Session 7: Infrastructure Markets

1.463 Globalization of the E&C Industry

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What is Infrastructure?

- Generic (dictionary) definitions:
  - "the underlying foundation or basic framework (as of a system or organization)"
  - "the permanent installations required for military purposes"
  - "the system of public works of a country, state, or region"
    - Public works: "works (as schools, highways, docks) constructed for public use or enjoyment, especially when financed and owned by the government"

- Do these definitions seem adequate/accurate?

Source: Merriam-Webster's Online Dictionary. Available at: http://www.merriam-webster.com/dictionary/infrastructure. Accessed 10/19/2009.

Economic Attributes of Infrastructure

- Capital goods (not consumed directly)
  - Derived demand
- "Lumpy" investment
- Long life-spans/design-service lives
- Location-specific (not mobile)
- Prone to market failures
  - Public goods
  - Externalities
- Consumed by households and enterprises

Source: Prud'homme, R. 2005. Infrastructure and Development, in: F. Bourguignon and B. Pleskovic, (eds). *Lessons of Experience (Proceedings of the 2004 Annual Bank conference on Development Economics)*. Washington: The World Bank and Oxford University Press, pp. 153-181.

Infrastructure Services & Systems

Service	Associated Infrastructure
Transportation	Roads, bridges, tunnels, rail tracks, harbors, etc.
Water Supply	Dams, reservoirs, pipes, treatment plants, etc.
Water Disposal	Sewers, used water treatment plants, etc.
Irrigation	Dams, canals
Garbage Disposal	Dumps, incinerators, compost units
District Heating	Plant, network
Telecommunications	Telephone exchanges, telephone lines, etc.
Power	Power plants, transmission & distribution lines

Source: Prud'homme, R. 2005. Infrastructure and Development, in: F. Bourguignon and B. Pleskovic, (eds). *Lessons of Experience (Proceedings of the 2004 Annual Bank conference on Development Economics)*. Washington: The World Bank and Oxford University Press, pp. 153-181.

Categorizing Infrastructure

- Because “infrastructure” is a broad term encompassing a wide variety of facilities and systems, it may be useful to seek an organizational framework or typology

- …but, categorization is no straightforward task, either, as utility of a given framework depends on one’s perspective.

ASCE Infrastructure Categories

Types of Infrastructure "Graded" by ASCE		
Aviation	Bridges	Dams
Drinking Water	Energy	Hazardous Waste
Inland Waterways	Levees	Parks & Recreation
Rail	Roads/Highways	Schools
Solid Waste	Transit	Wastewater

- ASCE publishes a periodic "report card" on America's infrastructure. The fifteen categories of infrastructure assessed in the most recent report card are listed in the table above.

Source: ASCE (2009). *2009 Report Card for America's Infrastructure.* Reston, VA. American Society of Civil Engineers.

Infrastructure Investment Classes

Class	Example Assets
Transport	Bridges, roads, tunnels, airports, rail, ports, urban & regional transport systems
Energy & Utilities	Electricity generation and distribution, water supply and waste water treatment, renewable energy
Social	Universities, schools, student accommodation, prisons, hospitals and health care, public and mixed large-scale housing development, sports facilities and community facilities
Communications	Cable networks, WiFi networks, mobile phones and broadcast towers, etc.

- Infrastructure has emerged as an investment "asset class." The table above is adapted from a publication by Ernst & Young, an investment/financial advisory firm active in infrastructure.

Source: Ernst & Young (2006). *Infrastructure: Risks and Rewards of the Asset Class.* London, UK.

Infrastructure Typology

- Economic infrastructure
  - Transportation, communications, information, energy
- Social infrastructure
  - Educational, health care, water supply, waste management, recreation, environmental protection
- National security infrastructure
  - Defense installations, border security systems

Two Types of Infrastructure

- Network structure
  - Many parts, each functioning independently and requiring small-to-medium budget
  - Complexity emerges from density & interactions
  - Examples: transport systems, sewage systems, power distribution networks, communications networks
- Stand-alone facilities
  - Often large, complex, and costly; require all components to be in place for facility to deliver intended service
  - Examples: power plants, petrochemical plants, skyscrapers, environmental remediation

