

# \*Energy and Money

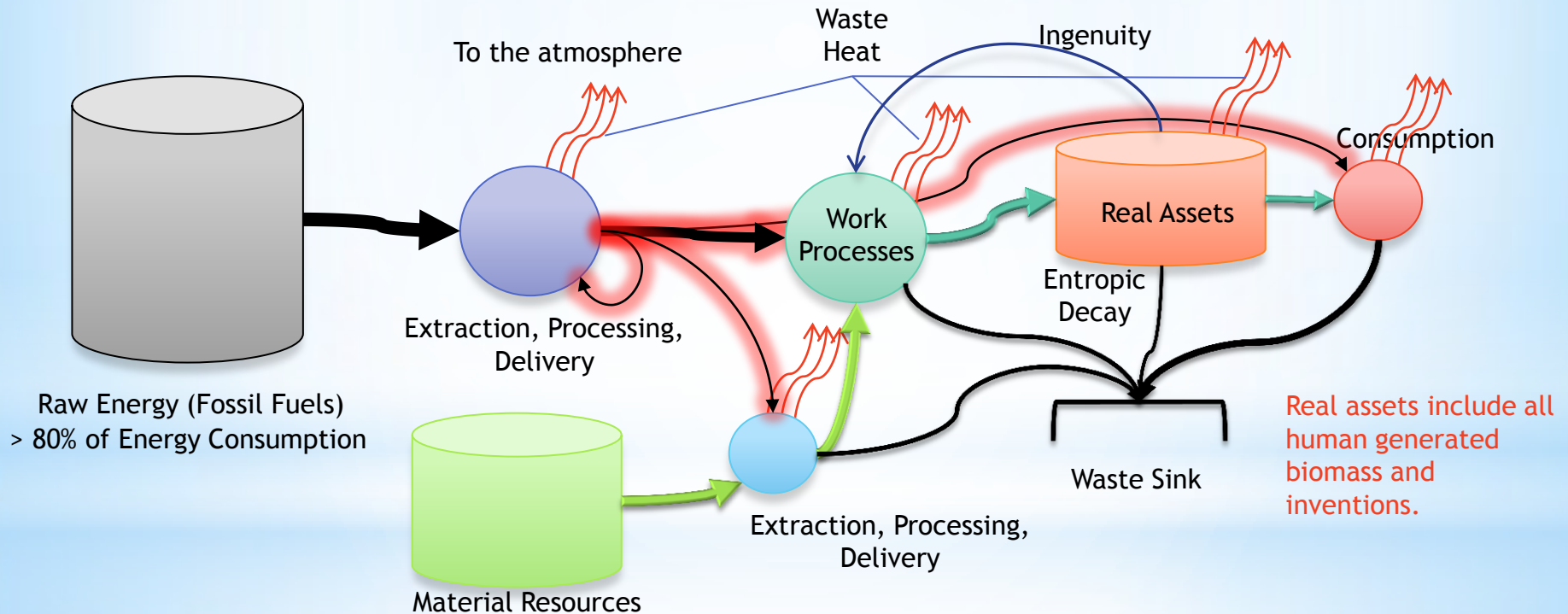
George Mobus,

*Institute of Technology, University of  
Washington Tacoma*

Fourth Annual Biophysical  
Economics Meeting

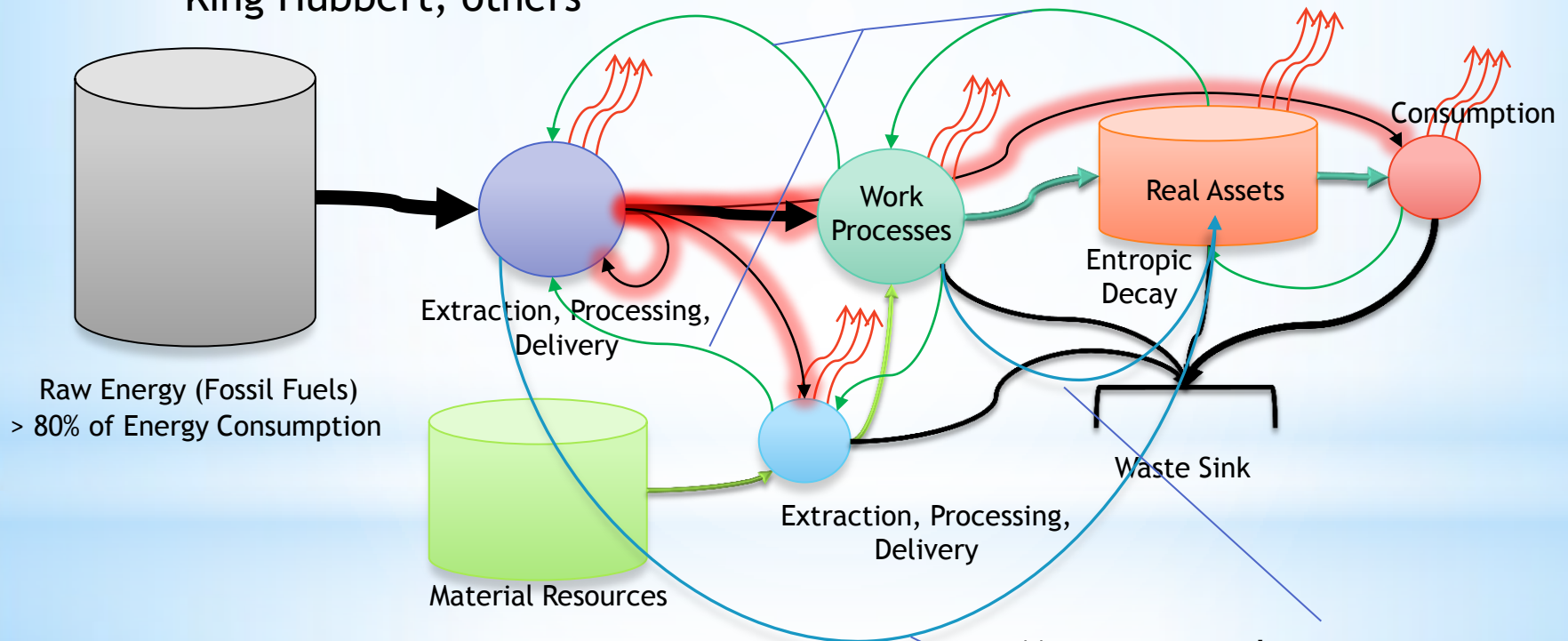
# \*Energy, Work, & Wealth

Its all just biophysical process. Energy flow through the system drives the transformation of high entropy material to low entropy assets. Energy is continually dissipated.



