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CRITICAL ROLE OF WASTE IN GOVERNING NEXUS INTERACTIONS

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Sustainability Challenges at the Food, Energy, Water Nexus

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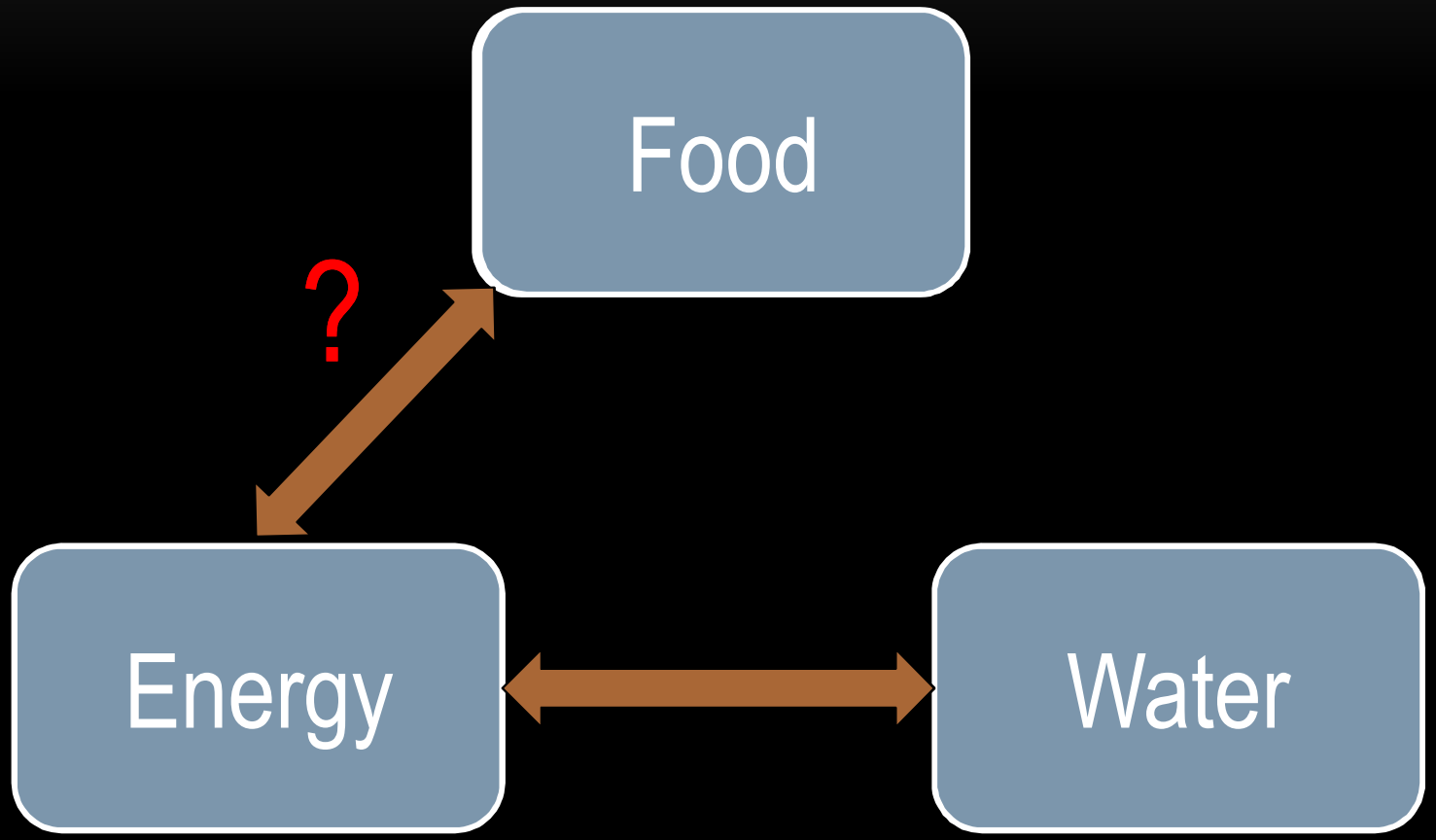
PROBLEM

- We lack an inclusive framework for managing the “nexus”
- The result:
  - suboptimal operations,
  - policies with unintended consequences, and
  - hidden costs to society.

