

Managing Induced Seismicity in an Energy System Context

Donald L. Paul

Executive Director of the USC Energy Institute
and William M. Keck Chair of Energy Resources

Fred Aminzadeh

Professor of Petroleum Engineering



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Outline

- Induced Seismicity headlines
- An energy system model for context
- A science-based framework
 - Hydraulic fracturing (HF)
 - Fluid injection and / or removal (production, waste water disposal, etc.)
 - CO₂ Capture and Sequestration (CCS)
- A sociological framework for communications
- The USC Induced Seismicity Consortium

Bloomberg

Fracking Tied to Unusual Rise in Earthquakes in U.S.

By Mark Drajem - Apr 12, 2012 12:32 PM PT

A spate of earthquakes across the middle of the U.S. is “almost certainly” man-made, and may be caused by wastewater from oil or gas drilling injected into the ground, U.S. government scientists said in a study. [Researchers](#) from the [U.S. Geological Survey](#) said that for the three decades until 2000, seismic events in the nation’s midsection averaged 21 a year. They jumped to 50 in 2009, 87 in 2010 and 134 in 2011. Those statistics, included in the abstract of a research paper to be discussed at the Seismological Society of America conference next week in [San Diego](#), will add pressure on an [energy industry](#) already confronting more regulation of the process of hydraulic fracturing.

An energy plant along the southern San Andreas earthquake fault near Calipatria, California. In northern California, engineers are drilling to great depths to force water into bedrock, a process that causes slippage and small earthquakes.
Photographer: David McNew/Getty Images



“Our scientists cite a series of examples for which an uptick in seismic activity is observed in areas where the disposal of wastewater through deep-well injection increased significantly, "David [Hayes](#), the deputy secretary of the U.S. Department of Interior, said in a [blog](#) post yesterday, describing research by scientists at the [U.S. Geological Survey](#)

Bloomberg

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‘Fairly Small’ Quakes

The earthquakes were “fairly small,” and rarely caused damage, Hayes said.

He said not all wastewater disposal wells induce earthquakes, and there is no way of knowing if a disposal well will cause a temblor.

Last month, Ohio officials concluded that earthquakes there last year probably were caused by wastewater from hydraulic fracturing for natural gas injected into a disposal well.

In hydraulic fracturing -- or fracking -- water, sand and chemicals are injected into deep shale formations to break apart underground rock and free natural gas trapped deep underground. Much of that water comes back up to the surface and must then be disposed of. There’s “a difference between disposal injection wells and hydraulically fractured wells,” Daniel Whitten, a spokesman for the America’s Natural Gas Alliance, which represents companies such as [Chesapeake Energy Corp. \(CHK\)](#) and [Cabot Oil & Gas Corp. \(COG\)](#), said in an e-mail. “There are over 140,000 disposal wells in America, with only a handful potentially linked to seismic activity.”

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‘Committed to Monitoring’

“We are committed to monitoring the issue and working with authorities where there are concerns, but it should be noted that currently there is no scientific data associating hydraulic fracturing with earthquakes that would cause damage,” he said.

An abstract of the federal study, which was led by William Ellsworth, Earthquake Science Center staff director for the U.S. Geological Survey in [Menlo Park, California](#), was published online earlier this month. A full version of the study wasn’t immediately available.

The area studied included a swath of the country running from [Ohio](#) to Colorado and [Oklahoma](#), the study said.

“A naturally-occurring rate change of this magnitude is unprecedented outside of volcanic settings or in the absence of a main shock, of which there were neither in this region,” Ellsworth and his colleagues wrote.

The Environmental Protection Agency is preparing to release rules on air pollution from gas wells and on the treatment of wastewater. Other state and federal rules could force more disclosure of the chemicals used by the drilling companies.

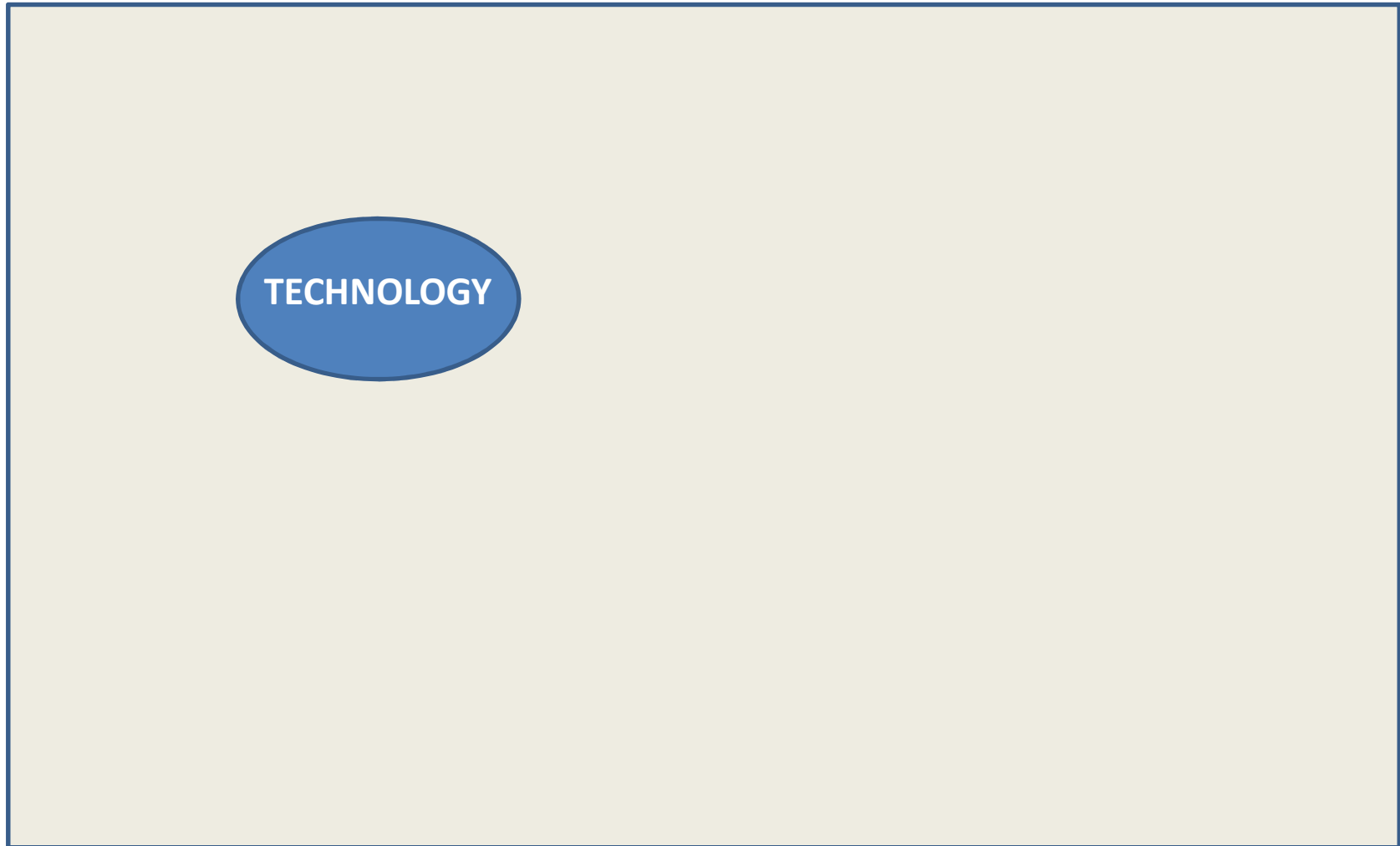
The Interior Department is considering rules to update well-design standards and require disclosure of the chemicals in fracking on public lands.

