Climate, Decision Making, and Behavior

Amy K. Wolfe

GCEP Orientation

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Statements like "the problem is..." or "what we need is..." typically are flawed

Three "simple" messages

- **Decisions/policies have consequences**
  - **Positive *and* negative**
  - **Vary over space and time**
  - **Distributed unevenly, possibly inequitably**
- **Perspectives differ**
  - **At any level, from individual through global**
  - **Definitions vary: "good," "value"**
  - **Assumptions can be dangerous**
- **"Acceptability" is fluid** (of technologies, policies, behaviors...)
  - **Conditional, rather than absolute**
  - **Changes over time, via interactions, with information**
  - **Affected by more than the topic/technology/solution at issue**

Good intentions are insufficient to develop effective solutions to climate change issues, at any scale

Two illustrative cases

- **Energy-efficient technologies**
- **Integrating energy-water decision making**

Energy vs. Non-Energy Attributes: If not for energy efficiency, why buy new technologies?

Amy K. Wolfe

David J. Bjornstad

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Thesis: market penetration is a function of energy + non-energy attributes

- **Why do energy-efficient technologies fail to achieve market acceptance?**
- **What non-energy attributes could increase market penetration?**
- **Which of these attributes can be incorporated into R&D…to increase market penetration?**

The EERE mission is to strengthen America's energy security, environmental quality and economic vitality in public-private partnerships that:

- ***Enhance energy efficiency and productivity;***
- ***Bring clean, reliable and affordable energy technologies to the marketplace; and***
- ***Make a difference in the everyday lives of Americans by enhancing their energy* choices *and their quality of life.***

Source: http://www1.eere.energy.gov/office_eere/mission.html

EERE = Energy Efficiency and Renewable Energy

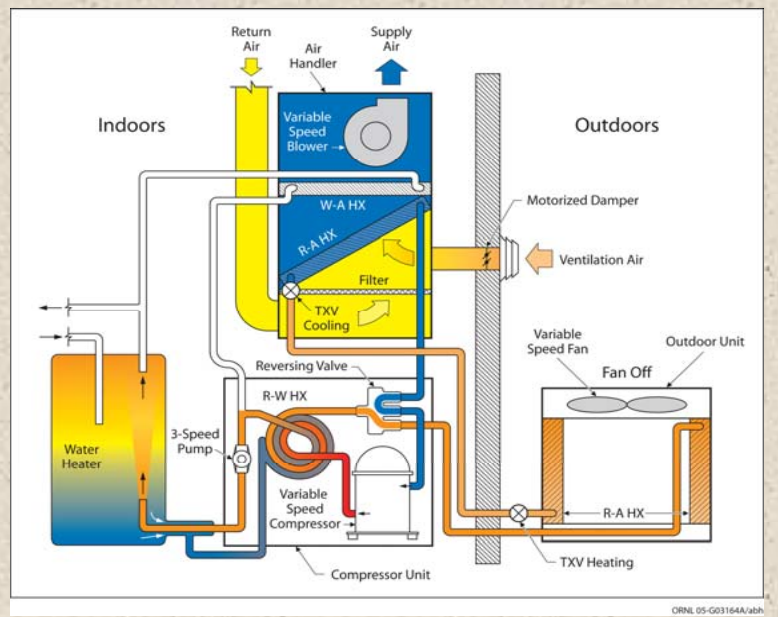
EERE runs 10 energy programs

- **Biomass**
- **Building Technologies***
- **Federal Energy Management**
- **FreedomCAR & Vehicle Technologies**
- **Geothermal Technologies**
- **Hydrogen Fuel Cells & Infrastructure Technologies**
- **Industrial Technologies**
- **Solar Energy Technologies**
- **Wind and Hydropower Technologies**
- **Weatherization & Intergovernmental**

*co-funded our project, with Planning, Budget, and Analysis

What is the air source integrated heat pump (ASIHP)?

- **Full integration to heat, cool, ventilate, dehumidify, and heat water, as needed**
- **In laboratory prototype phase of development**
- **Designed to use ~50% less energy than competing electrical HVAC (heating, ventilation, air conditioning)**
- **Key element of DOE's net zero energy home concept**
- **Estimated to have ~$3000 higher first costs, with a 5.5–10 year payback period**



If not for its energy-efficiency, why would people buy the ASIHP?