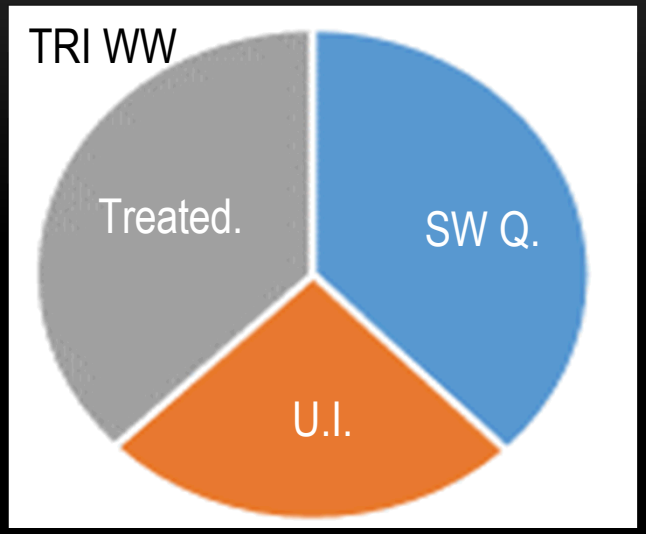
FRAMEWORK CHALLENGE: CONCEPTUAL

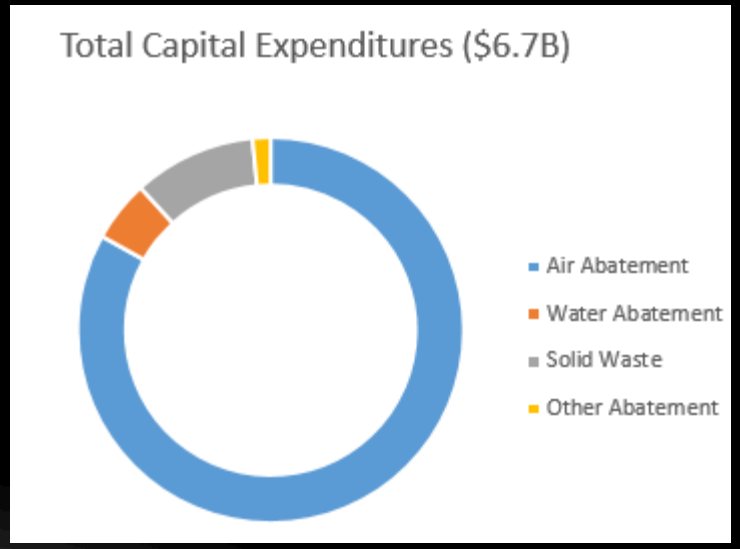


"Ultimately, everything that is extracted must be sunk back into the environment in some form, after sufficient time" (UNEP, 2016)

FRAMEWORK CHALLENGE: WASTE STREAMS

- Generation
  - WW: 124 trillion gallons per year (~7x public supply water withdrawals)
  - Solid waste: 2.5 billion tons per year (10% MSW; 34 mil tons is hazardous)
  - Air: 6.8 billion tons eCO2, criteria air pollutants, and 370K tons of toxics
- Investments in treatment
  - $5 million WWTP in Idaho; $9.3 billion invested in electric sector in 2014 alone
  - 117 million MWH for FGDs
- Impacts other produced resources
  - Well-known concerns (spills, UST leaks, etc.)
  - Emerging concerns (microplastics, black carbon, CC, etc.)
  - Reuse considerations

