# Comparative Analysis of Intelligent Systems in the Transportation and Energy Sectors

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## Background

**National Broadband Plan**
- Chapter 12 "Energy and the Environment" mentions transportation and energy sectors as strategic areas for broadband development, implementation, and innovation in information and communication technologies.

**Transportation sector: Intelligent transportation systems (ITS)**
- Definition: "A broad range of advanced communications technologies that, when integrated into transportation infrastructure and vehicles, relieves congestion, improves safety, and mitigates environmental impact" (Federal Communications Commission, 2010, p. 352).
- Thus: network infrastructure of highways, surface roads, vehicles, and traffic management, enriched with a digital two-way communication network infrastructure.

**Energy sector: Smart grid systems (SGS)**
- Definition: "The electric delivery network, from electrical generation to end-use customer, integrated with sensors, software, and two-way communications technologies to improve grid reliability, security, and efficiency" (Federal Communications Commission, 2010, p. 353).
- Thus: network infrastructure of generation, transmission, distribution, and consumption of electric power (electricity), enriched with a digital two-way communication network infrastructure.

**Research Question:**
- "What can we learn from comparing the transportation sector and the energy sector; intelligent transportation systems and smart grid systems respectively, that are in **"networked transition?""**

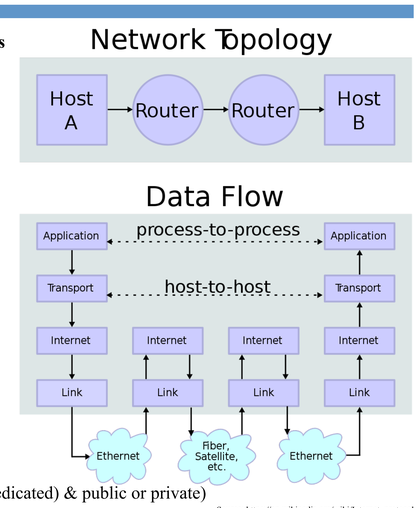
**Method:**
- Qualitative: exploratory, inductive & interpretative analysis of document content.
- Literature review: governance, communication networks, and ITS & SGS technology and policy.

## Conceptual Framework

**Hybrid framework for analyzing networked transitions**

**1. Governance framework:**
- Operational domain (systems or sectors):
  - High-level functions
  - Policy challenges
  - Stakeholder groups
  - Pilot projects
- Institutions (rule-making procedures):
  - Regulatory organizations
  - Standard-setting organizations
- Prescriptions (rules):
  - Laws, regulations, and policies
  - Technological standards

**2. Layered model of Internet connectivity:**
- Content layer:
  - User data/information
- Application layer:
  - **[Applications and services]**
- Network layer:
  - Networks (TCP/IP or non-TCP/IP (dedicated) & public or private)
- Link layer:
  - Physical (tele)-communication links (wired or wireless)




Source: https://en.wikipedia.org/wiki/Internet_protocol_suite

## Preliminary Conclusions

**ITS & SGS are in networked transition:**

**1) Supplier-side infrastructure (back-office):**
- ITS: State DOTs ITS management systems
- SGS: Grid management systems

**2) User-side infrastructure (front-office):**
- ITS: State DOTs web portals, apps, and systems
- SGS: Utility companies web portals and apps

**3) Supplier-side ←→ user -side infrastructure:**
- ITS: Connected vehicles (V2X) pilots
- SGS: Advanced metering infrastructure (AMI) pilots

**4) User-side aftermarket (front-office):**
- ITS: telematics infotainment systems and apps
- SGS: home energy management systems and apps

**Thus:** ITS & SGS infrastructure apps (1-3) seem to be more about control and services through private and/or dedicated systems, whereas, the aftermarket apps (4) are about capturing value of open data and/or crowd based data of user apps on the public TCP/IP platform and using wireless links. In contrast to SGS, for ITS, as vehicle move around, wireless links with low latency are absolutely essential.

**Recommendation:** To capture value creation in ITS and SGS, stimulate open data, crowed-based data, the use of the TCP/IP platform for app development, and high bandwidth & low latency wireless communication links.