From the National Research Council 2012 Report:

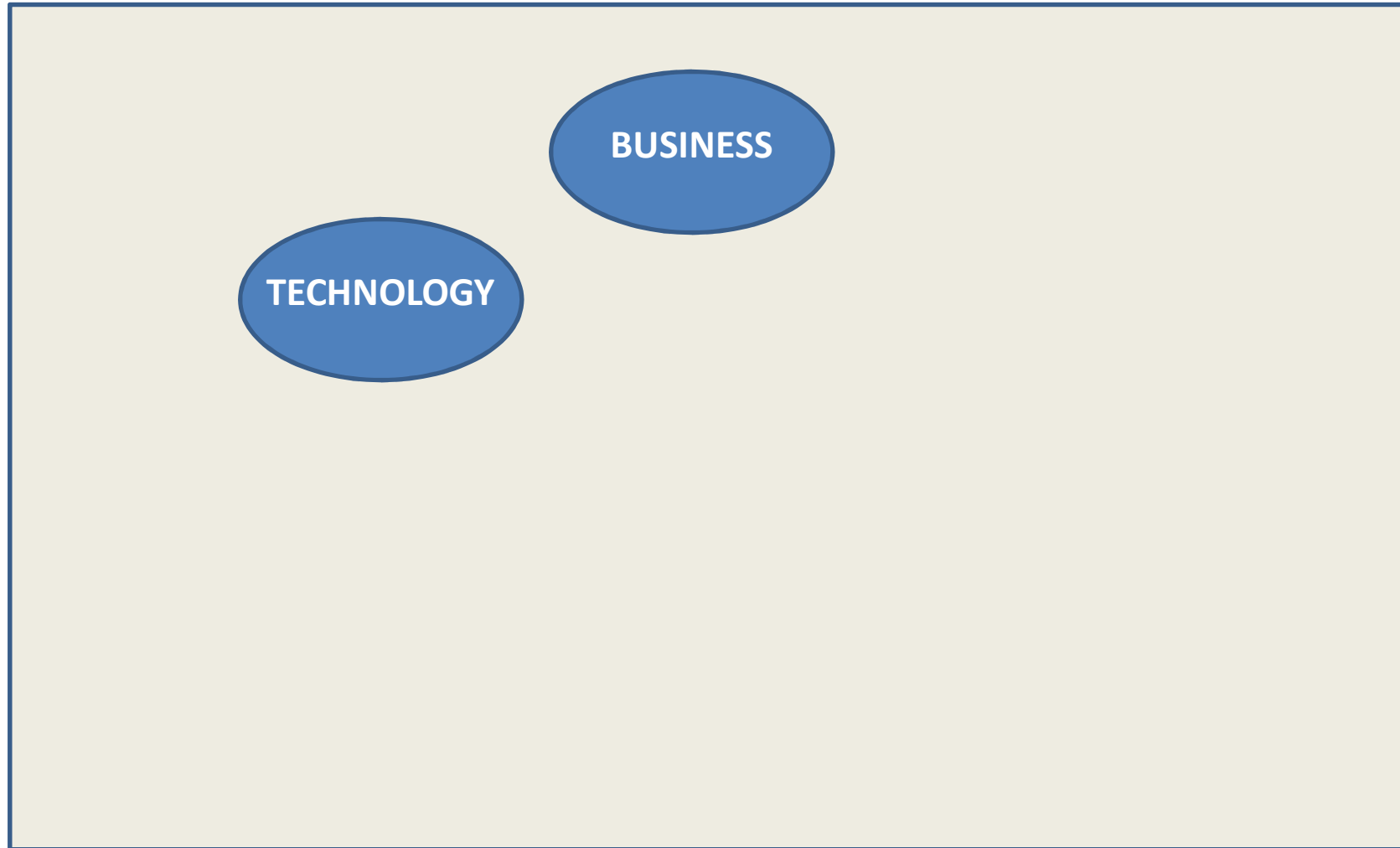
“To better understand, limit, and respond to induced seismic events, work is needed to build robust prediction models, to assess potential hazards, and to help relevant agencies coordinate to address them.”