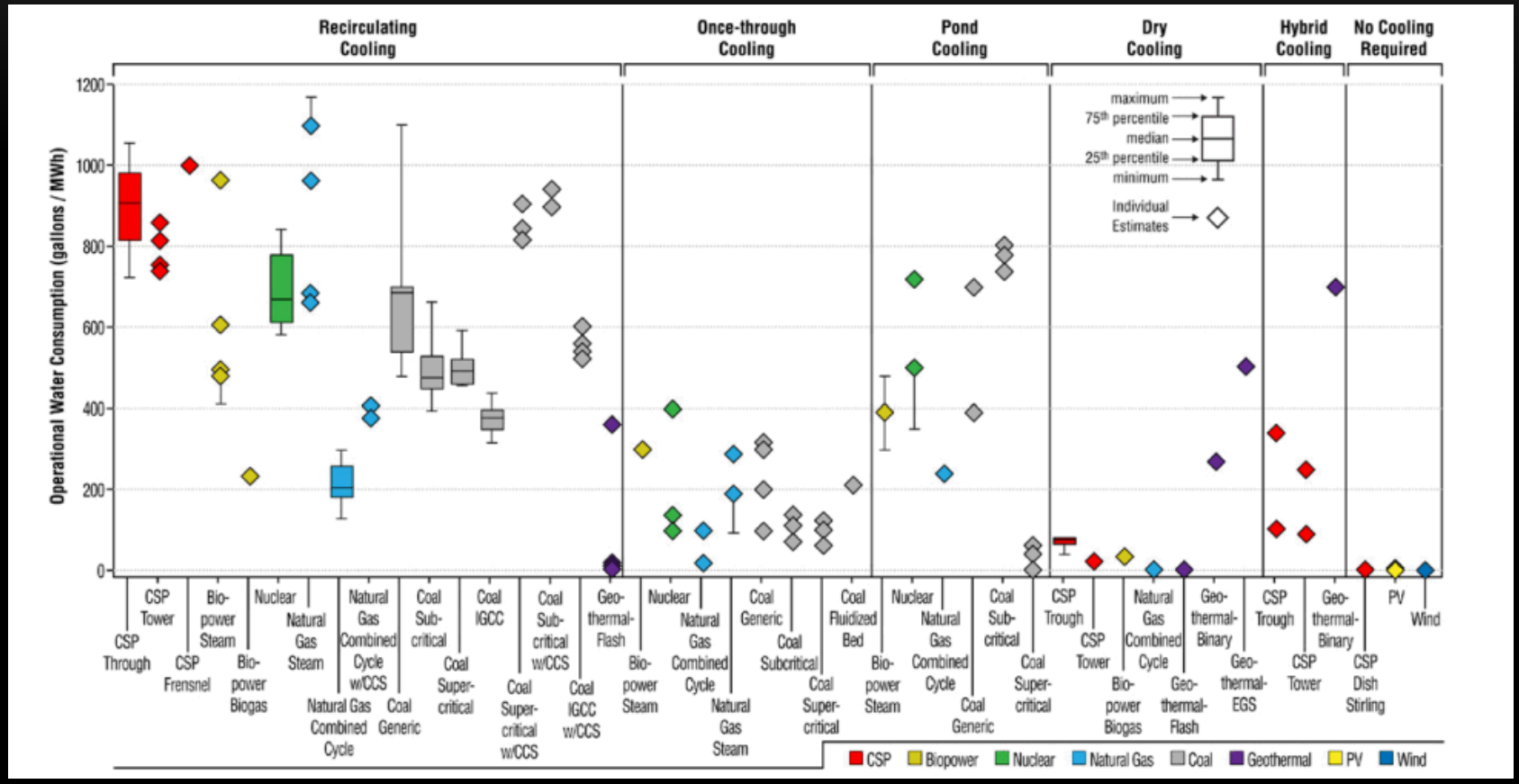




Electric Sector

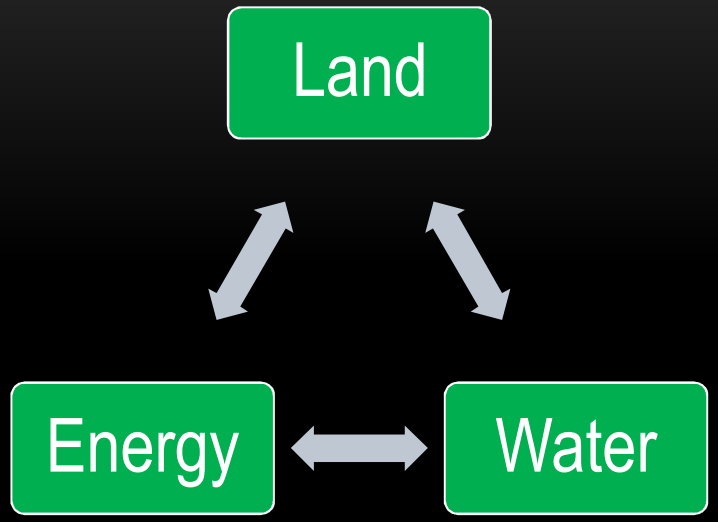
FRAMEWORK CHALLENGE: TECHNOLOGY

- Selection is influenced by regulatory requirements and/or economics
- Impacts
  - how much energy, land and water is used in production and waste management
  - how much and type of waste is generated (cooling technologies)
  - how resulting waste is managed (captured vs. released; treatment)



(Macknick et al., 2012)

ANALOGOUS FRAMEWORKS

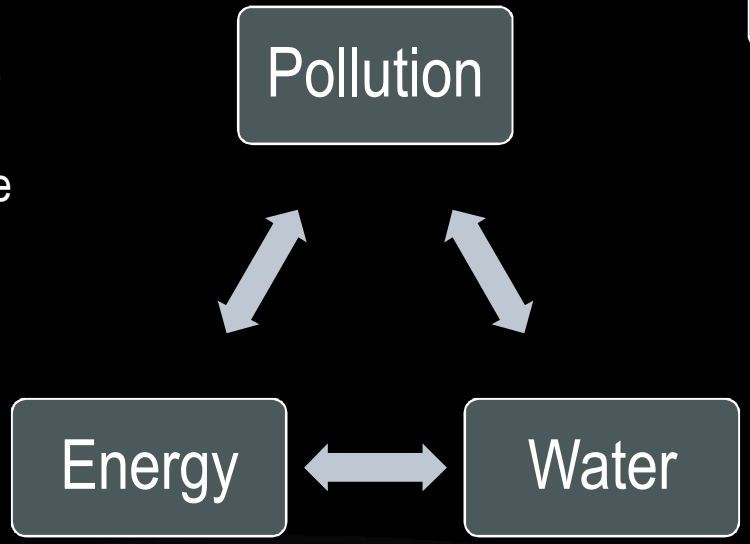


Conflation of natural and produced resources
Produced resources not explicitly stated