- **Particularly given**
  - **Substantially higher first costs**
  - **Long pay-back period (for individual to achieve monetary savings)**
  - **Other alternatives**
    - **To achieve energy efficiency, generally**
      - **e.g., insulation, sealing**
    - **For HVAC plus water heating**
      - **e.g., gas-fired units; tankless water heaters**

Which decision makers matter in the residential new housing market?

- **Consumers**
  - **Purchase finished products (bundles of attributes)**
- **Builders**
  - **Produce finished products**
    - **Create bundled products**
- **Distributors**
  - **Provide builders with equipment**
- **Intermediaries**
  - **Validate/certify equipment**
  - **Select among options to support/promote**
- **Manufacturers**
  - **Supply distributors with equipment**
  - **Supply other manufacturers with component parts**

Decision makers' behavior — different considerations, motivations

- **Buyers as "investors"or "consumers"**
  - **Service or functional needs**
  - **Balance of positive vs. negative attributes**
    - **reliability, purchase price, payback period, operating/maintenance costs, aesthetic qualities**
- **DOE advocates energy efficiency, plus**
  - **Develops technologies attractive to investors; contributes to standard-setting, policy deliberations; etc.**
- **Supply chain considers investment + consumption motives**
  - **Business orientation — return on investment; market share; competition; business plans/strategies**
  - **Energy efficiency — means to achieve business goals**

Our approach: how supply-chain decision making affects market penetration

- **Interviews to learn perspectives, identify attributes that affect decision making**
  - **Semi-structured interview protocol**
  - **Purposive sample**
    - **Individuals knowledgeable about different perspectives**
    - **Small sample**
- **ASIHP in new residential housing**
  - **Not retrofit or replacement markets**

What issues potentially are key for ASIHP market acceptability?

- **Business strategy**
- **Integrated system**
- **Institutional issues**
- **History**
- **Leadership**
- **Tradeoffs and balancing**
- **Non-energy attributes**

Business strategies can result in opposite criteria for ASIHP adoption

- **Leading-edge OEMS take risks to achieve a competitive edge**
  - **OEM:** *About a three-year payback would be necessary. It's a short payback period since we will have competitors. We constantly have to introduce new products and designs—others will follow and compete. There isn't much protection....Is the technology different enough...uniqueness in the marketplace. Also, especially if [the technology] is capital-intensive, how easy is it for others to duplicate what we've done? It's the fear that suddenly we have a competitor. [For the ASIHP] if it's a home run, it will be knocked off.*
- **"Follower" OEMs take a much safer route**
  - **OEM:** *One thing that drives the company is that a competitor has it. It's hard to be first.*

AISHPs are integrated as pieces of equipment and as parts of homes

- **Equipment — questions raised**
  - **Bundled, modularized, or a series of components?**
  - **Who installs, services, and repairs units (cross trade lines?)**
  - **Repair components or entire unit?**
- **New homes as bundled products**
  - **Homebuyers may not select HVAC or water heaters**
    - **[Distributor]:** *Contractors tend to give homebuyers budgets. We show what they can afford in their budget and give them an opportunity to buy up. But heating and air is the last thing people think about. The builder picks out the cheapest HVAC, so he can make more money on the house…. The homeowner doesn't know or specify HVAC systems—the systems are just there. Same with water heaters*.
    - [**Builder of energy-efficient homes]:** *Customers come to us because they want an energy-efficient house. They trust us to choose what goes into the house.*

Institutional roles/responsibilities are ambiguous; relationships matter

- **Interactions with other supply-chain players**
  - **Homebuilder:** *We usually sign 12-month agreements with manufacturers, and shop around annually....We have used the same heat and air manufacturer for the last 7 to 8 years.*
- **Production, sale, installation, servicing**
  - **Distributor:** *We have three sets of buyers— appliances/electrical, plumbing, HVAC—[ASIHP] probably would fall into HVAC*
- **Product rating or certification**
  - **Intermediary:** *[The ASIHP] would have to be sold as single unit for [this organization] to rate it…. If it is sold in component parts, there is no manufacturer control. However, there could be separate manufacturers for a single unit—for example, ...there may be different manufacturers for indoor and outdoor components, with some ability to mix and match.*

Negative historical experiences with predecessor products create bigger hurdles among manufacturers

- **OEM:** *Companies have long memories. Many know very well the [Company A] and [Company B] experiences. [The ASIHP] would have to be noticeably, visibly different…*

Leadership — a champion — within an organization affects support and risk-taking associated with a product

- **OEM:** *Executives took ownership of the idea [of integrated units…in the past] and went with it*
- **OEM:** *There will be niche markets. The question is who and how many would participate...and what manufacturers (large or small) will try. Small manufacturers have not succeeded in these ways.* [What makes companies try?] *Ego. Ego of executives who think they can differentiate themselves in the marketplace and have a competitive advantage….*

Supply-chain organizations regularly make tradeoff- and balancing decisions: you cannot have it all

- **Homebuilder, Habitat for Humanity**: *We need to balance up front and down-the-road costs...[and] affordability, energy-efficiency, and maintenance*.