**Loci & intensity of (user-side) innovations:**

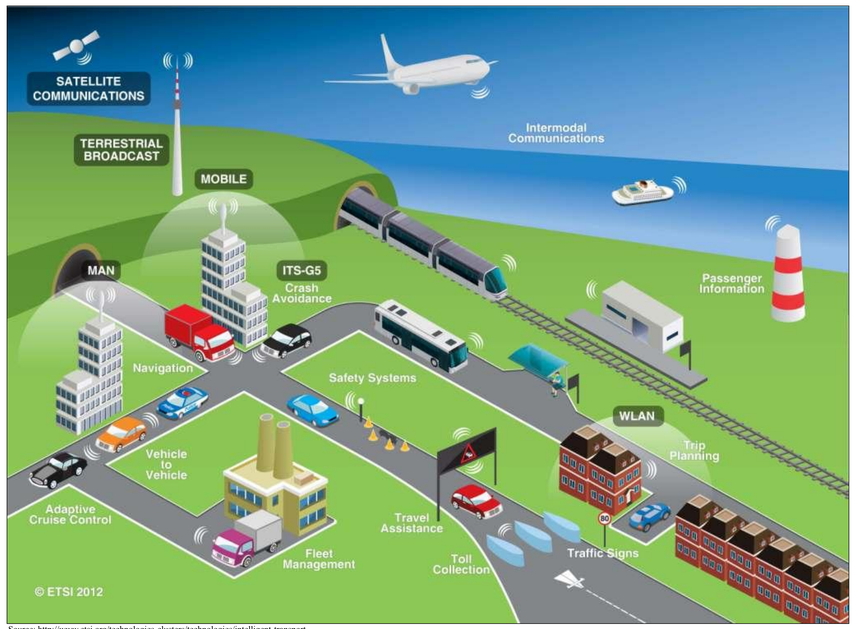
**1) ITS sector:**
- Sector-driven < Aftermarket-driven
- *Explanation*: aftermarket caters to less challenging system functions, has lower barriers of entry by private IT players, less government control, ease of crowd and open data based value creation & profitability on top of open TCP/IP platform, and increasingly available wireless links.

**2) SGS sector:**
- Sector-driven > Aftermarket-driven
- *Explanation*: SGS sector is driven by private players, ARRA stimulus funds for AMI pilots, value creation & profitability is challenging for IT players in the aftermarket due to value of user information, lack of crowd sourcing options even though apps are built on top of the open TCP/IP platform.

**3) Cross-sector comparison of sector-driven innovation:**
- SGS > ITS
- *Explanation*: SGS sector is mainly driven by private players, whereas the ITS sector is mainly driven by public players, less government control in SGS, ARRA stimulus funds for AMI pilots in SGS sector.

**4) Cross-sector comparison of aftermarket-driven innovation**
- ITS > SGS
- *Explanation*: mobility requirement in ITS allows for more value creation & profitability for IT players due to open data and crowd based apps that can reduce the uncertainty about fast-clock decision-making in and about traffic.

## Transportation Sector – Intelligent Transportation Systems (ITS)




Source: http://www.etsi.org/technologies-clusters/technologies/intelligent-transport

### Operational domain:

**High-level system functions:**
- Road safety
- Mobility of vehicles
- Efficiency of infrastructure
- Environmental protection
- Economic competitiveness

**Policy challenges:**
- Data security
- Data privacy
- Interoperability of standards
- 5 GHz frequency spectrum allocation
- Liability
- Public information benefits of ITS
- Distracted driving

**Stakeholder groups:**
- Regulatory/administrative organizations
- Car manufacturers
- Consumers
- Telecom operators
- ITS system providers
- IT system providers

**Pilot Projects:**
- Ann Arbor Safety Connected Vehicle Safety Pilot Program (V2X DSRC),
- AERIS (data for green transportation)

### Institutions & Prescriptions:

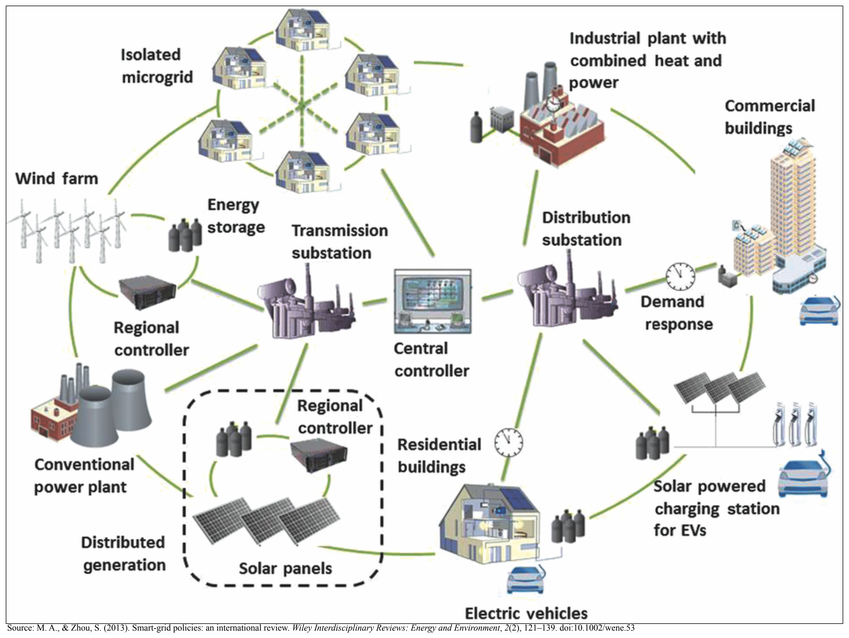
**ITS regulatory/administrative organizations:**
- US DOT
- NHTSA
- FHWA
- RITA-JPO
- ITSA
- State DOTs