# \* Controlling Energy and Material Flows

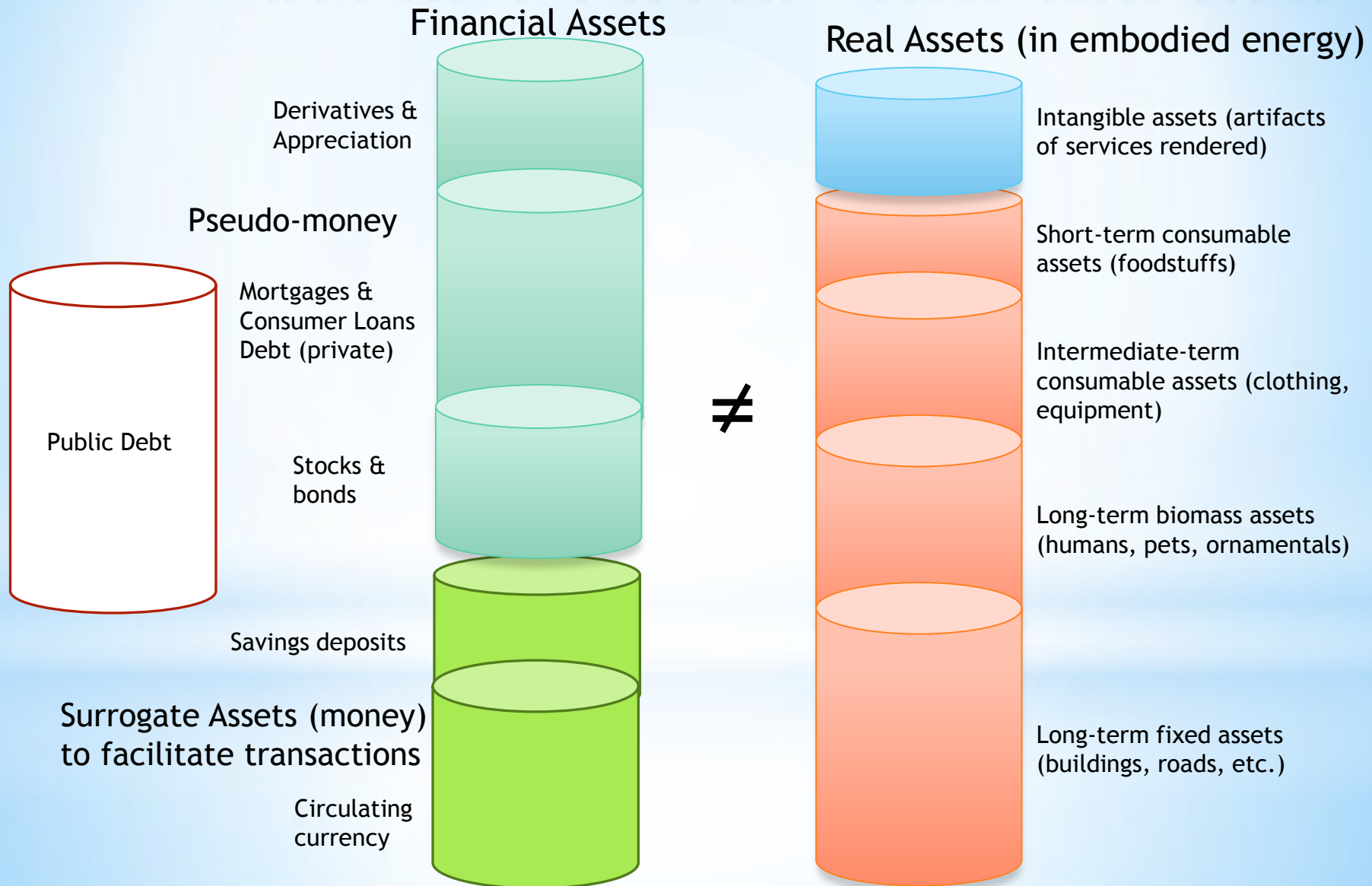
Currency (money) as flow *regulation messages* - Howard Odum, M. King Hubbert, others



We pay others for work to be done on stuff/services we want. We are paid to do work on stuff/services that others want.

Money recycles as wages to regulate human work.

# \* Asset Classes and Wealth



# \* Money

- \* Token used to denote *value* of goods and services (G&S) - **Real Assets**
- \* Origins and history of development - cuneiform in clay to physical tokens to coinage with intrinsic value
- \* Layers of abstraction to another kind of commodity
- \* Components of valuation calculus in the physical world
  - \* energy required to produce - a biophysical baseline
  - \* utility value (strictly)
  - \* hedonic value
  - \* less opportunity costs
  - \* less sunk costs
- \* In the modern world no one has any idea how to calculate most of these - we estimate based on presumed values of other G&Ls - let the markets decide!
- \* Financial *pseudo-assets* have become so abstracted from *real assets* that modern money is useless as a measure of wealth

# \* Exergy == Work

## \* Useful (economic) work

- \* extracting materials and energy (incl. food)
- \* refining
- \* shaping and forming
- \* manufacturing, construction, transportation, etc.
- \* services