- **OEM:** *Tradeoffs [are the topic of] hours of discussion [among the design team]. The customer weighs higher. Regulations weigh higher. Customer safety is always important. Reliability of product. Basic specifications are marketing attributes...it has to sell, quality and reliability, manufacturing...1/12 second off the line, engineering...does it work technically. If any of the four don't work, we have to fix it.*

Additional non-energy attributes matter: ASIHP must create value

- **ASIHP is not visible, prestigious, or a typical consumer product**
  - **OEM:** *People talk about [microwaves] on the cocktail circuit. HVAC is not cocktail party conversation*
  - **Intermediary:** *The key for a combination appliance is to think of it as a souped up, does-more-than-you-expect-it-to air conditioner, and not as a water heater....Approach it as a familiar air conditioner that does something else for you....It is not a prestige product like solar panels on the roof. It is not a consumer amenity product like refrigerators. It's much closer to a utilitarian function you expect for a furnace—not a consumer product. It stays out of the way; you don't think about it. It should deliver comfort and hot water, be unobtrusive—not noisy, and reliable.*

Behavioral and societal decision-making contexts are significant for global energy dynamics

- **Decisions about energy-efficient technologies — many competing, and possibly conflicting, attributes**
  - **Energy efficiency and energy savings — primary motivators for a relative few**
  - **Non-energy attributes may be more important**
    - **energy-efficiency as a positive by-product**
  - **Consider who actually makes production, purchasing choices**
- **If not for energy savings, why produce, sell, or buy?**

The Cumberland Energy-Water Nexus Pilot Study: An Overview

Brennan T. Smith

Michael J. Sale

Amy K. Wolfe

December 2006




Cumberland River Energy Water System (CREWS) among 4 pilot studies

- **Interdependencies, interactions between energy and water**
- **Projects emphasize**
  - **Water needs of energy production**
  - **Potential threats to energy production associated with water systems**
- **Funded by the U.S. Department of Energy**