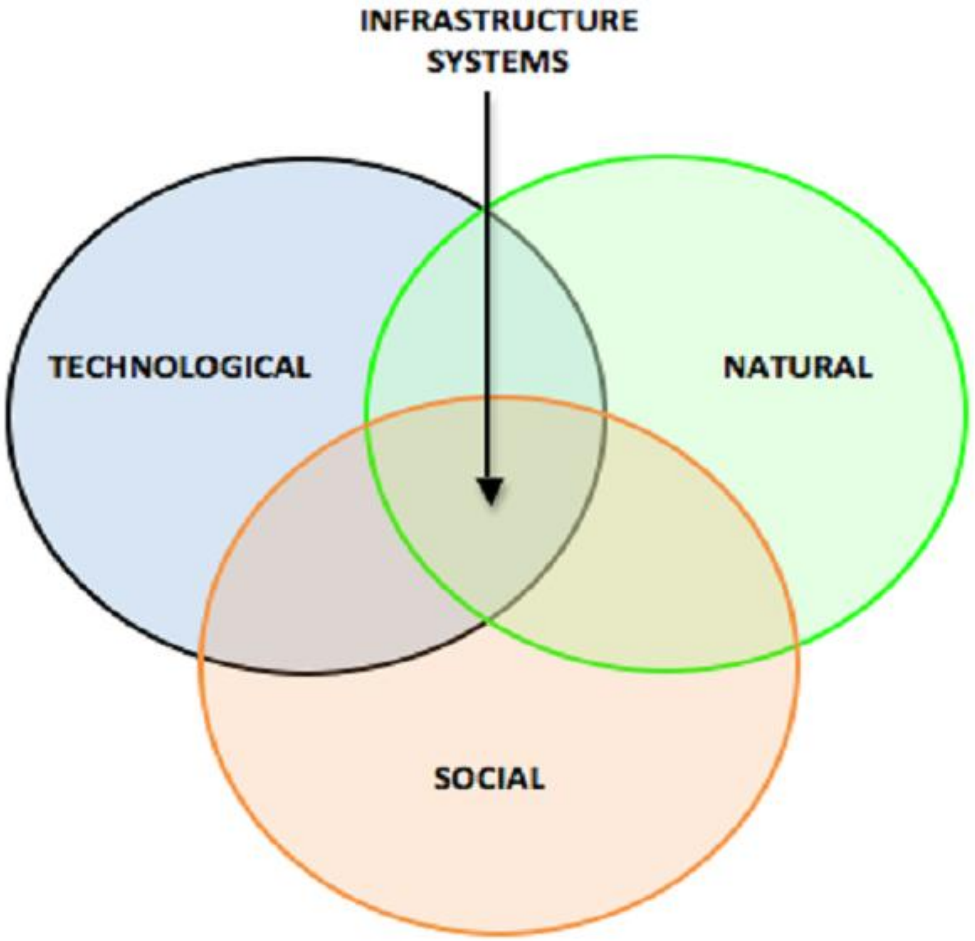
Infrastructure at the Intersection of Systems

Large-scale infrastructure systems occur at the intersection of three systems:

1) Social system – generates demand for services; establishes regulatory framework; includes economic systems

2) Natural system – “source and sink”; supplies resources for infrastructure systems and absorbs waste from their construction & operation

3) Technological system – enables realization of needs given constraints of (1) & (2)



