



UNIVERSITY OF
CALGARY



Institute for Sustainable
**ENERGY, ENVIRONMENT
AND ECONOMY**

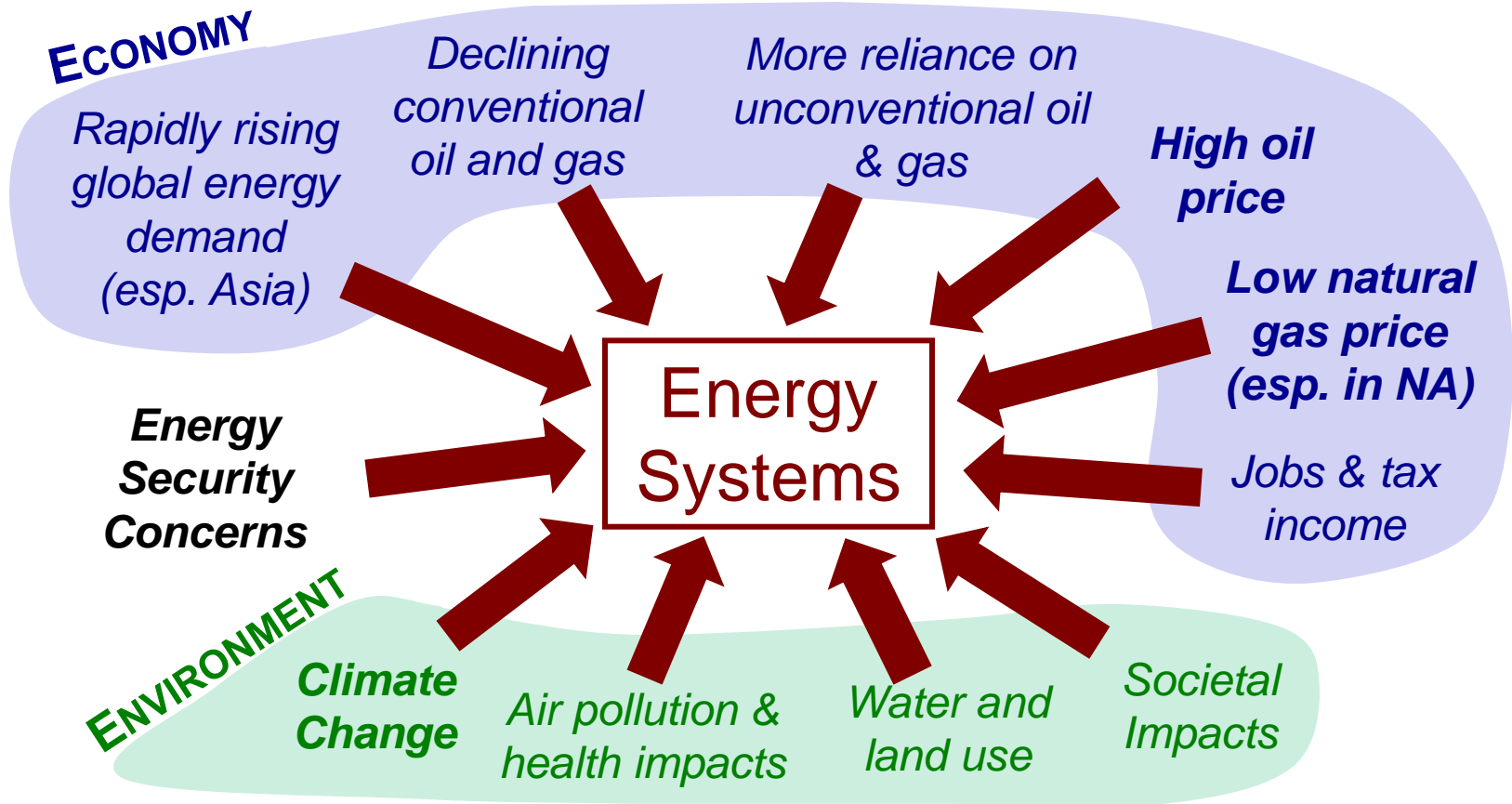
Natural Gas for Transportation

An exciting opportunity, but...