## \* Value of a product

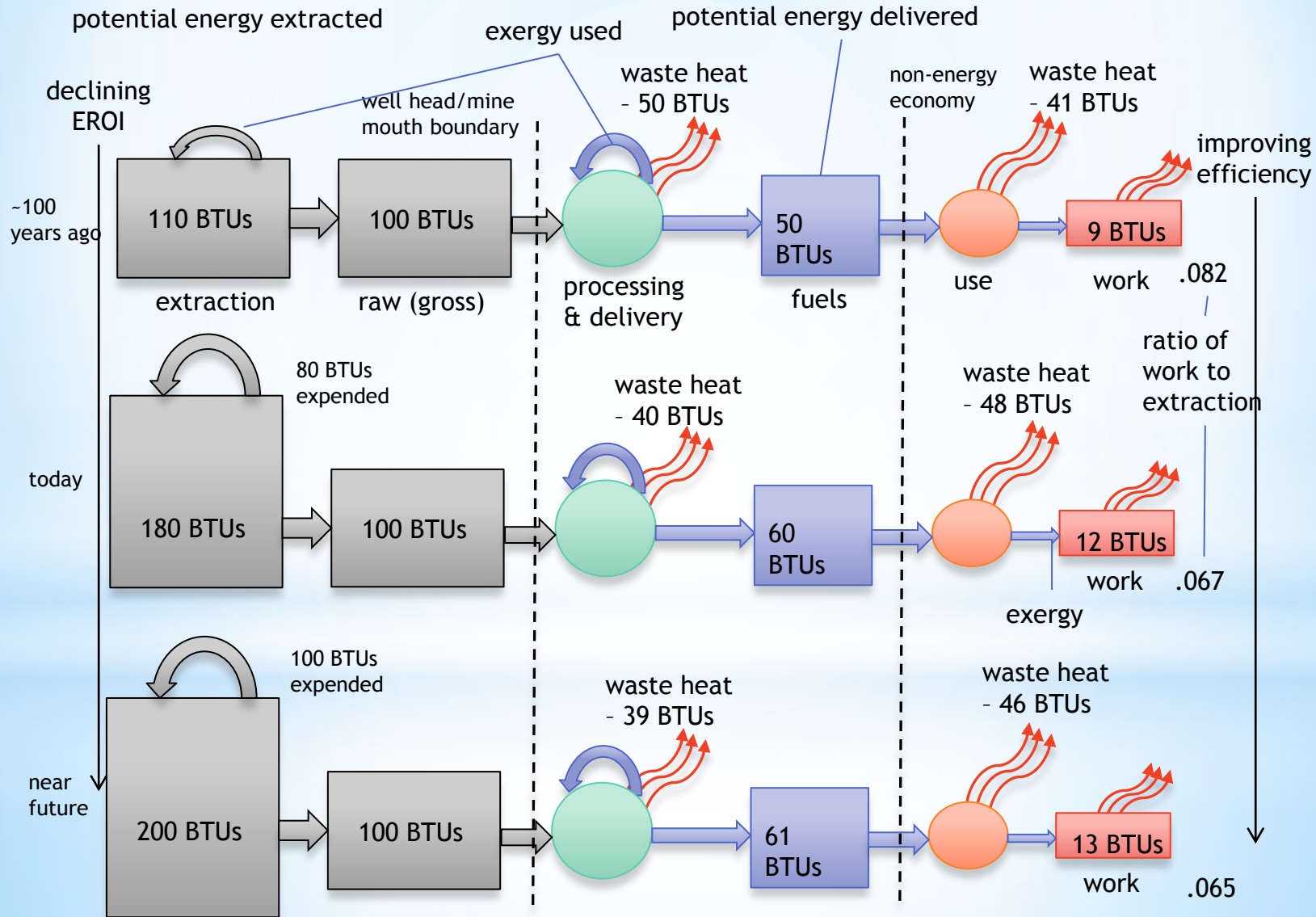
- \* embedded work
- \* utility of the product, e.g. increasing the efficiency of useful work or increasing flow of energy (tools)

\* Exergy is that portion of total energy required to obtain *useful work* (it depends on the nature of the work process as much as on the energy content of fuel)