An Energy System Model

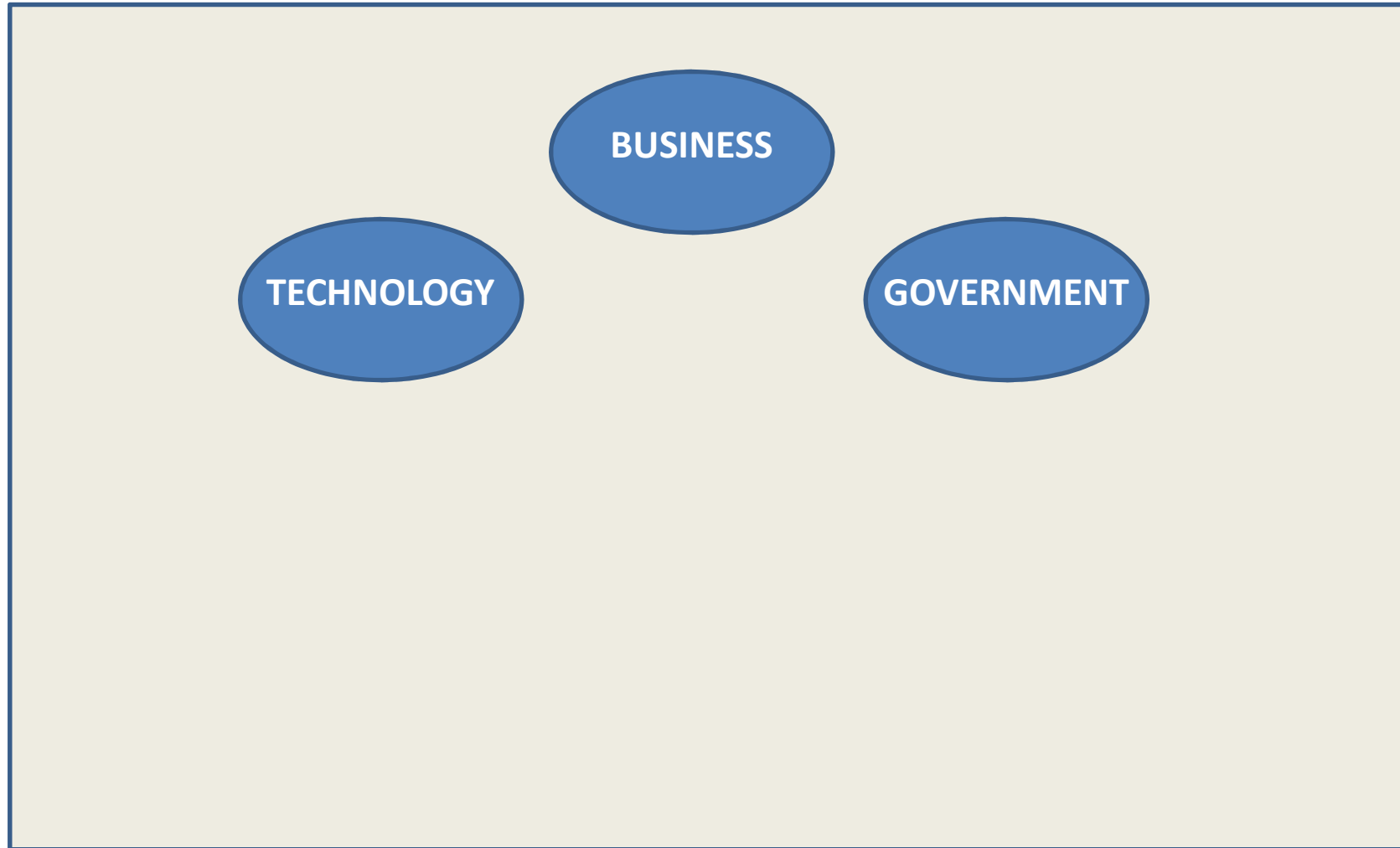
An Energy System Model



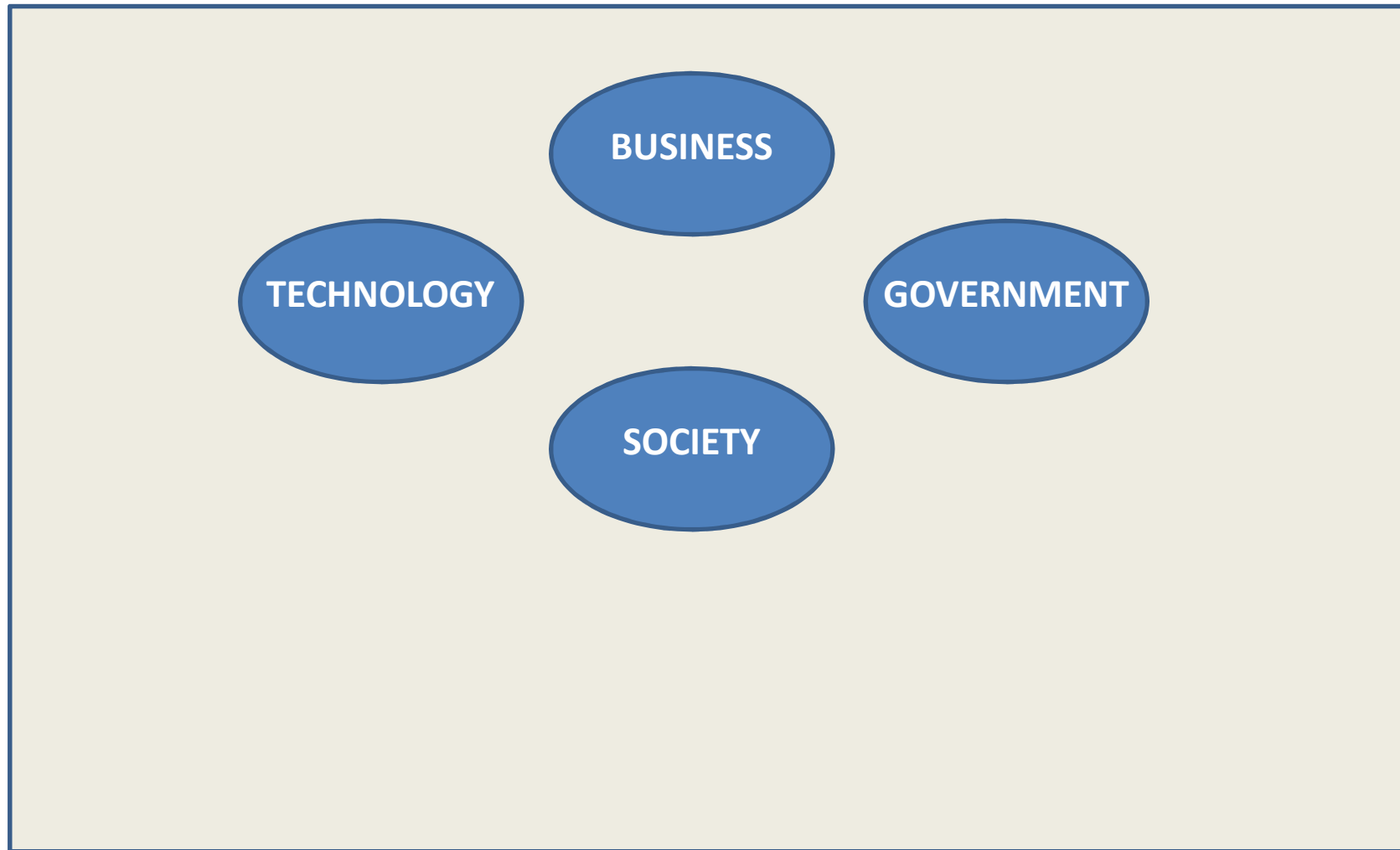
An Energy System Model



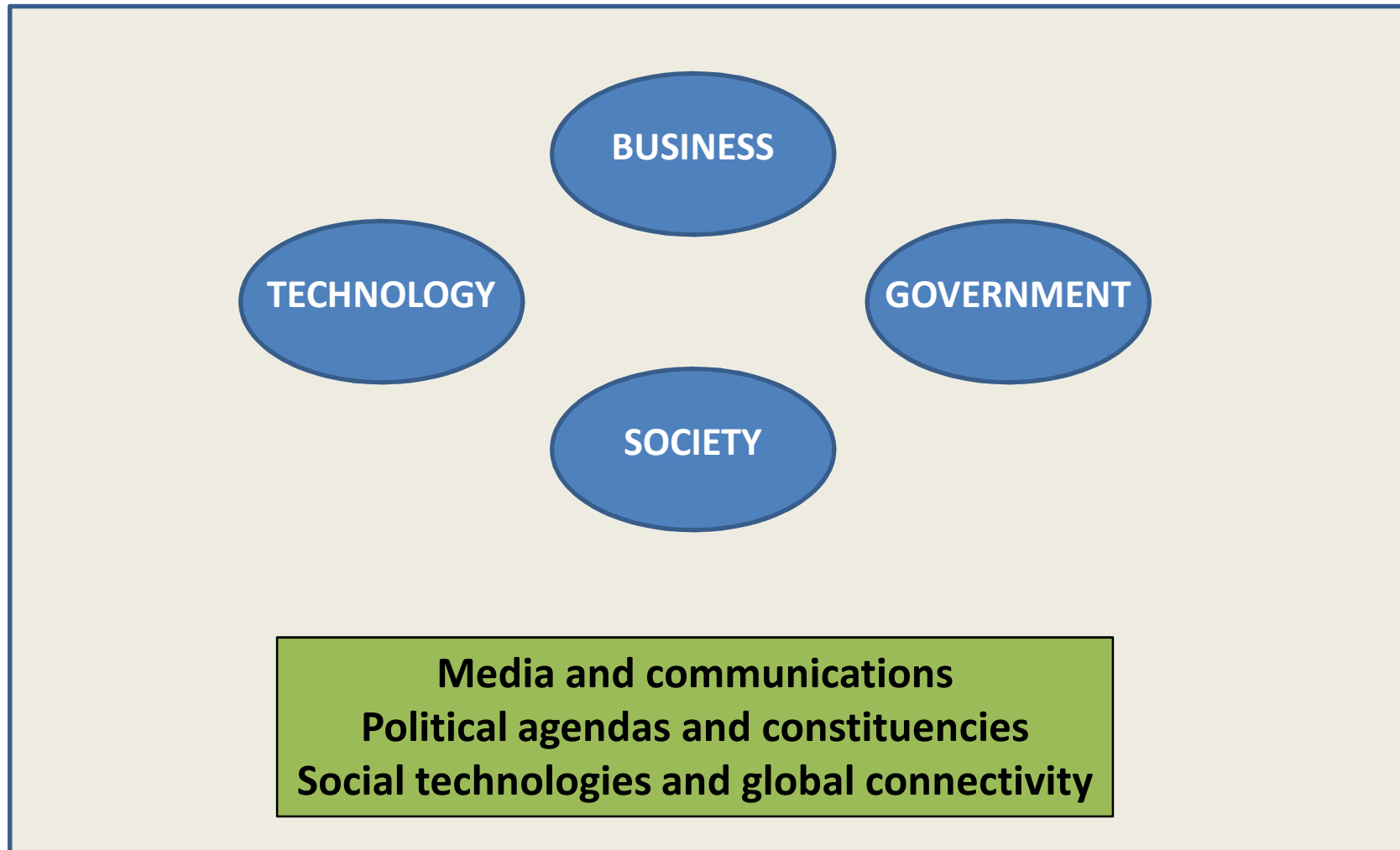
An Energy System Model