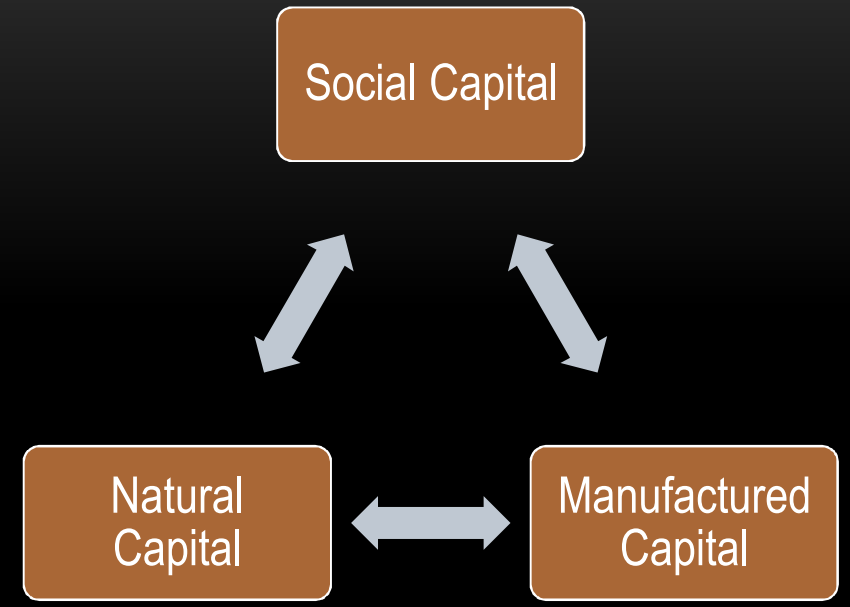
"The linkages can be defined in terms of resource demand, supply endowment, and technologies (including mechanisms, processes, and systems)."

(Skaggs et al., 2012)

Urban focus
Not comprehensive



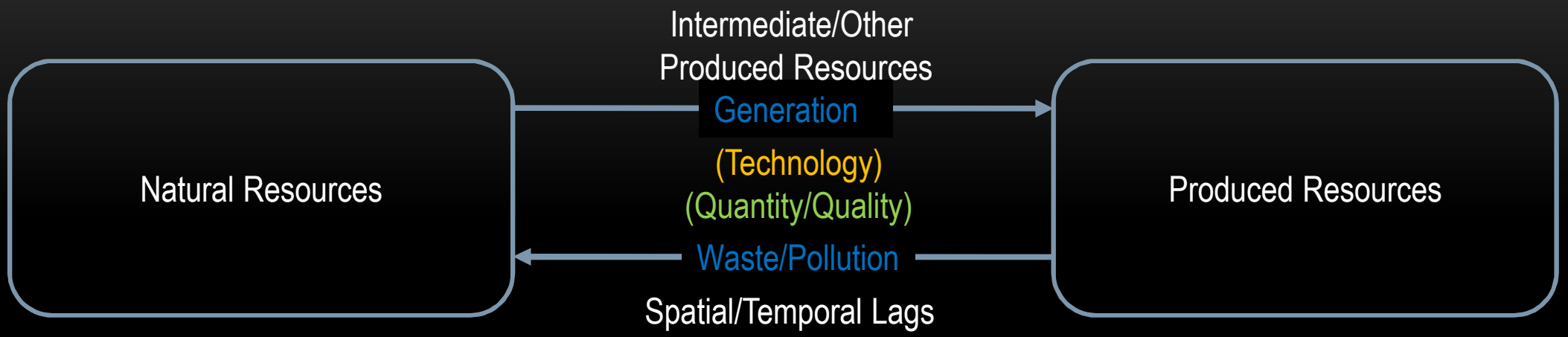
(Kumar and Saroj, 2014)



Focus limited to manufacturing goods
Lack of dynamic interactions between goods

(Weisz et al., 2015)