Objectives

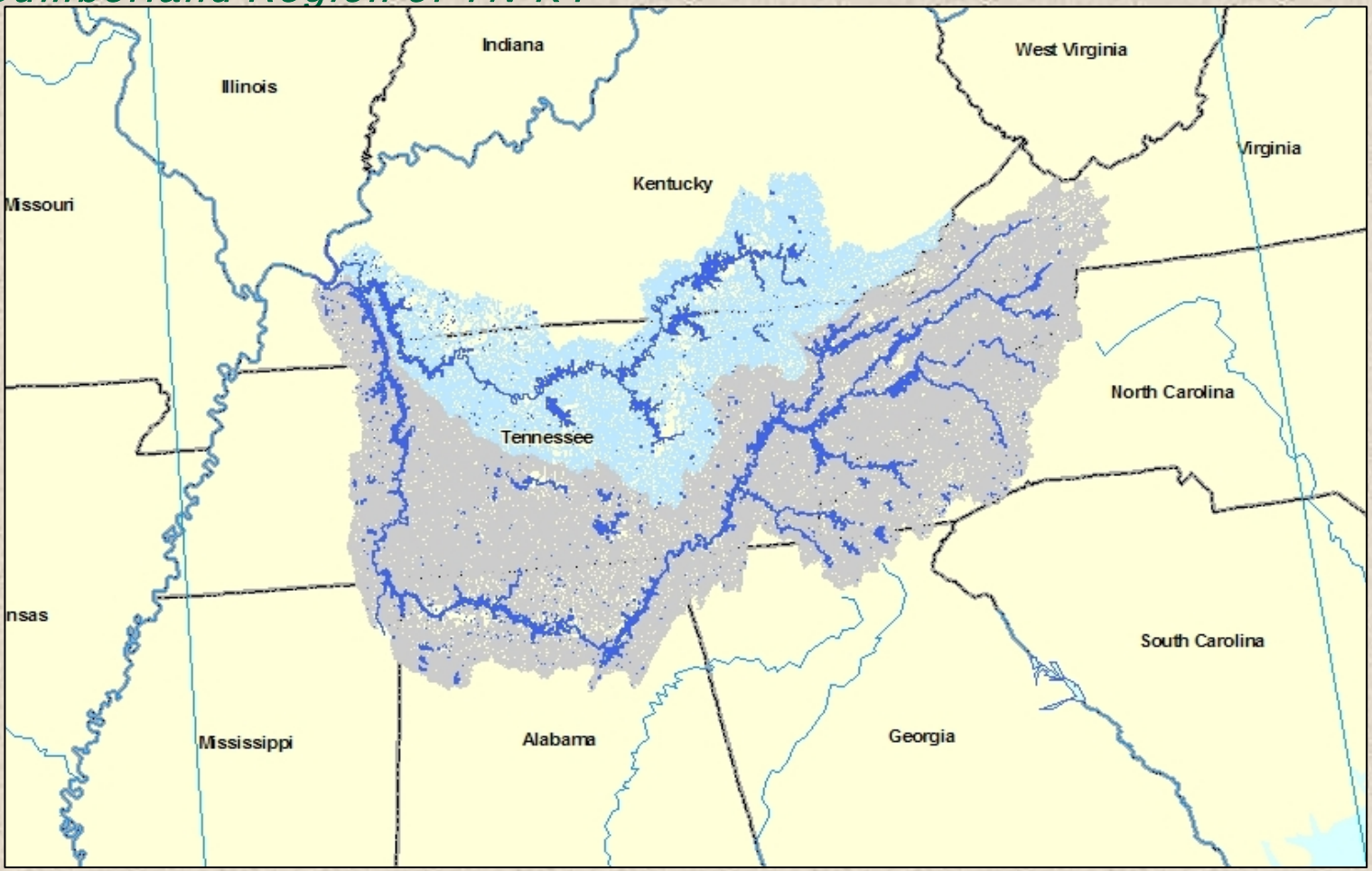
- **Validate energy-water research needs identified in EWN roadmapping:**
  - **Integrated resource planning and management**
  - **Water resource characterization and forecasting**
  - **Needs for technology-based mitigation of energy-water constraints**

- **Illuminate less-obvious but vital and strategic linkages that define energy-water networks**
  - **Enable stakeholders to communicate with common understanding and data**

- **Build rapport with energy-water agencies**
  - **Future EWN collaboration**
  - **Useful products for resource agencies**