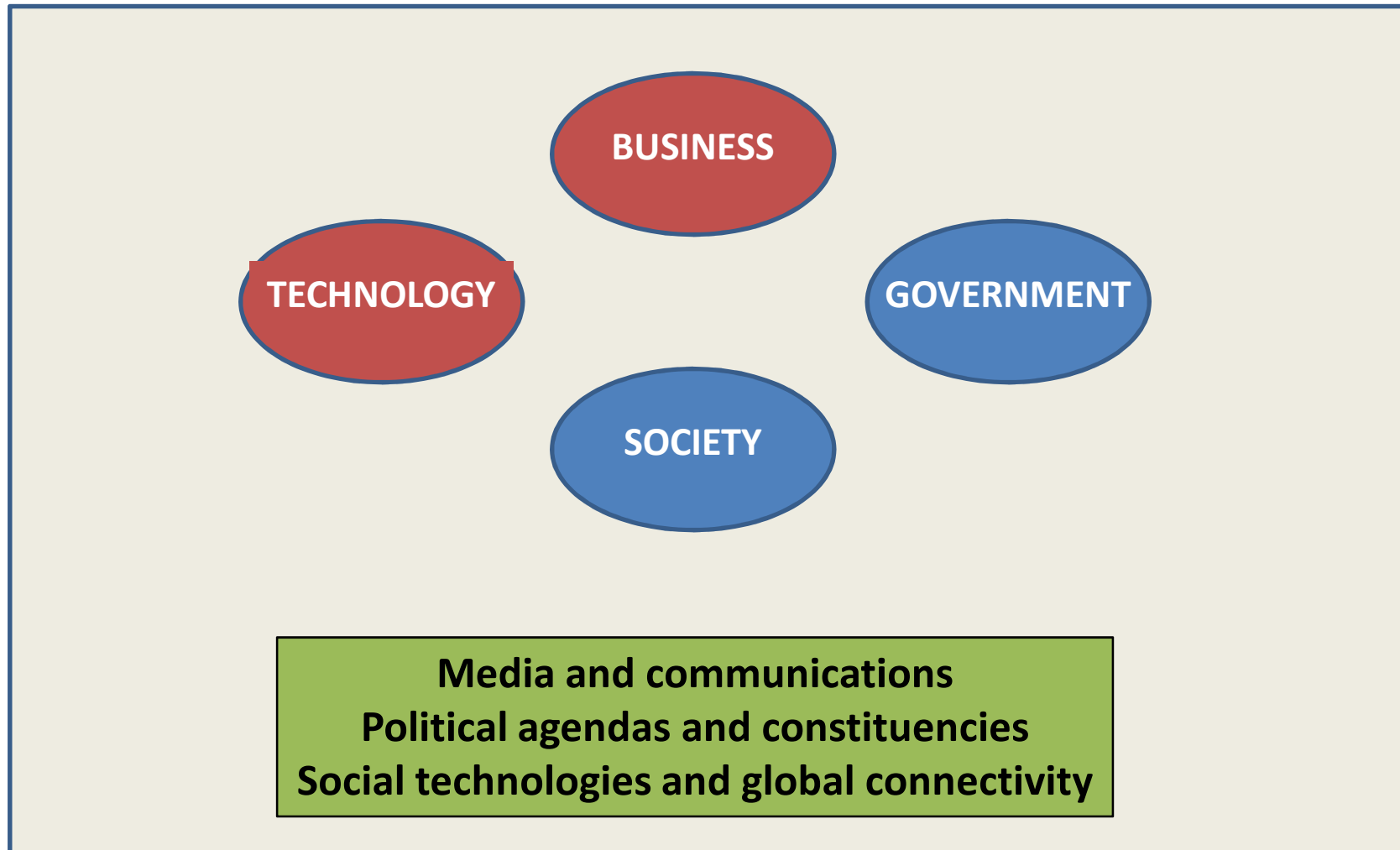
An Energy System Model



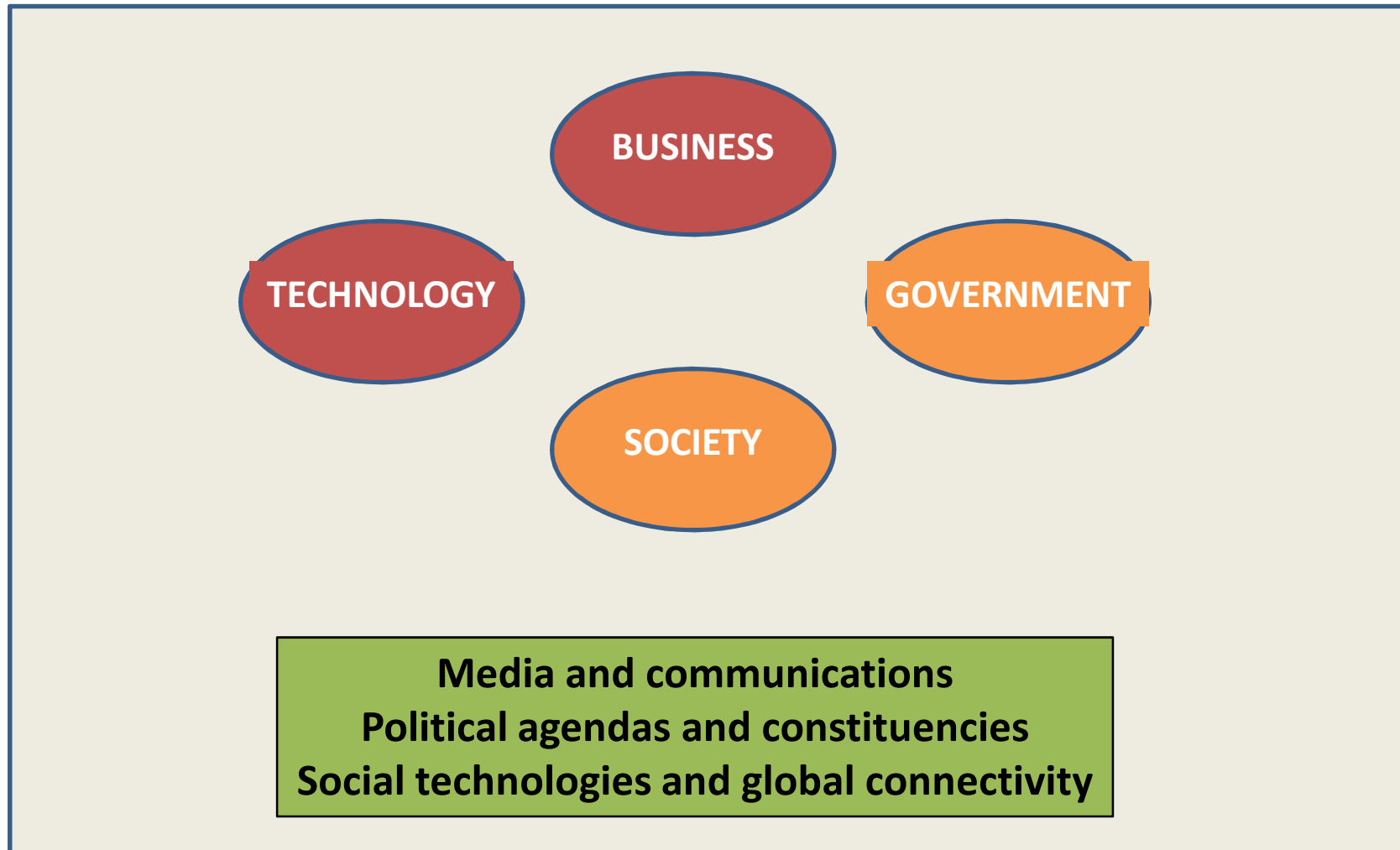
An Energy System Model



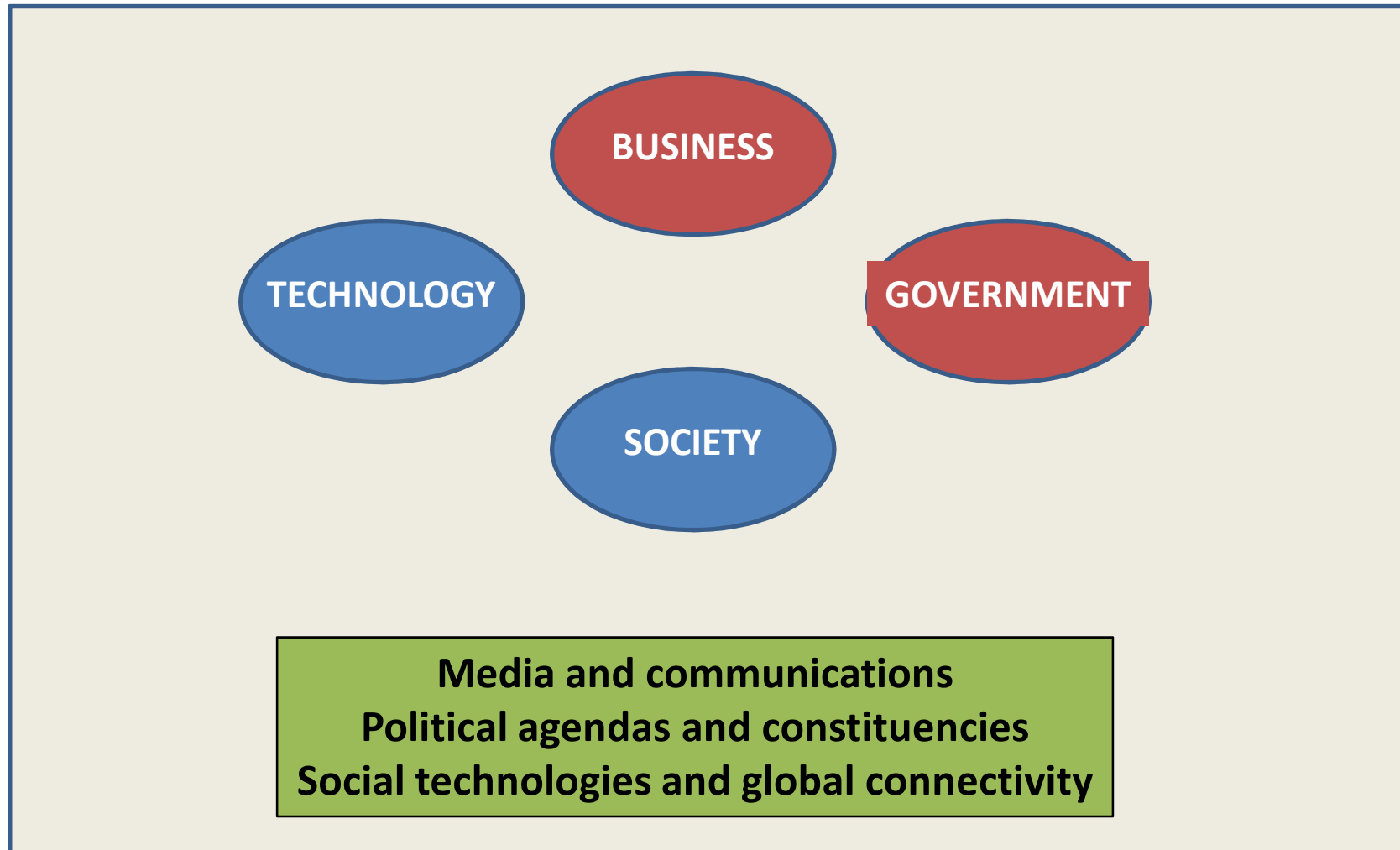
An Energy System Model: Example – Economic Risk Assessment