Interdependencies in Infrastructure Systems

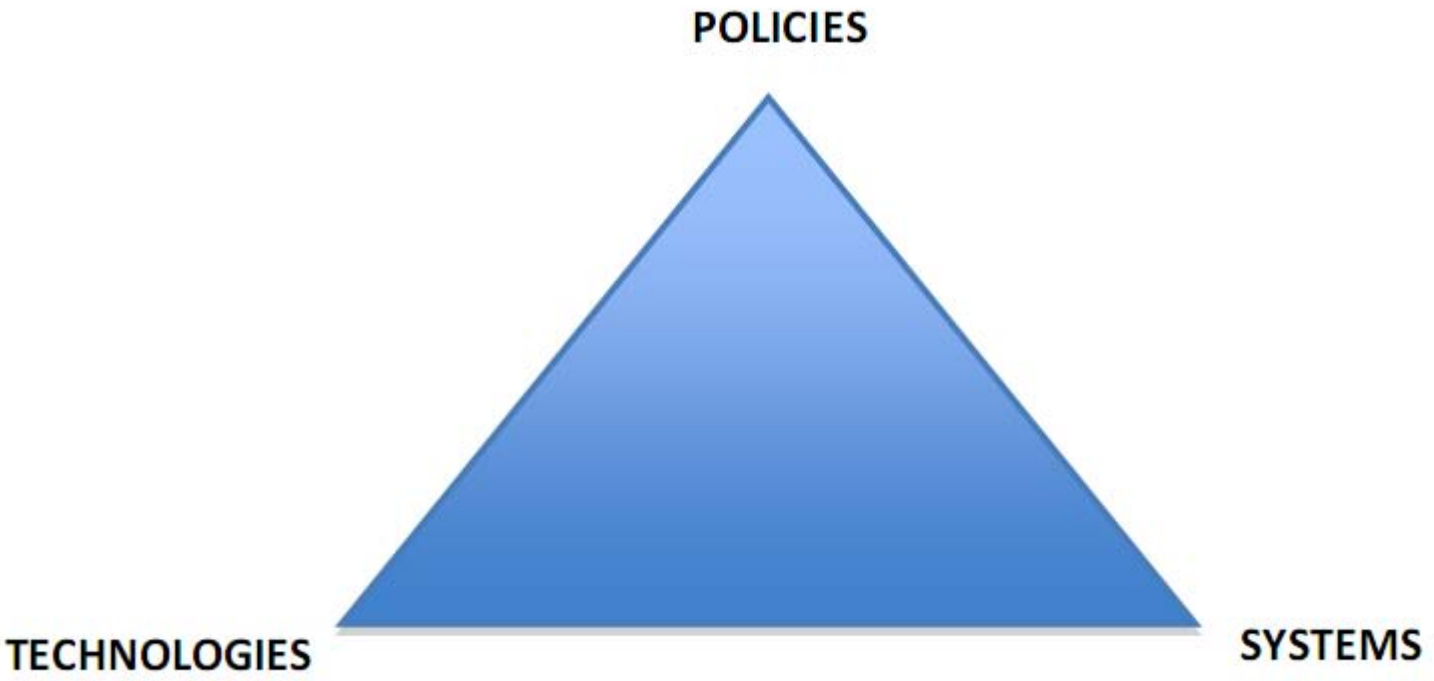
- Growing focus on interdependencies among various infrastructure systems
  - Motivated, in part, by increased profile of homeland security and disaster resilience
  - Emphasis on risk management/mitigation

- Lifeline systems: electric power, gas and liquid fuels, telecommunications, transportation, waste disposal, and water supply

Key Facets of Infrastructure Development

- Sustainable development
- Multiple stakeholders approach (inclusive)
- Lifecycle view
- Consideration of interdependencies
- Value stream perspective

Infrastructure Systems Architecture



Key Dimensions of an Infrastructure Systems Architecture

Development and Competitiveness

- As the “underlying foundation,” infrastructure creates value in multiple ways:
  - It is important to socioeconomic development, and
  - It contributes to productivity and economic competitiveness.

- These dual effects keep infrastructure on the policy agenda of developed and developing nations alike.

Infrastructure: A Global Market

- Although the location-specific nature (immobility) of infrastructure systems makes the specific context of a project important, the market for infrastructure has "globalized" in key ways:
  - Many E&C firms, the "suppliers" of infrastructure, compete for projects on a global basis, and
  - Financing of large-scale infrastructure projects taps the global capital markets.

Current Challenge(s)

- At a global level, there exists a need to upgrade or enhance infrastructure systems if infrastructure capacity is to be sufficient for supporting world economic growth.

- …but, there are major differences between the needs of emerging economies and developed economies.

A Distinction in Needs

- Emerging economies
  - Economic growth often constrained by physical infrastructure capacity
  - Implies demand for construction to relieve this constraint
    - With high projected growth rates in some emerging economies, mobilizing the resources to meet this demand is likely to be a central E&C challenge
- Developed economies
  - Need for physical expansion of infrastructure stock relatively small compared to base already in place ("legacy systems/assets")
    - Pressing challenges concern extracting more capacity from existing networks and facilities
    - Rehabilitation/renewal
    - Integration of systems as density/interdependency/complexity increases?