CORE CONCEPT



Natural Resource: material with a recognized value to humans

- Air, water, mineral, and land
- Quantity and quality

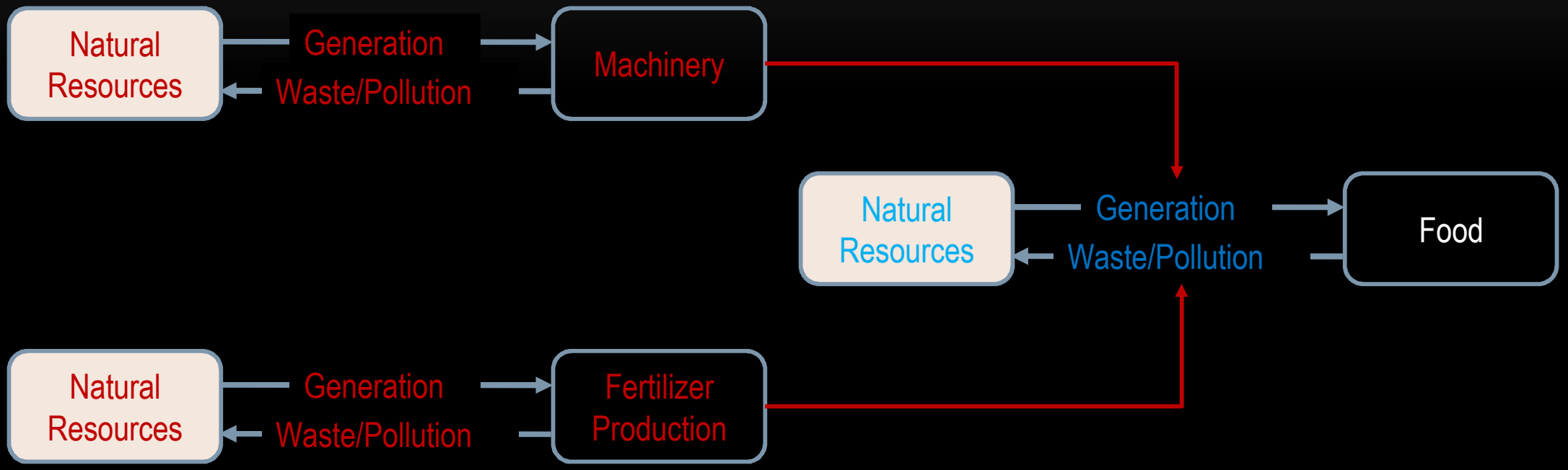
Produced Resource: material that has been processed in some way and is directly used by humans

Waste: concentrated material with no recognized value to humans, often generated as a byproduct of a produced resource

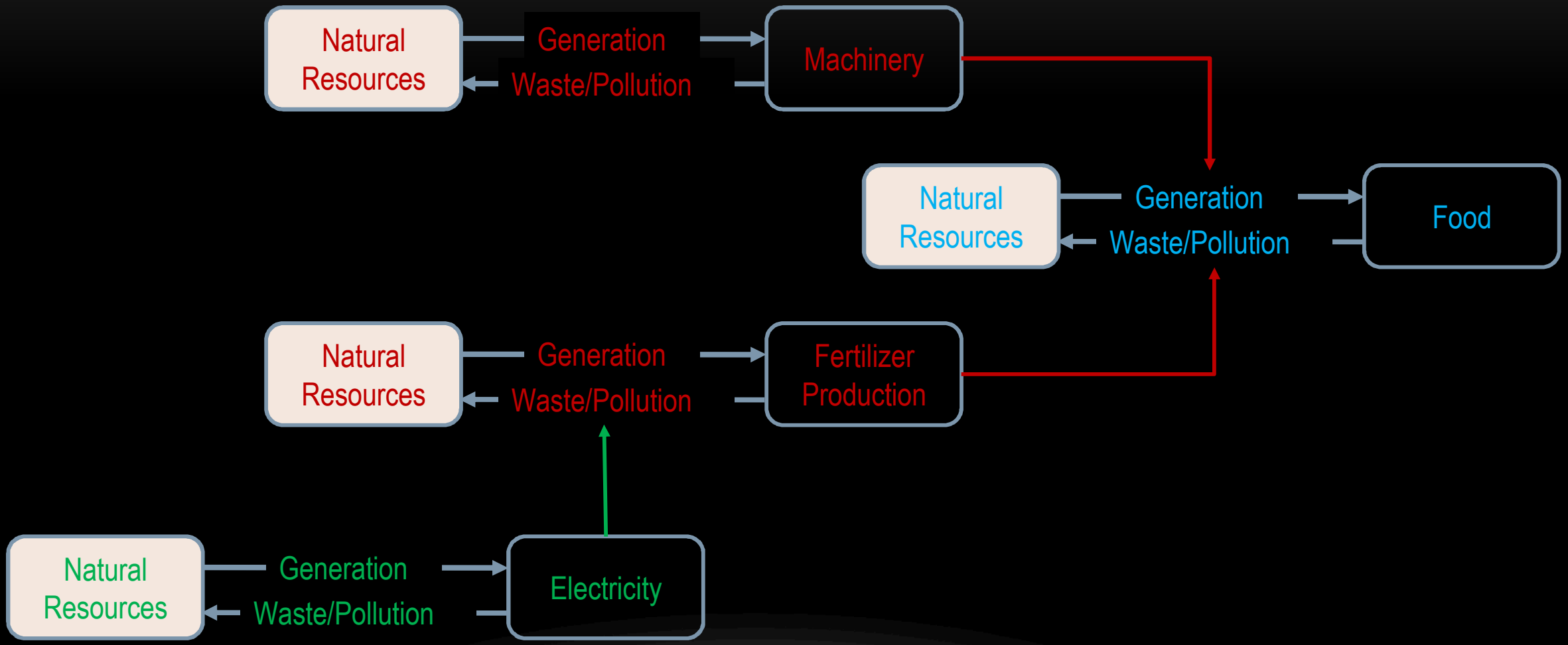
- Pollutant: material has undesirable effect on people, ecosystems, or other resources (often regulated)