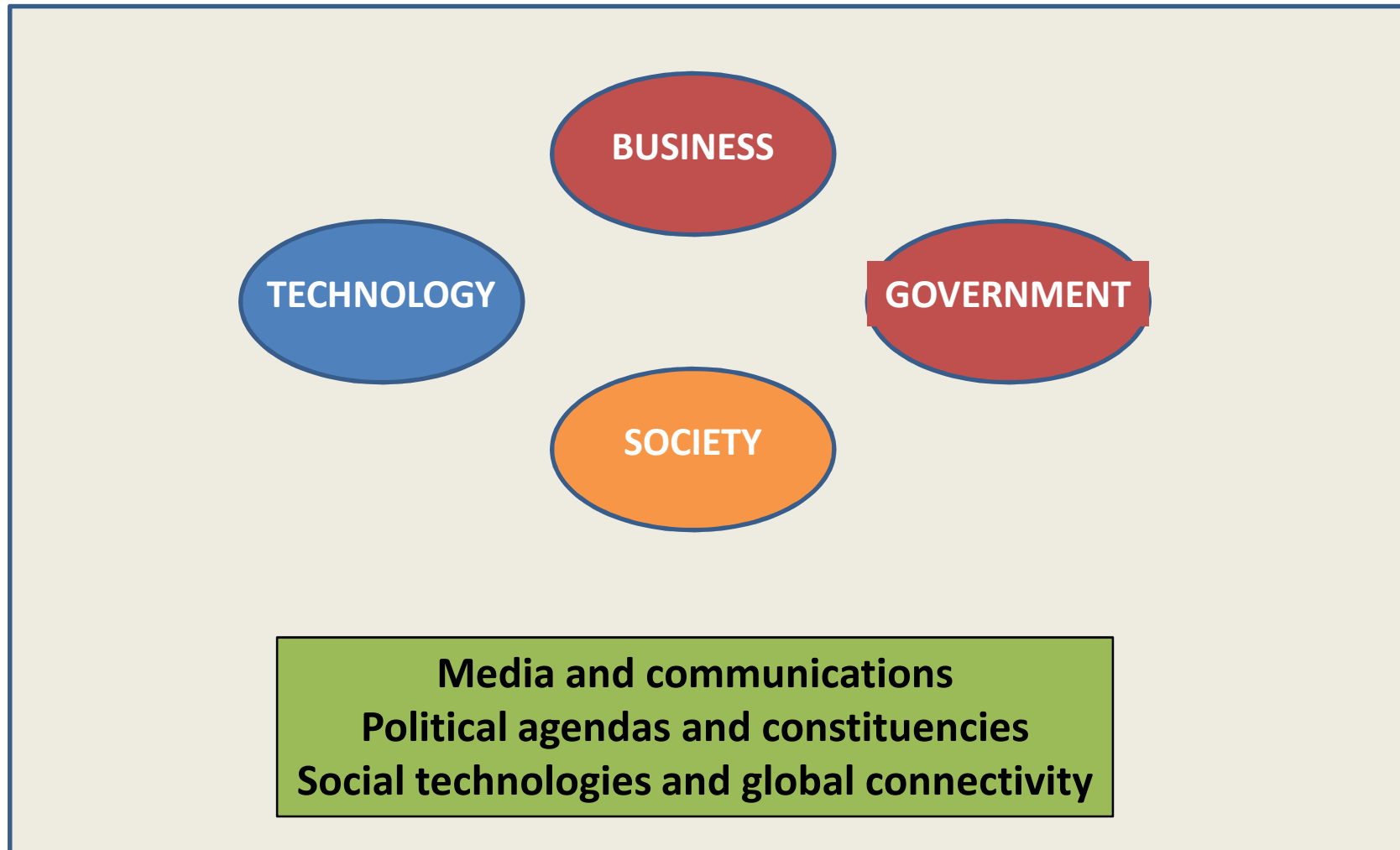
An Energy System Model: Example – Economic Risk Assessment