Global Market Needs (BAH estimate, 25-yr horizon)

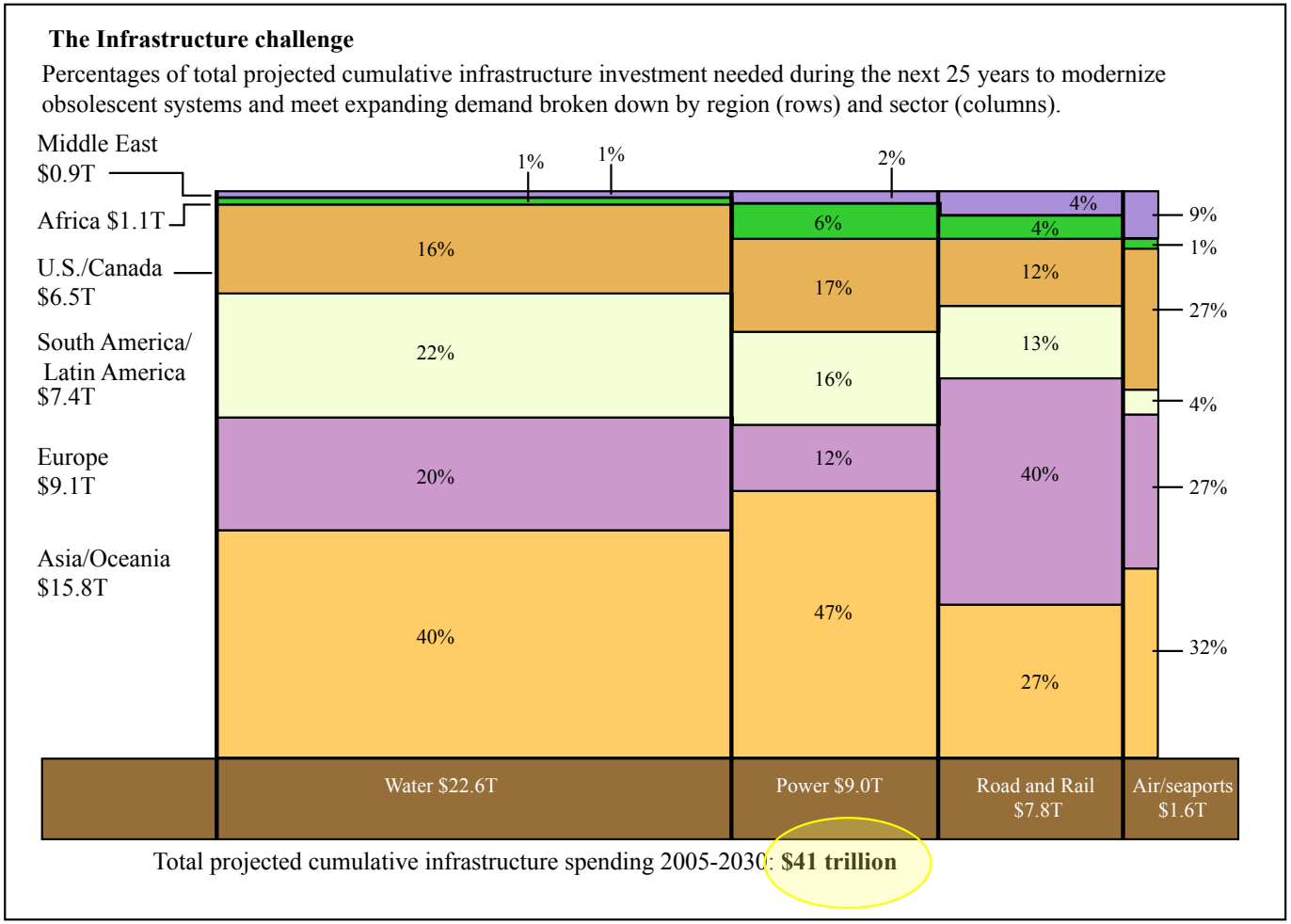


Figure by MIT OpenCourseWare.

Source: Doshi, V., et al. (2007). "Lights! Water! Motion!" *strategy+business,* Booz Allen Hamilton.

How are these needs to be met?

- Although generalizations should be made with caution, many infrastructure systems have “traditionally” been financed and owned by the public sector.
  - In the U.S. case, this is especially true for surface transportation and water infrastructure.