Fuel Forward: Propelling Transportation with Natural Gas
– *Calgary, AB - March 21, 2012 -*

David B. Layzell, Ph.D., FRSC, Professor and *Executive Director*
Institute for Sustainable Energy, Environment and Economy,
University of Calgary, AB Canada Web Site: www.iseee.ca

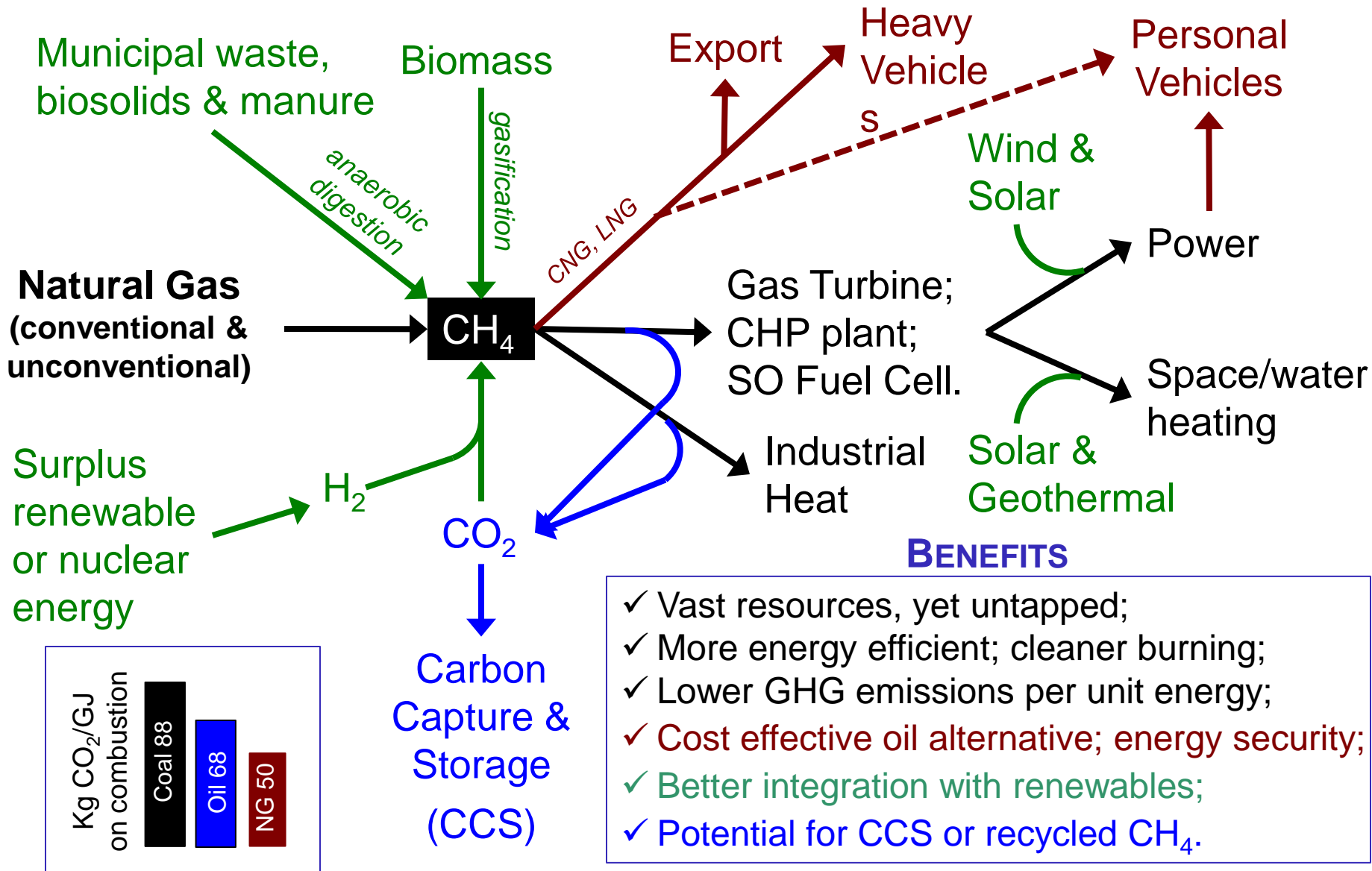
Forces for Energy System Transformation



The energy system technologies that address the most / all of these 'Forces' are most likely to move forward.

A Vision for a Methane Future

...made possible by hydraulic fracturing



BUT, Significant Environmental Concerns with Hydraulic Fracturing

Water

- Volumes used;
- Contamination of soil & ground water;
- Disposal

Air

Emissions

- Greenhouse gases (esp. CH_4)
- Smog

Earthquakes

- *Induced Seismic activity (waste water disposal)*

Land Use

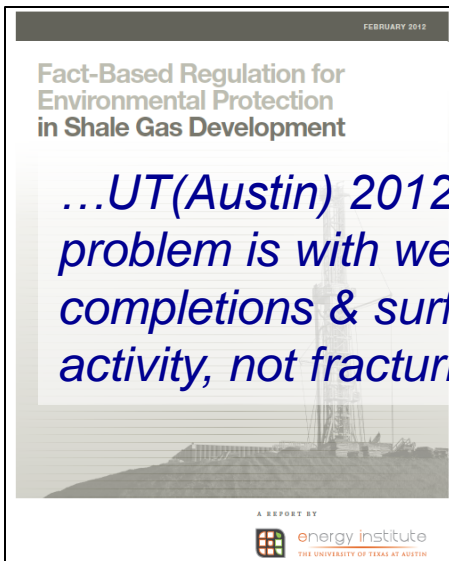
- Industrialization of agricultural lands;
- Ecosystem fragmentation (roads, pipelines, etc)

Rapidly facing & addressing these concerns will be essential for hydraulic fracturing to get the public license to operate.