FOOD EXAMPLE

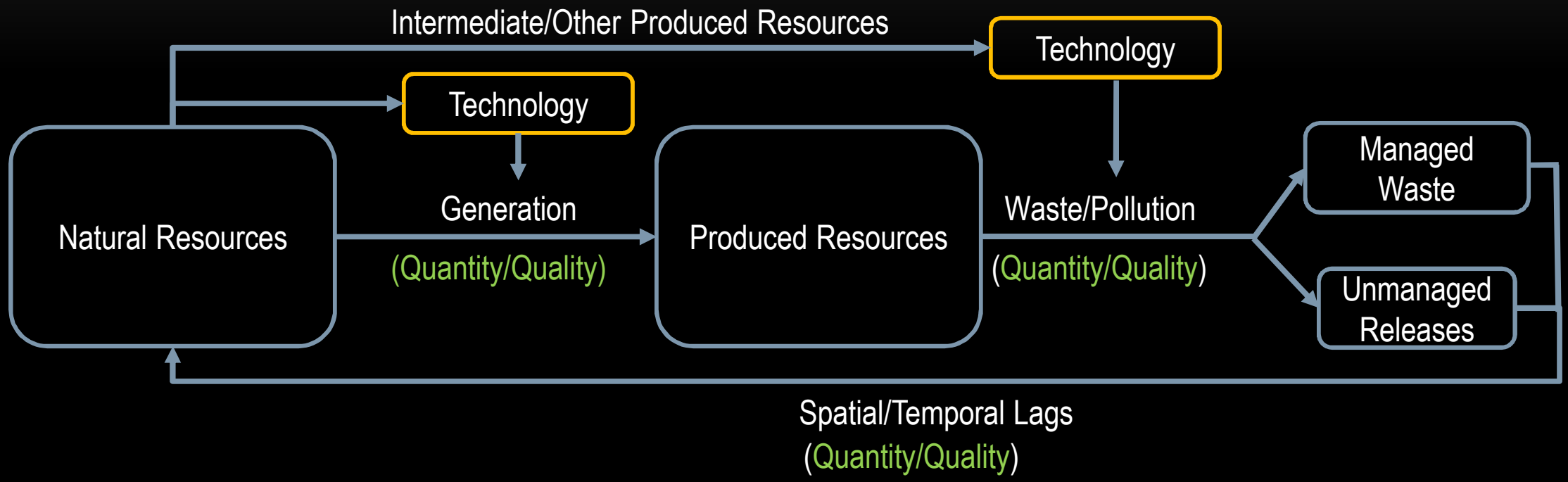
FOOD EXAMPLE WITH TECHNOLOGY



FOOD EXAMPLE WITH TECHNOLOGY NEXUS



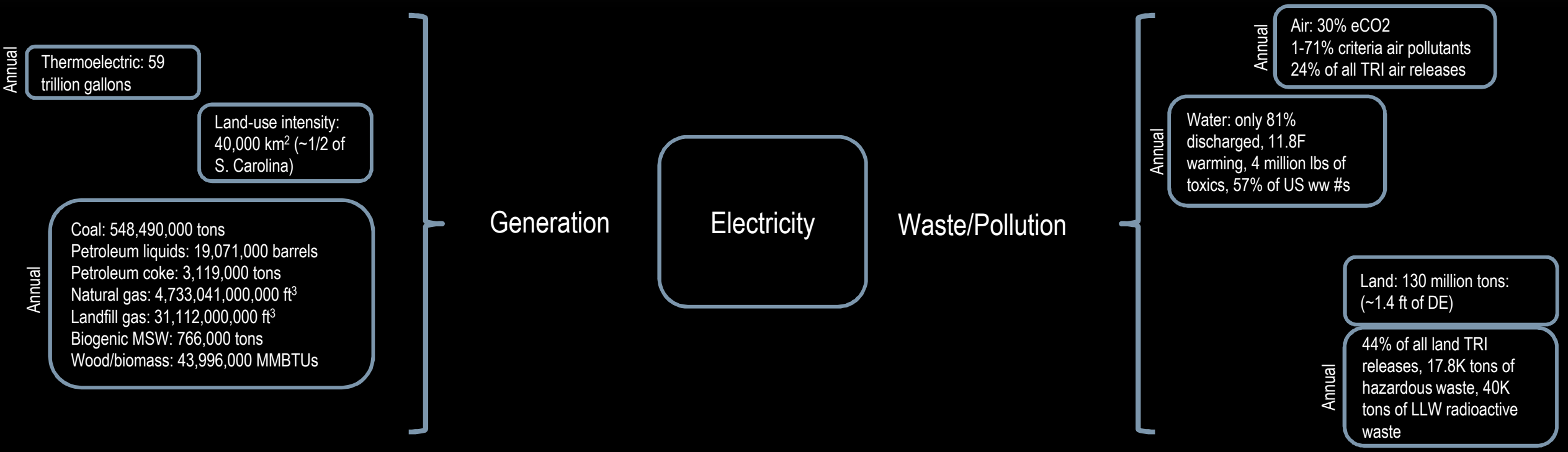
NEXUS FRAMEWORK