- Over past several decades, the private sector role has increased and evolved.
  - PPPs, privatization, etc.
  - Infrastructure as an asset class (see slides 8 & 19)

Infrastructure development/operation

- Arms-length investment funds are but one type of private involvement in infrastructure development and operation.
- Some E&C firms have moved into roles as infrastructure operators and managers, not just planners and builders.
  - Cintra
    - Spanish spin-off from Ferrovial; focuses on transport infrastructure development; international presence
    - Early U.S. investments through MIG-Cintra consortium (e.g., Chicago Skyway, Indiana Toll Road)

Infrastructure & Economic Stimulus

Go forth and multiply

Estimated impact on GDP of the fiscal stimulus package

Types of stimulus	Examples	Multiplier*
Direct federal spending, federal funding of state and local infrastructure	$165 billion on infrastructure improvents and science	1.0 to 2.5
Non-infrastructure transfers to states	$87 billion on Medicaid; $79 billion for fiscal stabilisation	0.7 to 1.9
Payments to individuals	$47 billion in unemployment insurance; $26 billion in health-insurance subsidies;	0.8 to 2.2
Temporary individual tax cuts	$142 billion Making Work Pay credits	0.5 to 1.7
Tax loss carry-back	$15 billion	0.0 to 0.4

Sources: Congressional Budget Office; congressional committees

*Dollar increase in GDP per dollar of stimulus

Figure by MIT OpenCourseWare.

- Infrastructure investment embraced as a strategy for creating jobs and jump-starting economy.
- What trade-offs and/or limitations might be important to thinking about this strategy?

Source: “Can the Centrists Hold?” (2009, February 5). *The Economist.*

Infrastructure in the U.S.

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Available at: http://politicalhumor.about.com/od/politicalcartoons/ig/Political-Cartoons/Infrastructure-Bridge.htm

Historical Development of Infrastructure

- Roles of public and private sectors
- Overarching goals/objectives: economic development, social equity, public health, environmental protection, etc.
- Economic and political drivers
- Overall vision or decentralized development?

Table 2-1 Highway Mileage and Expenditures Classified by Administrative Responsibility

Administration	Number of agencies	Highway miles (% of total) for which responsible	1999 Revenues (% of total) used for highways by collecting agency ($ millions)	1999 Expenditures for highways (% of total) by Expending agency ($ millions)
Federal agency	5	118,391 (3)	26,016 (22)	1,424 (1)
State agency	52	773,903 (20)	62,097 (53)	71,414 (61)
County agency	2,815	1,766,394 (45)	NA	NA
Town and township	14,051	1,206,917 (31)	NA	NA
Municipality	18,100	—	29,765 (25)	44,595 (38)
Other jurisdictions	—	66,399 (2)	NA	NA
Total	**35,023**	**3,932,004**	**117,878**	**117,433**

Figure by MIT OpenCourseWare.

Source: TRB. (2001). *The Federal Role in Highway Research and Technology: Special Report 261.* Washington, DC: Transportation Research Board, National Research Council.

Dimensions of the Problem

- The challenges to provision of infrastructure in the U.S. are multidimensional and (may) include:
  - Underinvestment in infrastructure
  - Deteriorating condition of infrastructure systems
  - Inadequate funding approaches and financing mechanisms
  - Fragmented governmental framework & institutional structure
  - Deficiencies in new technology development, transfer, and utilization

…and one more dimension…

- Lack of leadership or a compelling vision
  - Multiple sources identify this as one of the most important problems in the U.S. infrastructure sector
  - Leadership role typically suggested for the **federal** government

- What are the implications of this "leadership deficit" for the U.S. infrastructure market, from an A/E/C perspective?

Useful References & Further Reading

- *Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives* (NRC, 2009)
- *Public Works, Public Wealth: New Directions for America's Infrastructure, A Report of the CSIS Public Infrastructure Project* (Ehrlich & Landy, CSIS, 2005)
- Also several sources which have already been cited.

Concluding Thoughts

- What are the major issues in infrastructure?
  - Refining the government role (or, both public and private roles)
  - Accommodating future needs while utilizing legacy systems and institutions
  - Improving incentive mechanisms
  - Reducing the overall costs of infrastructure systems?
- What are the opportunities and risks from an E&C perspective?
  - What skills are needed?
  - How would you approach different global markets?

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