Pilot Study Area

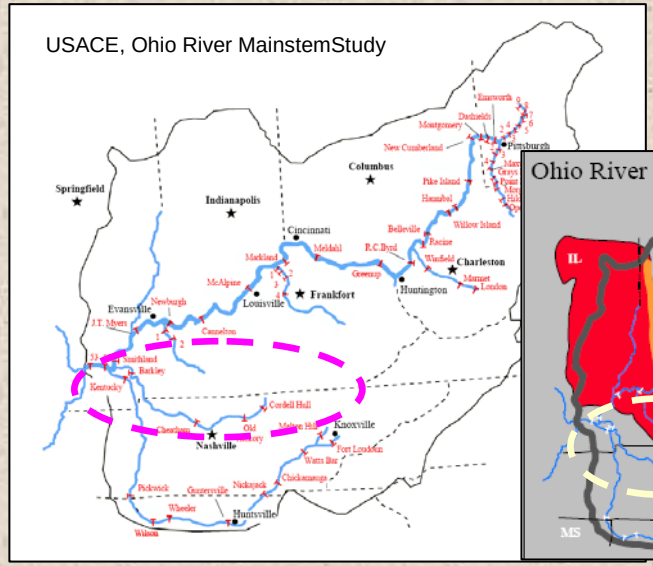
Cumberland Region of TN-KY

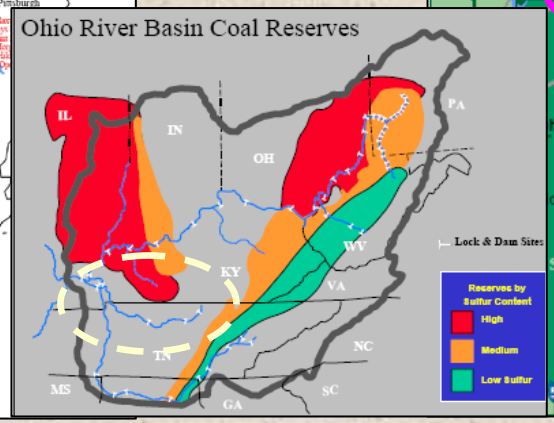


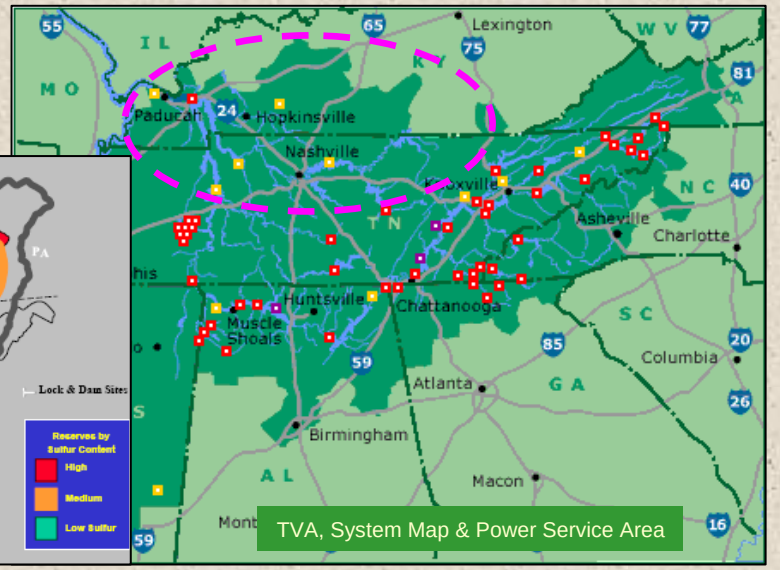
Recurring Issues

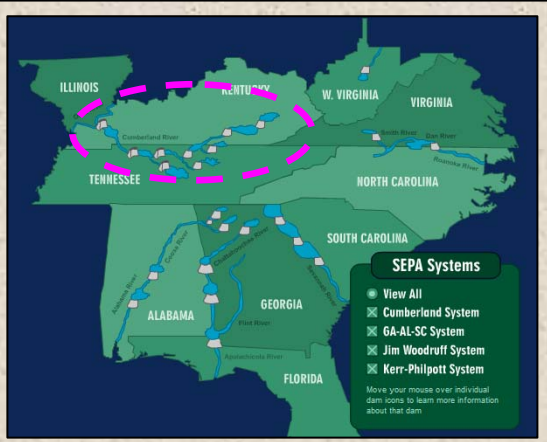
- **Energy Issues**
  - Water for hydropower
  - Water for thermoelectric cooling
  - Water for fuel
    - barge transport of coal
    - biofuel production
  - Infrastructure investments
- **Water Issues**
  - Water Quality
  - Flood Control
  - Water supply
  - Transportation
  - Navigation
  - Recreation
  - Infrastructure investments
- **Interbasin/interstate energy and water transfers**
  - Permitting authority
  - Institutional capacities to monitor and manage