An Energy System Model: Example – Land Use / Permitting

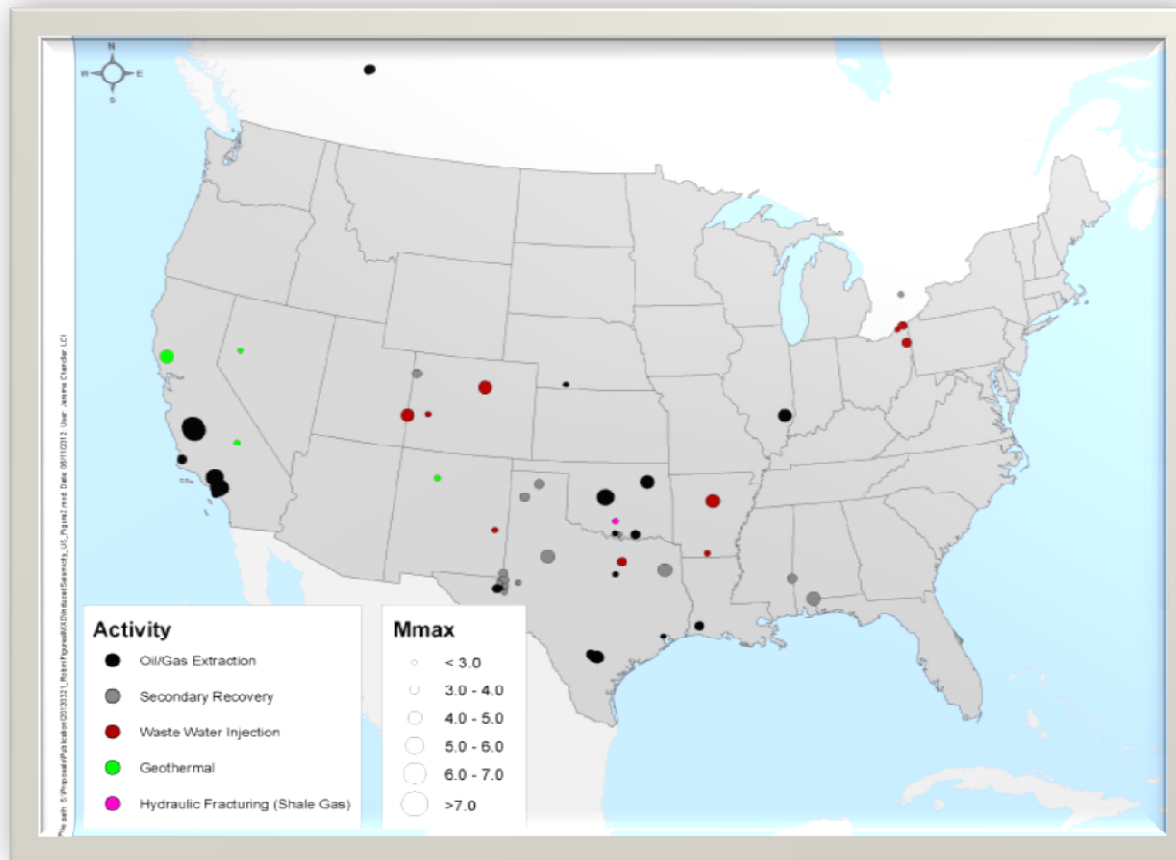


An Energy System Model: Example – Land Use / Permitting

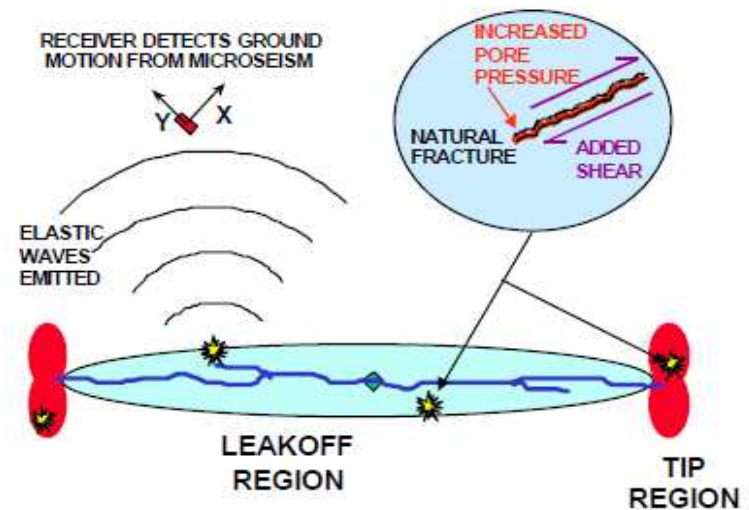
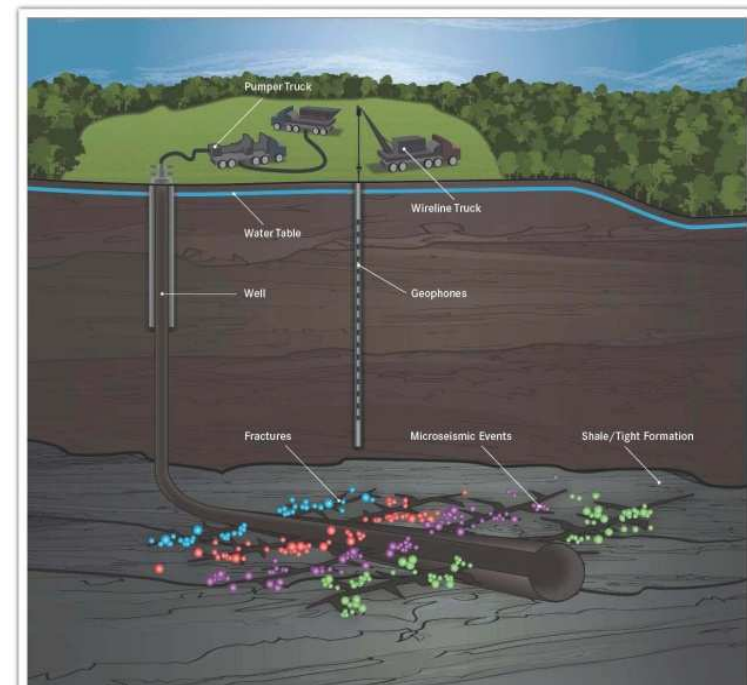
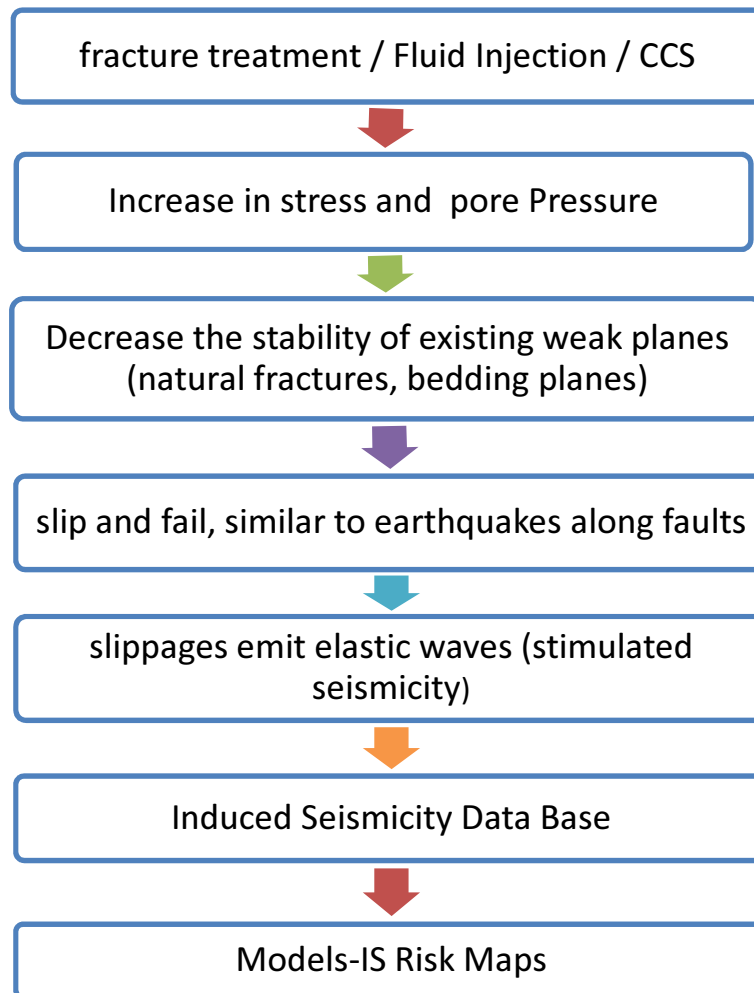


A Science-based Framework: Documented Induced Seismicity of Energy Related Operations (ERO)

- Seismic events have been measured and felt at a limited number of energy development sites in the United States.
- Seismic events caused by or likely related to energy development have been documented in Alabama, Arkansas, California, Colorado, Illinois, Louisiana, Mississippi, Nebraska, Nevada, New Mexico, Ohio, Oklahoma, and Texas