CASE STUDY: ANNUAL U.S. ELECTRICITY PRODUCTION

(Quantity/Quality)
Natural Resources
Water Air Mined

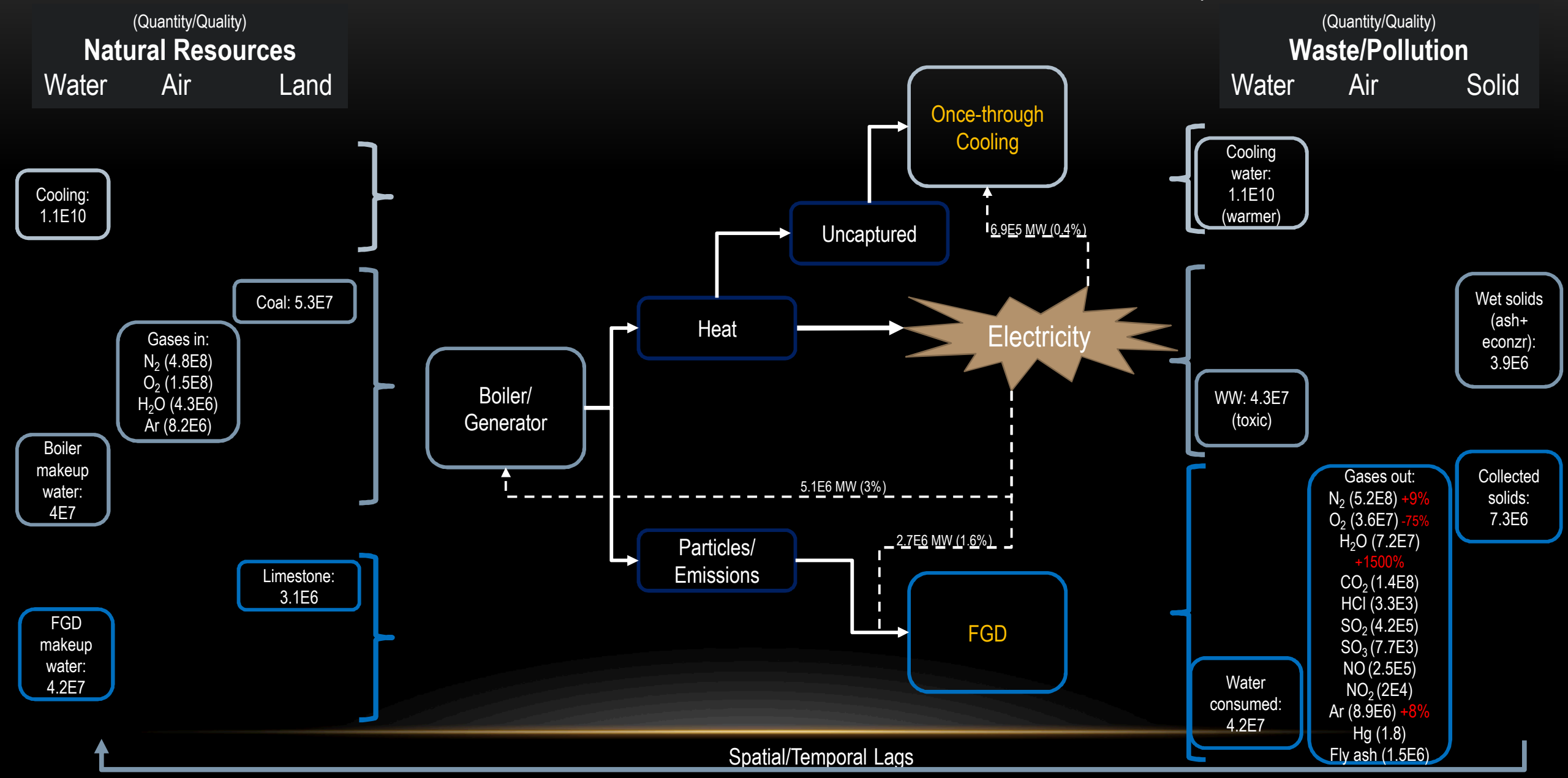
(Quantity/Quality)
Waste/Pollution
Water Air Solid



