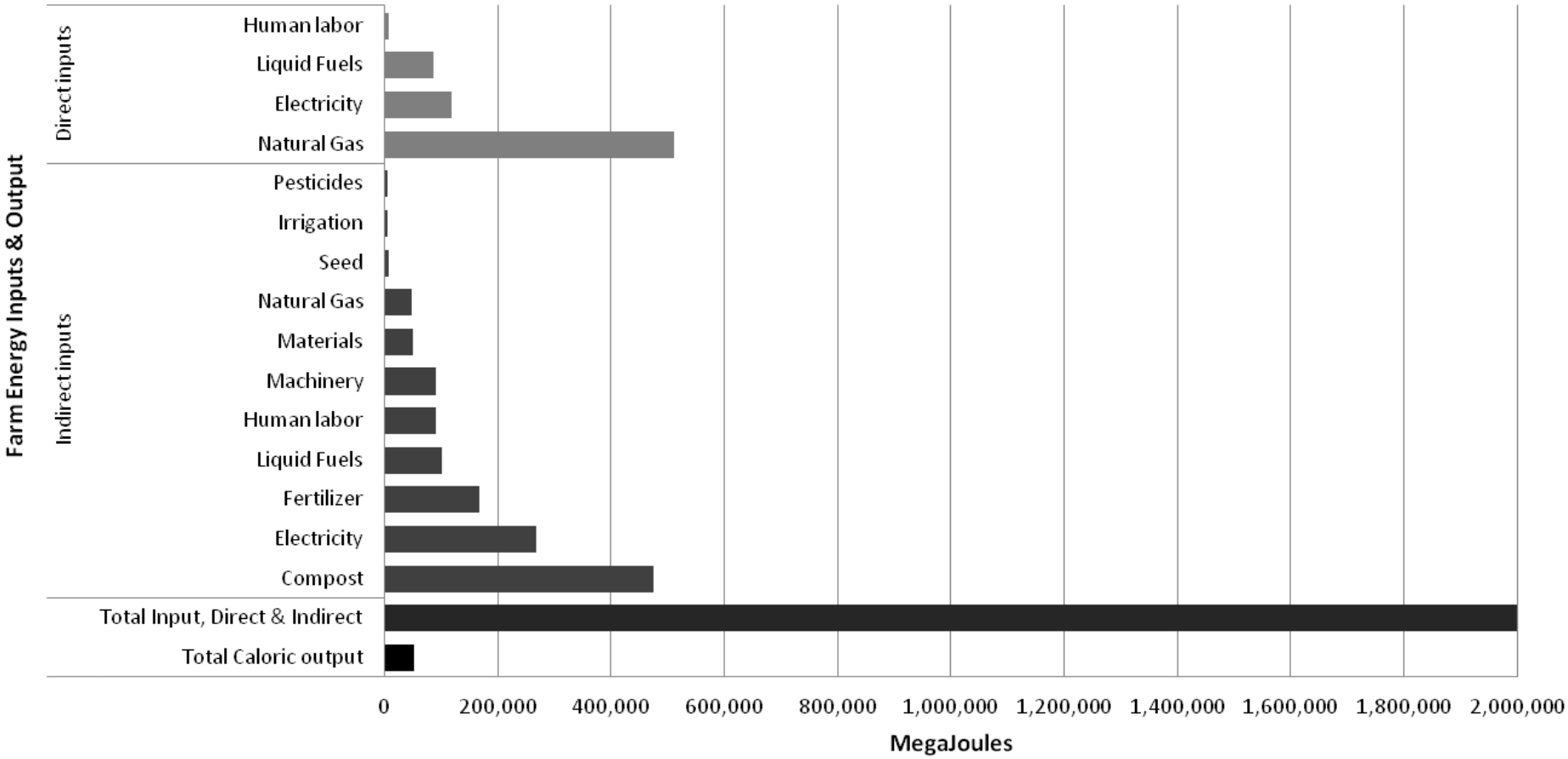