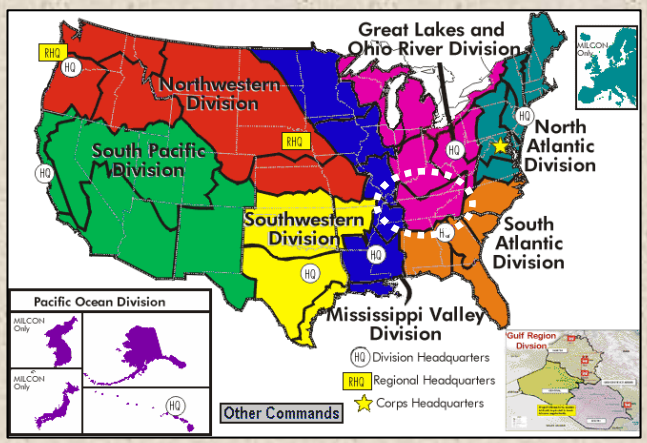
Institutional Perspectives

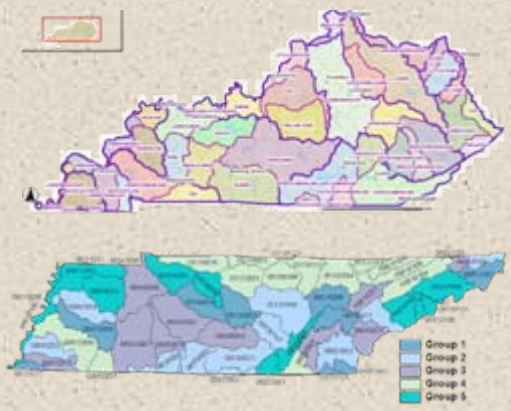












OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

UT-BATTELLE

Institutional perspectives vary

Corps of Engineers, Nashville District

- Navigation
- Flood damage reduction
- Hydropower
- Environmental stewardship
- Recreation
- Emergency response
- International and interagency support

Tennessee Valley Authority

- Energy
- Environmental stewardship
- Economic development

Southeastern Power Administration

- Market and deliver federal hydroelectric power (Corps-operated reservoirs)
- Lowest possible rates
- Does not own transmission facilities

Pilot Study Area

Cumberland Region of TN-KY

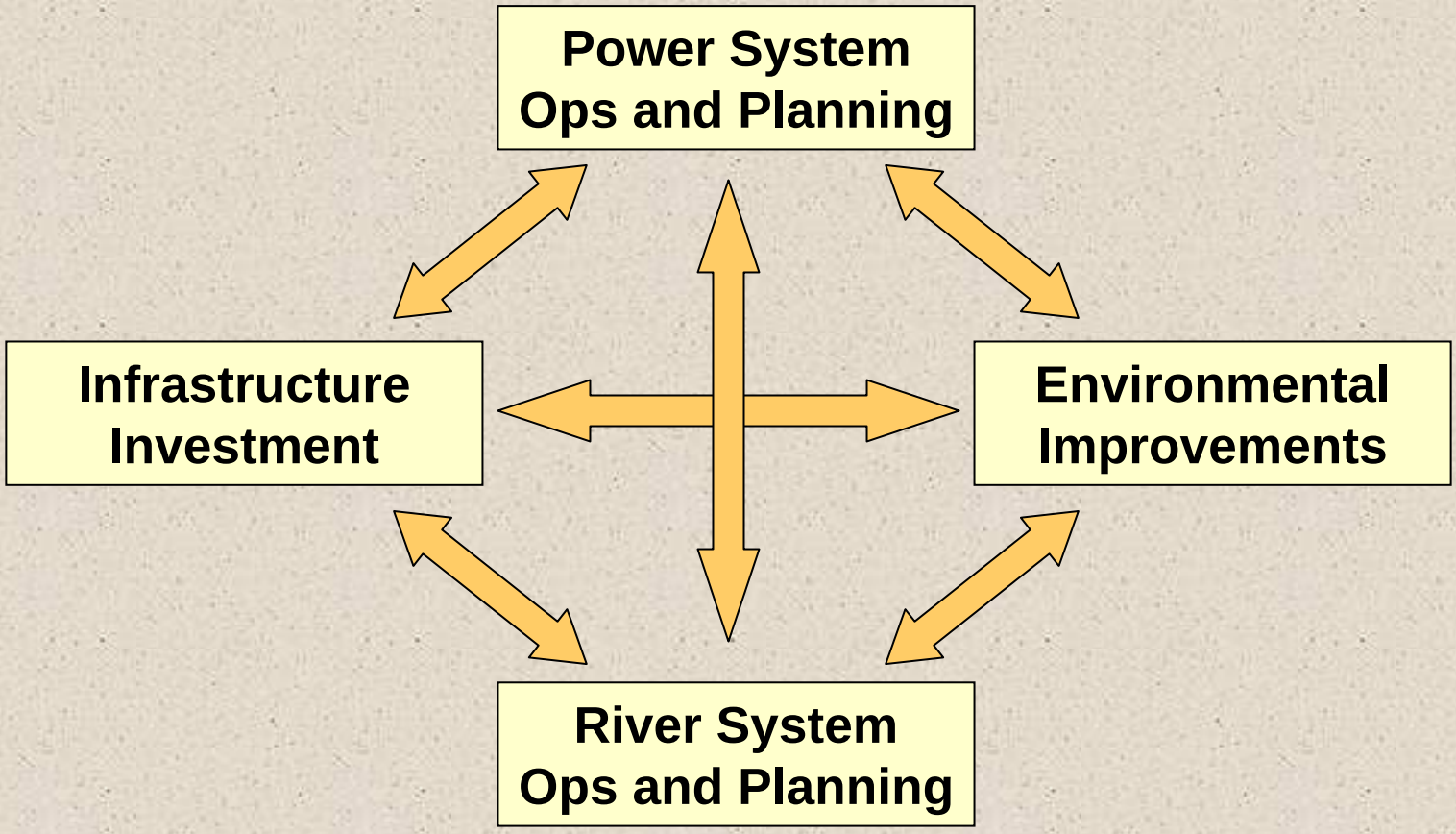
- **Cumberland River Basin**
  - 694 mile length, 17914 sq. mi. drainage
  - Flood control coordination with Tenn., Ohio, Miss. Rivers
  - Water supply for thermoelectric, industrial and municipal
  - Navigation coordination with Tenn., Ohio, and Miss. Rivers for coal and commodity transport
  - Water quality concerns
- **Significance**
  - Globally significant biodiversity
  - Most diverse mussel fauna
  - Half of freshwater fish in US
  - Threatened & endangered species
  - Booming population growth