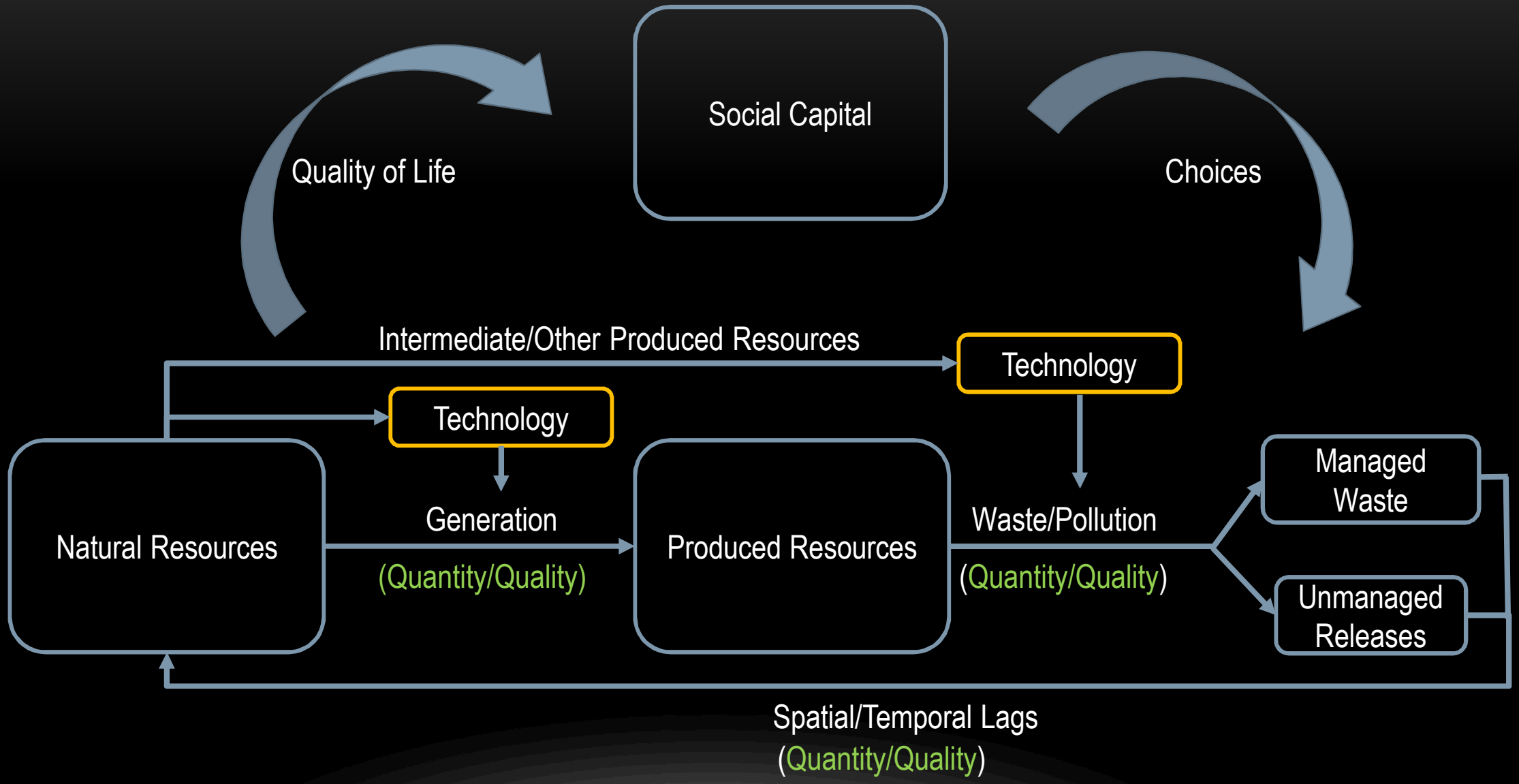
Spatial/Temporal Lags

CASE STUDY: COAL-FIRED POWER PLANT

IECM: 650 Mwg gross electric output
Appalachian Medium Sulfur bitmunious coal
tangential boiler – supercritical unit
All numbers are tons/30 years(unless stated otherwise)



EXPANDED NEXUS FRAMEWORK



SUMMARY

- Highlight need to distinguish interaction between natural resources and produced resources in nexus analyses
- We draw from multiple, ongoing conversations to highlight the need to include waste in the nexus interactions and to actively recognize the role of technology in influencing these dynamics
- Waste impacts are becoming increasingly pronounced from multiple viewpoints: human health, financial costs, technology needs, and even litigation
- Our method provides a versatile approach that accounts for the various factors that influence decision-makers during the selection of technology and subsequent waste management strategies (use CFPP as a case study)