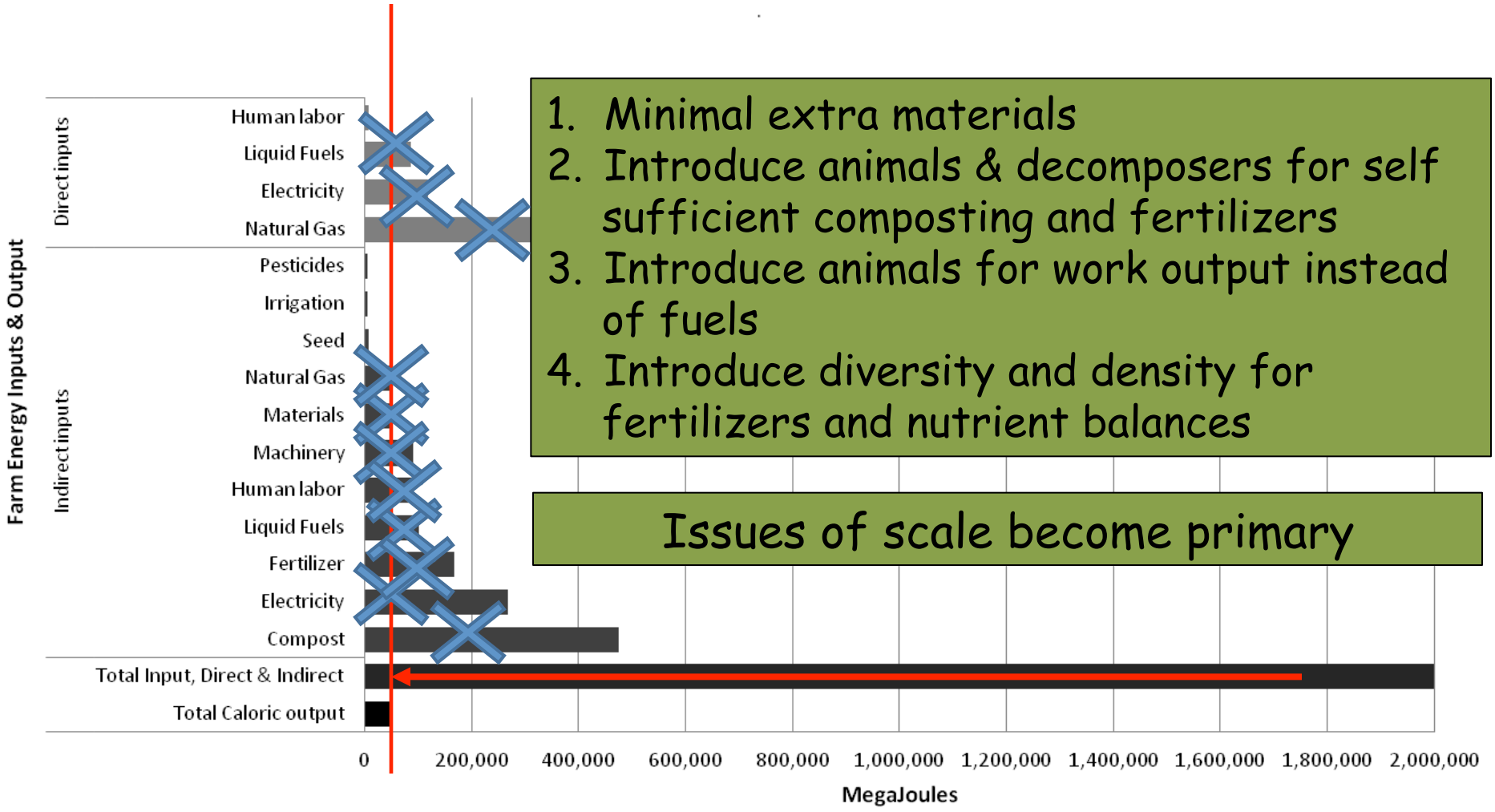