**IT regulatory/administrative organizations:**
- FCC, NTIA

**Standard-setting organizations:**
- US: IEEE, SAE Int'l
- EU: ISO, ETSI, CEN

**Regulatory/administrative prescriptions:**
- "ITS Strategic Research Plan 2010-2014" (2012)
- "ITS Standards Program Strategic Plan for 2011- 2014" (2011)
- "National Broadband Plan" (2010)
- "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)" (2005)
- "Transportation Equity Act for the 21st Century (TEA-21)" (1998)
- " Inter-modal Surface Transportation Efficiency Act (ISTEA)" (1991)

## Energy Sector – Smart Grid Systems (SGS)




Source: M. A., & Zhou, S. (2013). Smart-grid policies: an international review. *Wiley Interdisciplinary Reviews: Energy and Environment*, *2*(2), 121–139. doi:10.1002/wene.53

### Operational domain:

**High-level system functions:**
- Reliability of grid
- Efficiency grid
- Flexibility grid
- Safety grid
- Affordability of electricity
- Grid security
- Energy security
- Environment protection
- Renewable energy sources
- Distributed power generation
- Integration of electric (PEV) & hybrid (PHEV) vehicles
- Economic competitiveness

**Policy challenges:**
- Capital investments
- Technical risks
- Existing pricing scheme & market monopoly structure
- Imperfect public information about benefits
- Data security
- Data privacy
- Interoperability standards

**Stakeholder groups:**
- Regulatory/administrative organizations
- Utility providers
- Conventional energy companies
- Renewable energy companies
- Consumers: residential, commercial, industrial
- Advanced metering infrastructure (AMI) vendors
- Telecom operators
- IT system providers
- Environmental groups

**Pilot Projects:**
- PG&E,
- AEP,
- Southern California Edison (SCE),
- Georgia Power,
- Florida Power & Light,
- Oncor,
- DTE,
- CenterPoint,
- Pepco Holding (PHI),
- Duke Energy,
- Sempra/San Diego Gas & Electric,
- Ontario Smart-Metering Initiative,
- Portland General Electric Co.,
- Future Renewable Electric Energy Delivery and Management Systems Center

### Institutions & Prescriptions:

**SGS regulatory/administrative orgs:**
- US DOE
- FERC
- NIST
- NERC
- NARUC
- Federal Smart grid task force
- Gridwise Architecture council
- State legislators
- Public utility commissions

**IT regulatory/administrative orgs:**
- FCC, NTIA

**Other regulatory/administrative orgs:**
- US DA, US DOC, US DHS, US DOD, EPA

**Standard-setting orgs:**
- ANSI, IEEE-PES, IEC, SAE Int'l

**Regulatory/administrative prescriptions:**
- National broadband Plan (2010)
- Recovery and Reinvestment Act (2009)
- Energy Independence & Security Act (2007)
- Energy Policy Act (EPA) (2005)

## Application and Service Areas

### Current State Intelligent Transportation Systems (ITS)

**1) Supplier-side sector infrastructure (back-office)**
- State DOTs management of ITS infrastructure, e.g., the GDOT NaviGAtor ITS system (hardware and software)
- *Sector-driven innovation:* 3rd party traffic data, and connected vehicles (see application area 3)

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- Layered model:

**C:** Incidents, traffic & weather conditions info., vehicle geo-locations and IDs info.
**A:** State DOTs ITS management system
**N:** TCP/IP private
**L:** Wire: Fiber, Ethernet & wireless: cellular (2G), Bluetooth

**2) User-side sector infrastructure (front-office)**
- State DOTs traffic information web portals, e.g., GDOT NaviGAtor website, 511 phone system and Android/iOS apps, CMS, radio broadcast
- *Sector-driven innovation:* more functions web portals, and connected vehicles (see application area 3)