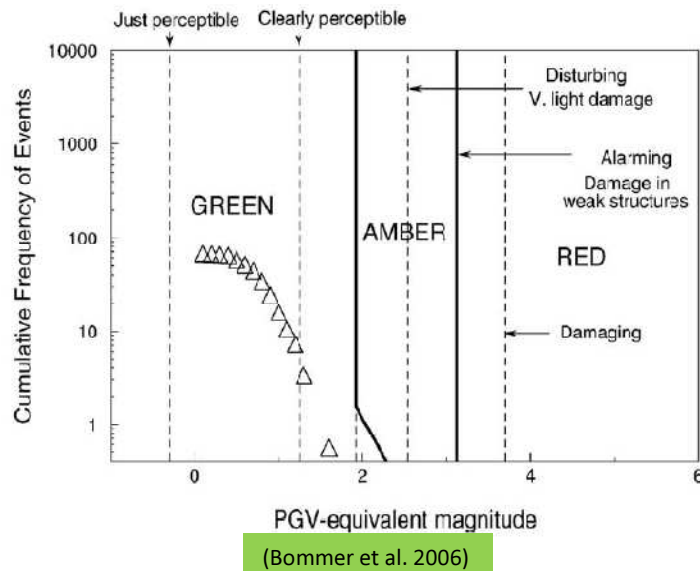


A Science-based Framework



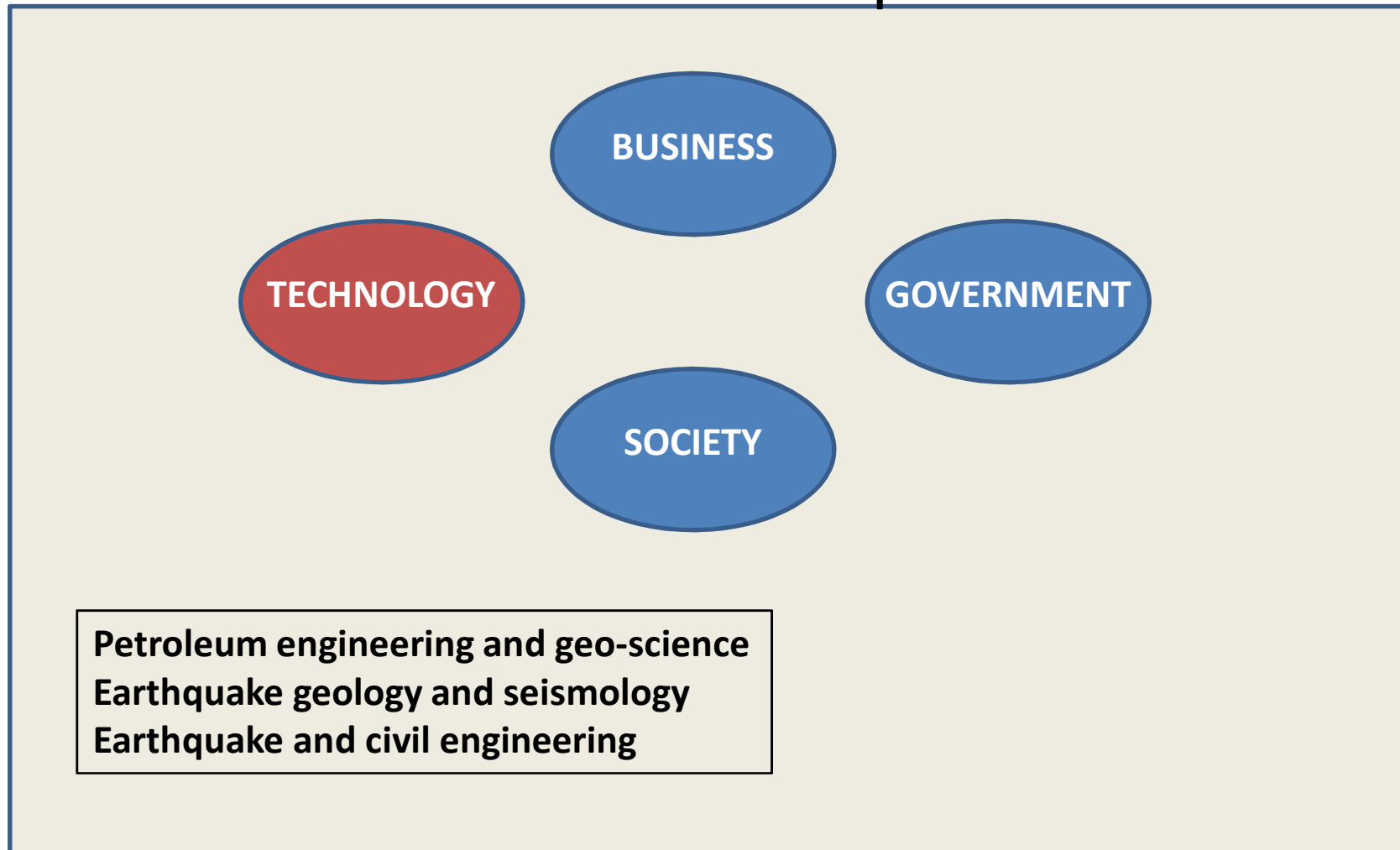
A System to Control the Hazard Associated with Induced Seismicity

- The monitoring system comprises of seismograph network, strong motion accelerographs and a center to gather the whole data on a real-time basis.
- A real-time data acquisition system would be a beneficial tool to address hazard issues associated with tectonic activities of faults
- Ground movements caused by induced seismicity can be monitored and managed dynamically

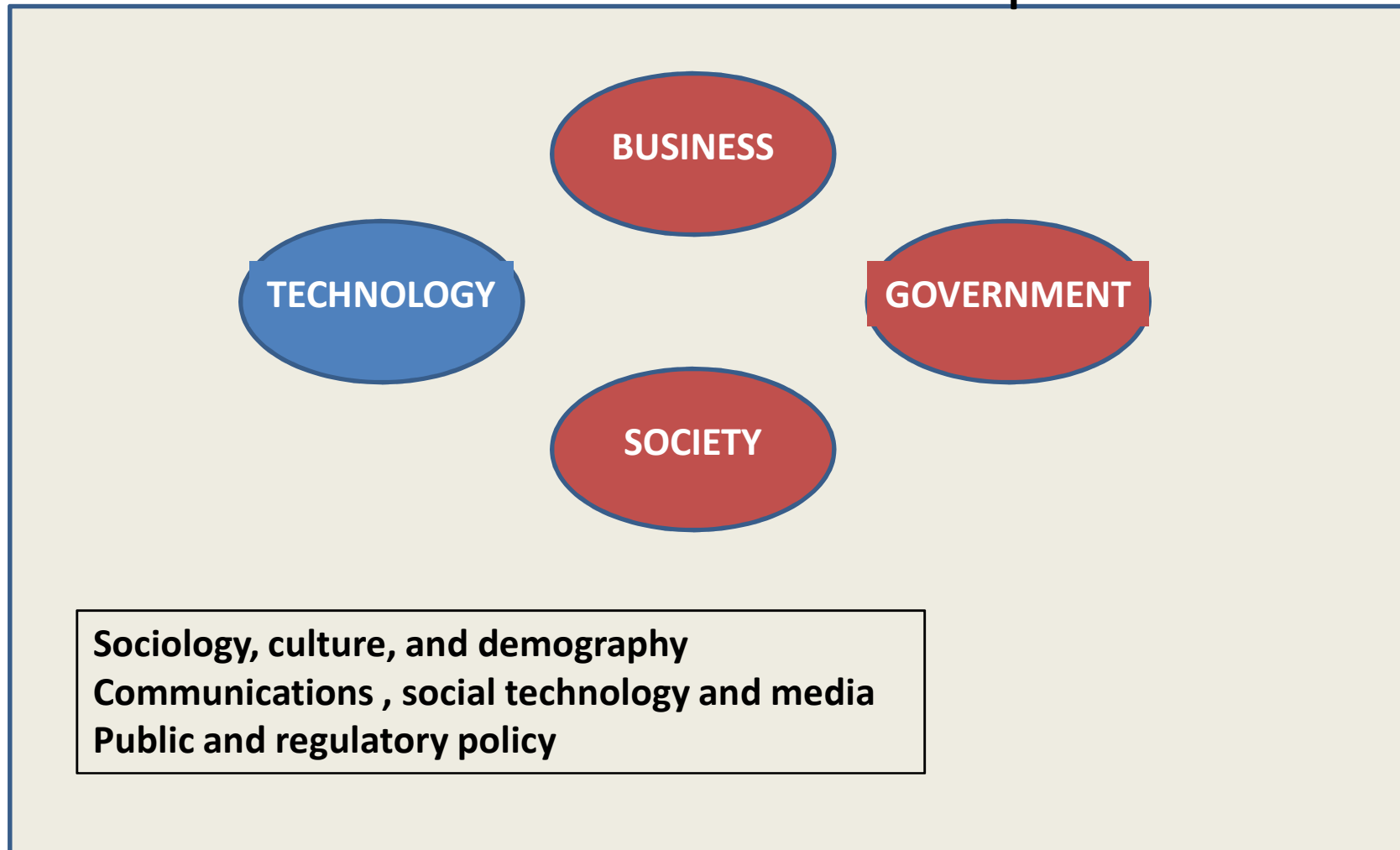


- **Red Zone - Stop the injection process because of the high hazard potential of the accompanying seismic activities**
- **Amber Zone- Make adjustments in operational parameters since the level of IS reaching the thresholds which are sensed by human or potentially dangerous to structures.**
- **Green zone: Continue the injection process , the HF process and all the elements of system are perfectly in operation.**