from Sustainable to Trophically Balanced Agriculture?



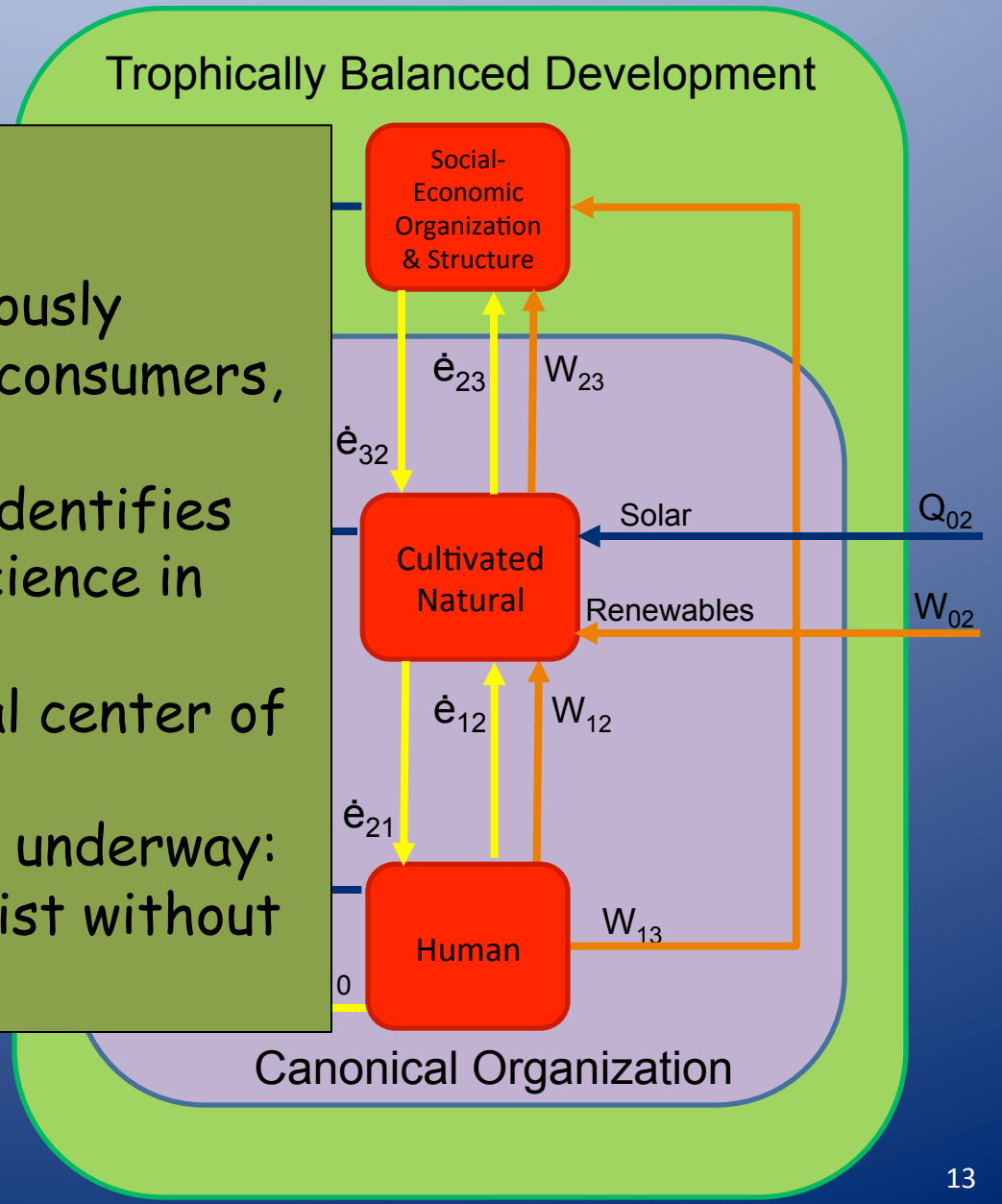
1. Minimal extra materials
2. Introduce animals & decomposers for self sufficient composting and fertilizers
3. Introduce animals for work output instead of fuels
4. Introduce diversity and density for fertilizers and nutrient balances

Issues of scale become primary

Conclusions

Where are the Networks?

1. Agriculture must simultaneously include primary producers, consumers, and decomposers.
2. Ecological network theory identifies the lack of sustainability science in modern energy systems.
3. Farmers are the intellectual center of a sustainable community
4. First principle development underway: ~Sustainability does not exist without energy networks/cycling.



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Low Energy Systems Engineering and Research.

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