# \* Exergy Return on Energy Extracted

## Declining EROI as Compared with Increasing Work Efficiency



# \* Four Factors Collide

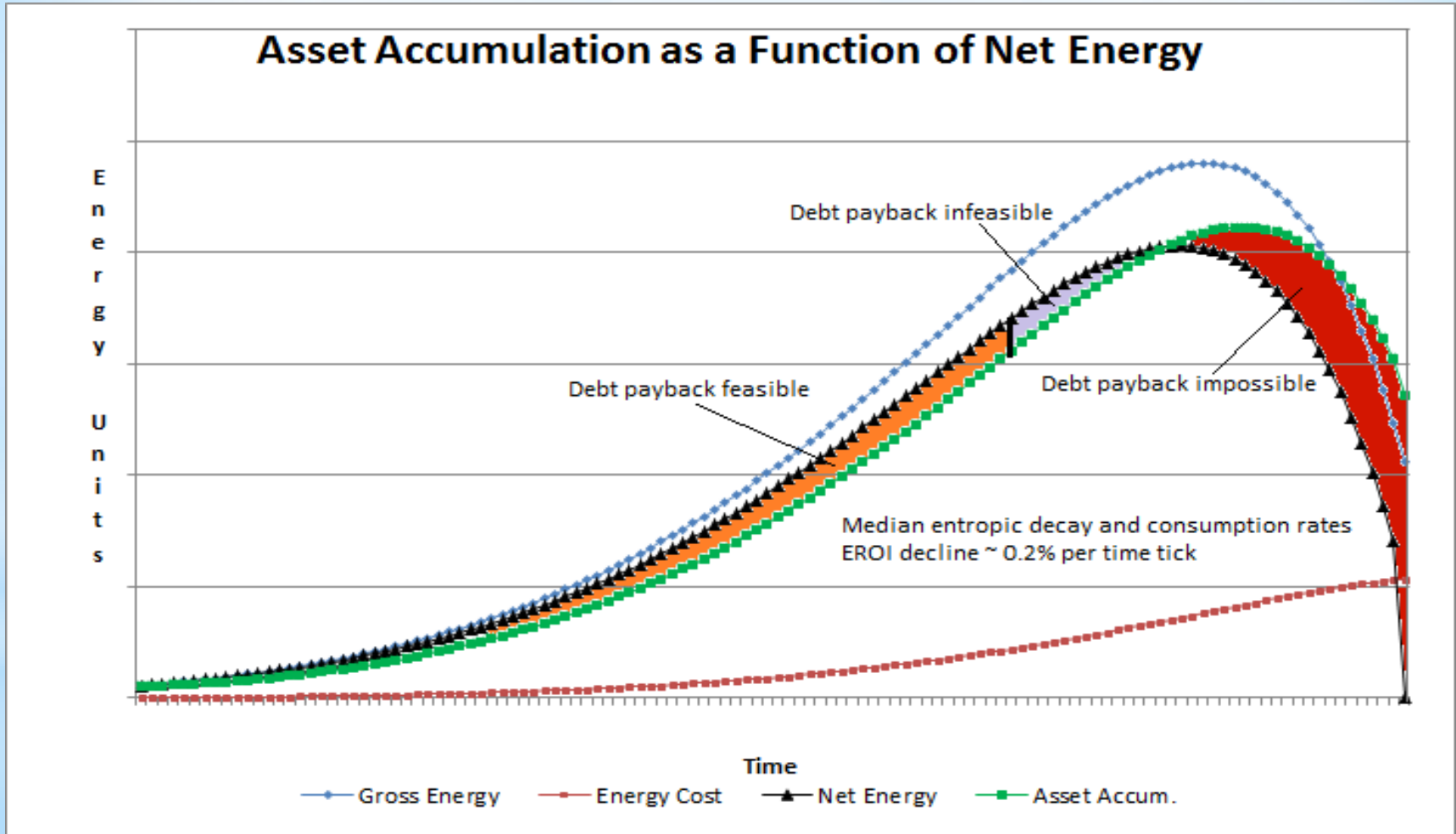
- \* Depletion and geophysical limits - e.g., Peak Oil
  - \* Limiting supply driving up prices
- \* Declining EROI (mine mouth/well head)
  - \* Increasing costs of extraction (e.g., non-conventional methods)
- \* Decreasing rate of efficiency improvements (e.g. Carnot's limit)
- \* Increasing population (with increasing expectations)
  - \* Decreasing net energy available per capita
- \* Lead to:
  - \* Diminishing total work to produce real assets
  - \* Less wealth per capita over time
  - \* Increasing disparity between wealthy and poor?



# \* Exergy Basis for Currency

- \* Similar to a “gold” standard in stabilizing value without the silliness of gold fever
- \* Exergy resource - based on actual amount of work that can be done in the near future
- \* Exergy embodied - based on actual amount of work already done
- \* Value of assets can be computed from work done in past
- \* Total circulating currency + savings determined by excess net energy available
- \* Borrowing from savings to invest in future returns
- \* When net energy peaks asset production peak will follow - there will be no savings!

# \*Relation: Energy-Work-Assets



Based on two of the factors - Depletion and Declining EROI

## \* Future work

- \* Investigate the dynamics of all four factors operating in the system
- \* Incorporate stocks and flows of money as a regulation system - maybe a hybrid with agent-based modeling
- \* Continue to watch the evolution of our global system

\* Questions