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- Layered model:

**C:** Traffic & weather conditions info.
**A:** State DOTs web portals, apps, and systems
**N:** TCP/IP public
**L:** Wire: Fiber, Cable, DSL, Ethernet & wireless: cellular (2G, 3G, 4G) or Wifi

**3) Supplier-side ←→ User-side sector infrastructure**
- *Sector-driven innovation:* safety, navigation, and entertainment applications developed in the connected vehicle (V2X) pilot projects.
- US: IEEE WAVE/DSRC protocol stack
- EU: ISO CALM protocol stack

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- Layered model:

**C:** Traffic & weather conditions, vehicle IDs & geo-locations, maps, vehicle condition & performance info.
**A:** V2X safety, navigation, and infotainment apps
**N:** TCP/IP public or private & non-TCP/IP (dedicated)
**L:** Wire: Fiber, Ethernet & wireless: cellular: (2G, 3G, 4G), Wifi, DSRC (ad hoc mesh)

**4) User-side aftermarket: telematics (front-office)**
- *Aftermarket-driven innovation:*
- Telematics infotainment systems and apps of automotive OEMs, e.g., Ford Sync, GM Onstar, BMW Connected Drive
- Smart phone systems and apps of mobile OEMs, e.g., Waze, Google Maps, Inrix, Yelp Parker on Google Android, Apple iOS: probe and crowd based value creation.

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- Layered model:

**C:** Traffic & weather conditions, geo-location, vehicle condition and performance, maps, entertainment, billing info.
**A:** Telematics: navigation, vehicle info, entertainment
**N:** TCP/IP public
**L:** Wireless: cellular (2G, 3G, 4G), Wifi, "GPS"

### Vision future state ITS:
- Fully connected & networked vehicles with the ITS infrastructure and with each other (V2X) to improve safety, efficiency, environmental impact etc.

### Current State Smart Grid Systems (SGS)

**1) Supplier-side sector infrastructure (back-office)**
- Grid infrastructure management for generation, transmission, and distribution of electricity, e.g., Georgia Power
- *Sector-driven innovation:* AMI infrastructure (see application area 3)

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- Layered model:

**C:** Electricity currents and voltages, peak loads, outages, electricity use and demands info.
**A:** Grid management systems
**N:** TCP/IP private & non-TCP/IP (dedicated): (WAN–FAN)
**L:** Wire: Fiber, Ethernet, PLC

**2) User-side sector infrastructure (front-office)**
- Utility companies web portals and apps to monitor energy consumption, e.g., Green Button initiative
- *Sector-driven innovation:* more functions web portals and apps, and AMI infrastructure (see application area 3)

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- Layered model:

**C:** Electricity consumption and billing info.
**A:** Utility companies web portals and apps
**N:** TCP/IP public
**L:** Wire: Fiber, Cable, DSL, Ethernet & wireless: cellular (2G, 3G, 4G) or Wifi

**3) Supplier-side ←→ User-side sector infrastructure**
- *Sector-driven innovation:* advanced smart metering infrastructure (AMI) (smart meters) developed in pilot projects.
- Demand response management (DRM) between utility and consumers to manage electricity, pricing, and billing info.

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- Layered model:

**C:** Electricity consumption, dynamic pricing rates (TOU, CPP, RTP), dynamic incentive options (DLC, IS, BBP, EDRP).
**A:** AMI (smart meters)
**N:** TCP/IP private & non-TCP/IP (dedicated): (NAN-WAN)
**L:** Wire: PLC, DSL, Fiber & wireless: cellular (2G, 3G), WiMax, RF mesh, ZigBee

**4) User-side aftermarket: home energy management (HEM) (front-office)**
- *Aftermarket-driven innovation:*
- Green Button web portals and smart phone apps
- Web portals, e.g., Microsoft Hohm (discontinued), and Google PowerMeter (discontinued)
- Networked sockets systems and apps, e.g., Visible Energy
- Home automation systems and apps, e.g., Control 4

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- Layered model:

**C:** Electricity consumption, device control info.
**A:** HEM: smart phone apps, sockets, home automation, web portals and apps
**N:** TCP/IP private or public: (HAN-NAN)
**L:** Wire: Ethernet & wireless: cellular (2G, 3G, 4G), Wifi, ZigBee (ad hoc mesh), Bluetooth

### Vision future state SGS:
- Fully connected & networked grid components with the existing infrastructure, extending beyond, e.g., decentralized renewable energy, and extending into the home to improve grid reliability, efficiency, carbon footprint etc.