Pilot Study Area

Cumberland Region of TN-KY

- **Cumberland Region Power**
  - **Cumberland River Hydro**
    - **Dale Hollow, Center Hill, Wolf Creek, Old Hickory, Cheatham, Barkley, J. Percy Priest, and Cordell Hull Projects**
    - **4055 GWh, 938 MW**
    - **$55.9M revenue**
    - **Corps operated, marketed by SEPA to TVA and others**
  - **TVA Coal-Fired Thermoelectric**
    - **Cumberland:18347 GWh, 2350 MW, 20000 tons/day**
    - **Gallatin: 7143 GWh, 988 MW, 12350 tons/day**
  - **All nested within TVA Power Service Area**

Linkages


Power System
Ops and Planning
Infrastructure
Investment
Environmental
Improvements
River System
Ops and Planning

Major Issues

- **Infrastructure investment**
  - aging dams, powerhouses, ports
  - risks to public safety, energy and water security
- **Power System Ops and Planning**
  - controlling, valuing, marketing hydropower energy
    - Corps projects ←→TVA ←→SEPA ←→ Private Utilities
    - Hydro ancillary services
  - development of new generation
  - hydro modernization (633 GWh increase in annual production)
- **River system planning**
  - scheduling and long-term forecasting
  - investment planning at the system vs. project level
- **Environmental Improvements**
  - turbine and diffuser technology for dissolved oxygen enhancement
  - instream flow augmentation

"Mapping" CREWS Institutions and Organizations

- **Why:**
  - **a foundation for later activities**
- **Who:**
  - **organizations using, controlling, making decisions about E-W issues**
  - **too many for exhaustive survey, must prioritize**
    - **Key: Corps, TVA, SEPA, …**
    - **Important: TN, KY, USGS, EPA, …**
- **What:**
  - **Organizational mission and goals**
    - **spatial and temporal scales of performance/decisions**
  - **Bounding:**
    - **What organizations must do vs. will not do**
    - **What they would like to do vs. indifferent**

Institutions and Organizations Essential to View and Manage Basin as an Energy-Water *System*

- **E-W-related information needs**
  - currently available and gaps
- **E-W-related issues of most concern**
  - help/hinder ability to achieve their goals
- **Interactions and dependencies**
  - with other organizations
    - adjacent, up- or downstream, regional, political, etc.
  - perspectives on interactions and dependencies:
    - is navigation organization concerned with water quality?
    - is power marketer concerned about water temperature?
    - is recreation organization concerned with infrastructure?

Integrated Planning and Management Needs

- **Synthesize institutional issues and perspectives**
- **Summarize existing data**
- **Identify gaps and opportunities, common and disparate objectives for Cumberland water and energy**
- **Review alternatives for improved energy-water planning and management**
- **Recommend planning and management approaches (including DSS requirements) needed to meet future energy and water needs**

Global change problems/solutions are framed/addressed within an institutional and societal context

- **Decisions have consequences**
  - Problem and choice set identification
  - Decision-making processes
  - Decision outcomes (near-, middle-, and long-term)
- **Perspectives differ**
  - Institutional roles and responsibilities
  - Incentives and disincentives
  - Role of leadership
- **"Acceptability" is fluid**
  - Influenced by institutional roles, responsibilities, dynamics
  - Affected by internal and external drivers (forcing conditions)
  - Rarely uni-dimensional