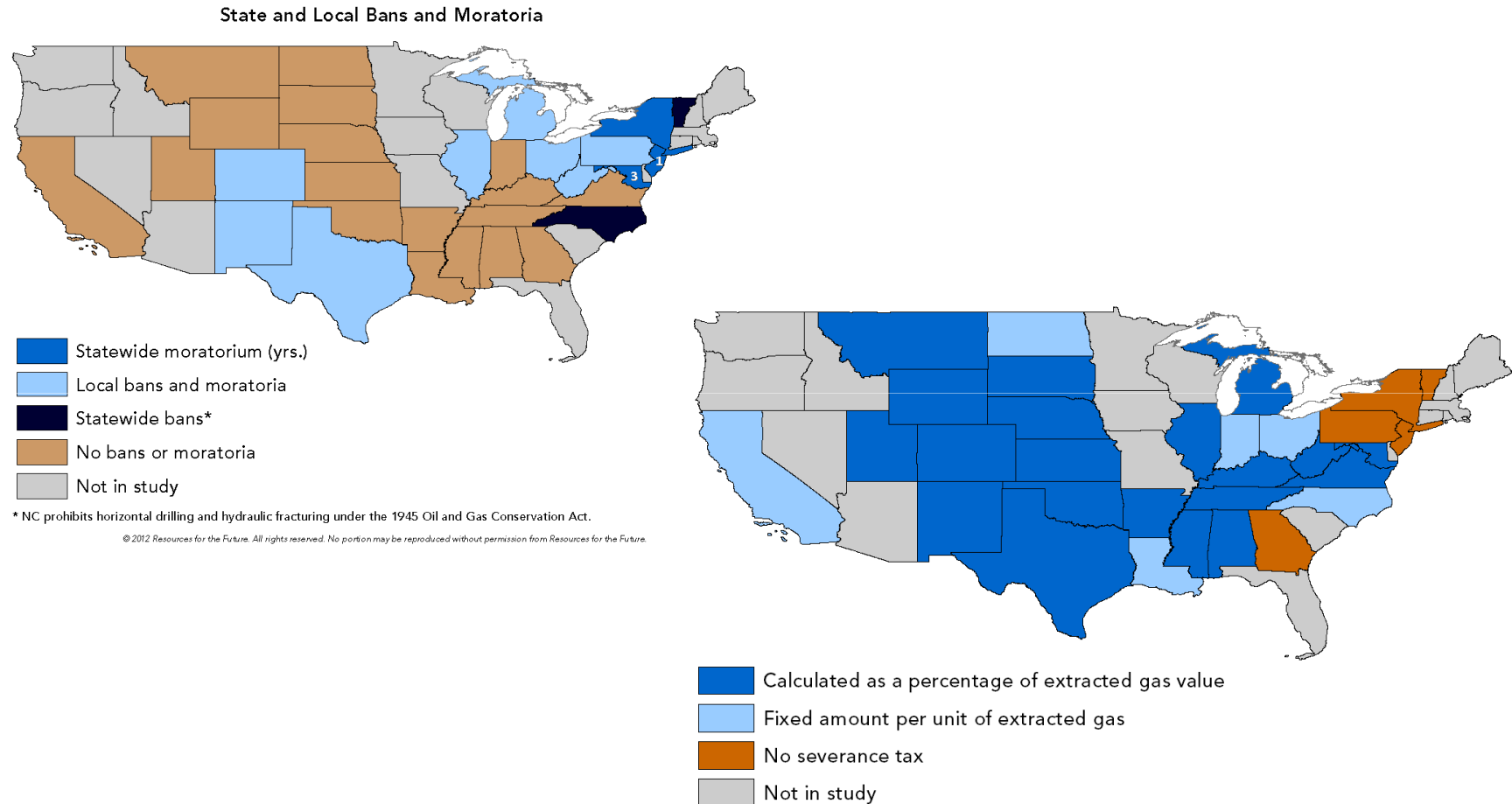
An Energy System Model: A Science-based Framework requires a combination of competencies



An Energy System Model: A Sociological Framework requires a different combination of competencies



Regional sociological, cultural, and historical differences influence regulatory and tax environments



http://www.rff.org/centers/energy_economics_and_policy/Documents/Shale_Maps/shale_maps_master.pdf

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USC Induced Seismicity Consortium (ISC)

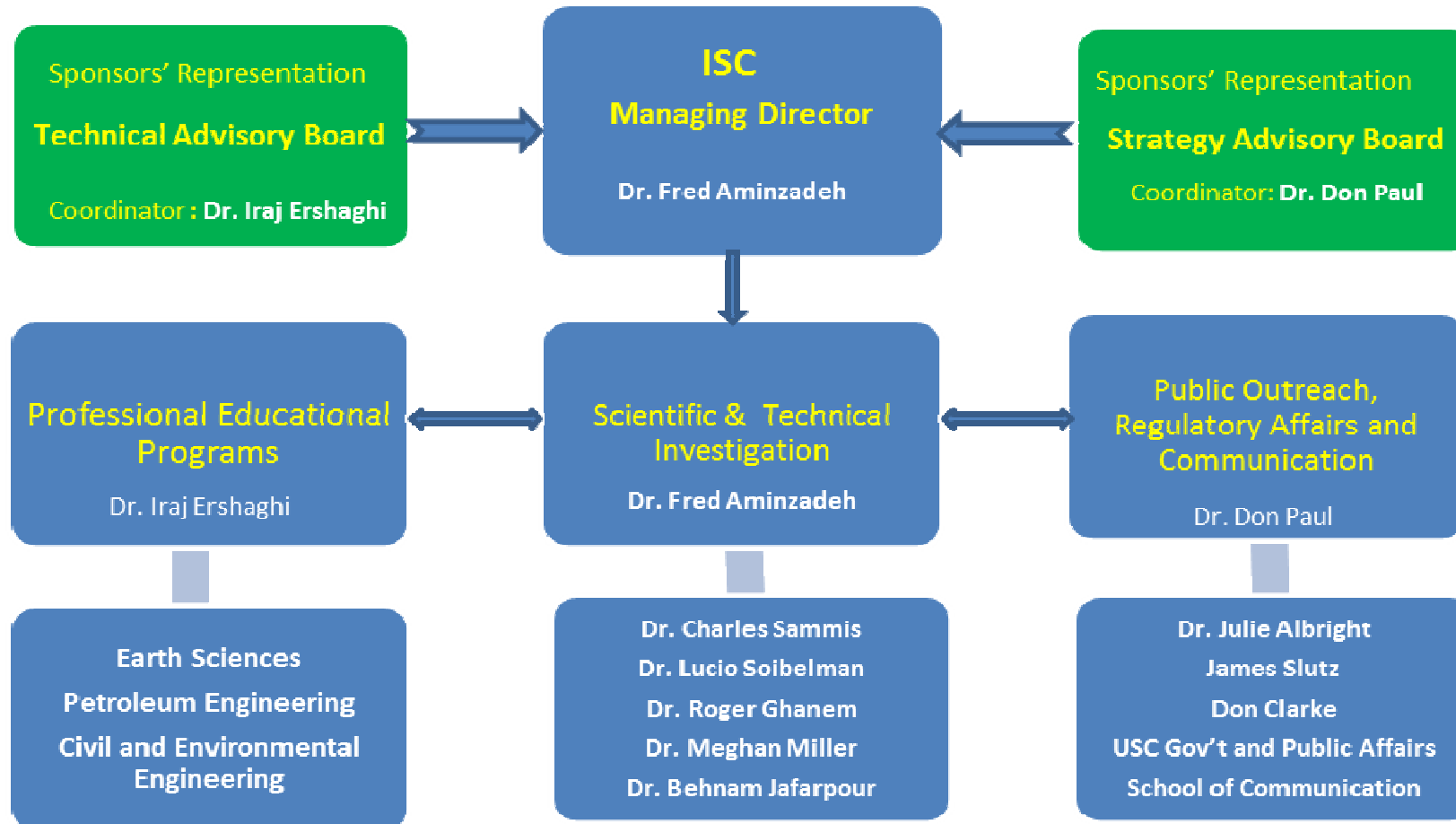
The Induced Seismicity Consortium will focus on the risk assessment of induced seismicity in connection with HF, WD and CCS. The goal is to develop IS hazard probability and deliver an effective science-based roadmap for best operational practices, policy decisions, regulatory processes, as well as public education and communication on induced seismicity in energy related activities worldwide.

From the National Research Council 2012 Report:

“To better understand, limit, and respond to induced seismic events, work is needed to build robust prediction models, to assess potential hazards, and to help relevant agencies coordinate to address them.”

➤ <http://gen.usc.edu/assets/001/81341.pdf>

USC Induced Seismicity Consortium (ISC) structure



Summary Thoughts

- Effectively managing IS issues require a system perspective:
 - Business, plus
 - Technology, plus
 - Government, plus
 - Society
- A sound science base is absolutely necessary for addressing IS issues, but is clearly not sufficient to produce an effective and responsible regulatory environment
- A sound sociological and communication framework is required to effectively engage governments, regulatory processes, and the public