Water & Earthquakes

Problem

1. Water demand & water disposal
2. Soil / ground water contamination



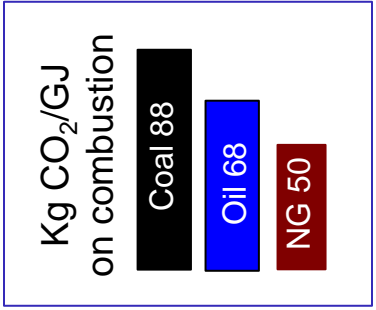
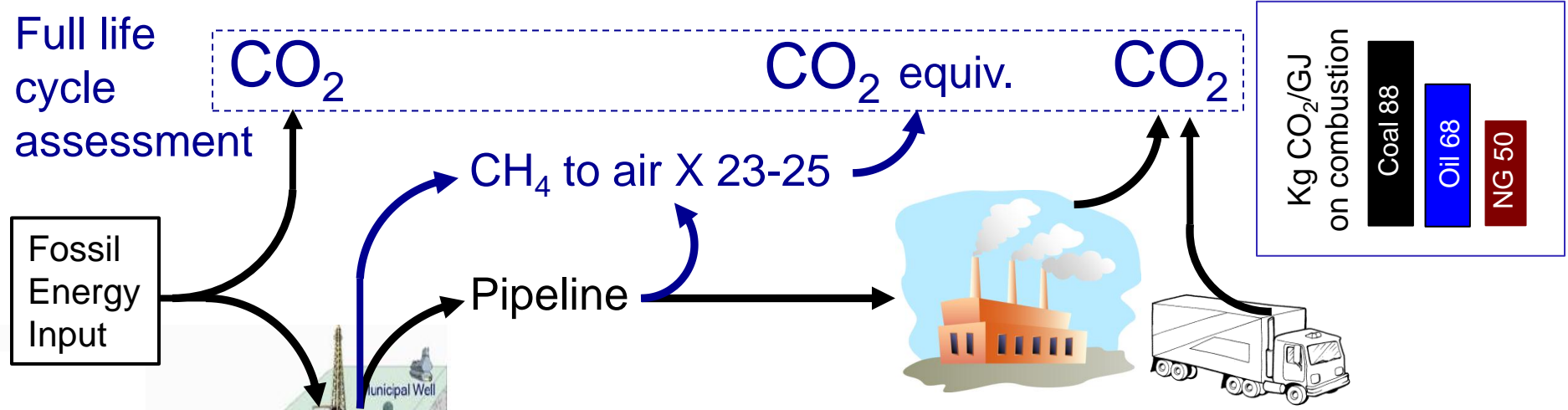
Possible Solution

- Possibly fracture with propane: No water use, less disposal.
- Enforce regulations on well completions, and surface activities etc.
- Standardize regulations across jurisdictions.
- Industry assoc'ns should weed out the 'bad apples'.
- Do baseline studies; fix problems when they occur.

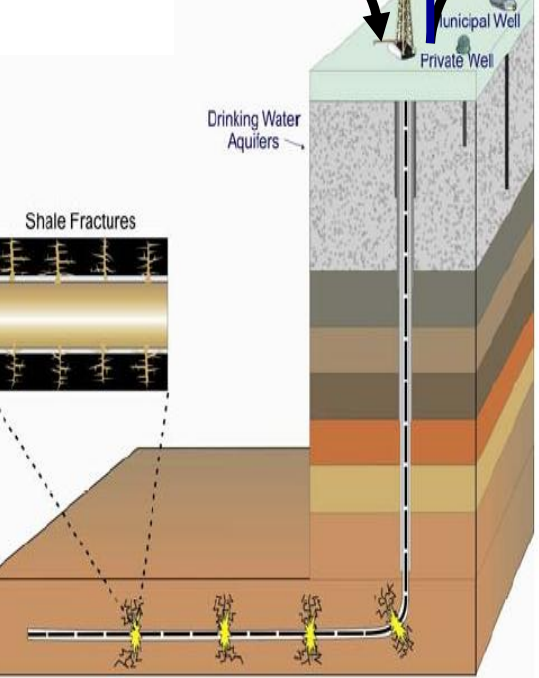
R&D Needs

- Full, independent LCA comparison;
- Improved water treatment technol.
- New measurement & monitoring tools
- Contribute to regulatory process

Greenhouse Gas Emissions



Fossil Energy Input



Hydraulic Fracturing

Most LCA work to date has been based on paper estimates:

- ✓ Wide variability
- ✓ Highly controversial

Only one study has actually measured CH₄ emissions from hydraulic fracturing...

What are the GHG Emissions Associated with Gas Operations?

Tollefson J 2012. Nature 482: 139-40 (9 Feb. 2012)

Pétron et al. 2012. J Geophys. Res. (in press)

NEWS IN FOCUS

SPACE Fission-powered spaceflight gets a boost at NASA #141
FUNDS Japanese university puts a donor's name in lights #149
DIAGNOSTIC Cystic fibrosis drug realizes 20-year-old promise #145
ETHICS The painful legacy of the Guatemala experiments #148



Natural gas operations in areas such as Wyoming's Jonah Field could release far more methane into the atmosphere than previously thought.

CLIMATE CHANGE

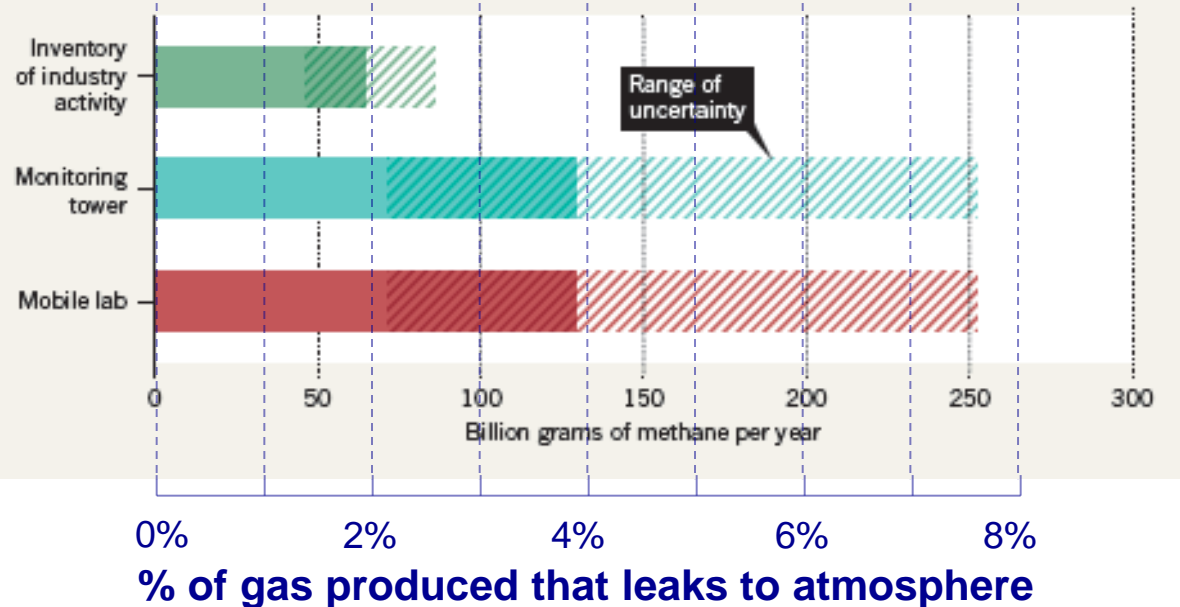
Air sampling reveals high emissions from gas field

Methane leaks during production may offset climate benefits of natural gas.

Is this Colorado field an exception or the rule??

A LOSING BATTLE

Estimates of methane losses from gas fields near Denver, Colorado, based on air sampling differ considerably from calculations based on industry activity.



- CH₄ in NG has ~23-25X the global warming potential of CO₂ (over 100 years);
- Therefore, at a ~4% leak rate, the Life Cycle GHG emissions would double, thereby eliminating:
 - NG benefit over coal for power generation,
 - NG benefit over oil for transportation

Greenhouse Gas Emissions

Problem

3. Greenhouse Gas Emissions

Possible Solution

- Capture & oxidize CH₄;
- Establish & enforce regulations on emissions to atmosphere;
- Standardize regulations across jurisdictions.

R&D Needs

- Develop technologies to reduce CH₄ to atmosphere
- Measure actual emissions from Cdn sites
- Carry out LCAs;
- Compare with other energy system choices.

There is a critical role for Universities...

...to generate the insights, tools & expertise that will provide arm's length decision support regarding energy / environment choices.

- *Costs, Benefits & Tradeoffs*

