Value of Information from the Perspective of Stakeholders: Lessons from US Shale Gas Developments

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Outline

1. Value of Information (VOI)
    a. Scientific
    b. Decision analysis

2. VOI for Consensus Building (Conflict Resolution)
    a. Among different experts
    b. Among different stakeholders
        → different perceived benefits and risk
        → different beliefs regarding the current science
        → different beliefs in accuracy of proposed new studies

3. Implications for shale gas research needs and monitoring requirements

Narratives Illustrative of Polarized Views on Shale Gas Development

Pro . . . .

Shale gas development is . . .

an innovative, well-tested technology employing subsurface hydraulic fracturing to recover large quantities of domestic natural gas, posing modest risks to the environment, public health and communities, but well-managed by the current mix of responsible drillers and operators following industry best-practices and state regulations, while providing broad economic, air quality, and greenhouse gas reduction benefits.

Con . . .

Shale gas development is . . .

an untested technology utilizing subsurface "fracking" and posing significant upstream, operational and downstream risks, implemented with inadequate safeguards and monitoring to protect against multiple contamination pathways and landscape and social disruption, with inadequate state and local capacity for regulation and oversight; and potential serious impact on long-term greenhouse gas emissions due to methane leakage and displacement or delay of low-carbon energy options.

Value of Information (VOI)

(1) Scientific

Knowledge ↑ ***(Expected) Uncertainty*** ↓

In the context of a predictive model:

- **<u>Expected</u>** improvements in model structure, parameter values, and goodness of fit
- **<u>Expected</u> reduction in uncertainty variance** of key model predictions

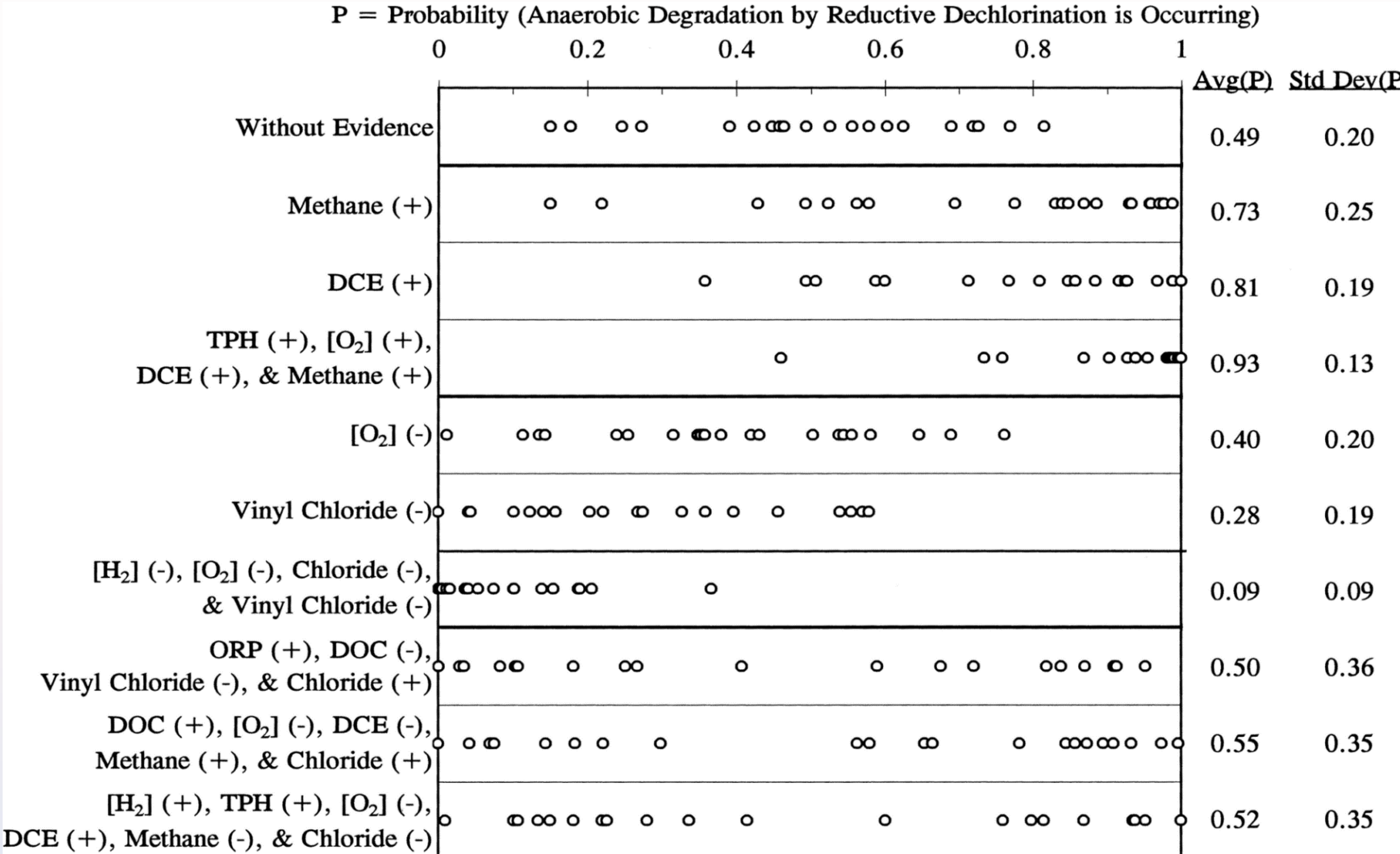
A. Effect of new studies and tests . . . .

for experts who weigh different studies and tests differently . .

A groundwater example:
Is natural attenuation occurring?

Stiber, N.A., M. Pantazidou and M.J. Small. 1999. Expert system methodology for evaluating reductive dechlorination at TCE sites. *Environmental Science & Technology*, 33(17): 3012-3020.

Effects of consistent and inconsistent evidence on posterior assessment of 21 experts:



(2) Decision Analytic VOI

Key elements of decision analysis when outcomes uncertain:

1. **Prior belief regarding the probability that different decision choices will lead to different outcomes**
2. **The ability of different findings of a proposed scientific study ("information") to modify these beliefs**
3. **The valuation of benefits and losses believed to result from different outcomes following the decision**

   →***VOI = Expected increase in value of optimal decision informed by information, compared to choice made under pre-information (prior) state***

   →***Information has value only if it can lead to a change in the decision option preferred a priori and the preferred decision changes depending on the outcome of the experiment or study.***

Most Decision Analysis - VOI studies assume

- Single decision maker with
  - Known prior beliefs regarding the different environ./econ. outcomes[decision options]
  - Known utility for different outcomes
  - Known (objective) likelihood function for scientific studies (FPR, FNR)

→ ***No clear way to compute VOI for cases with multiple stakeholders, who may have different priors, different utilities for outcomes, and different likelihood functions (different trust in competence and objectivity of science)***

A Proposed Alternative:
VOI Metric for Conflict Resolution (VOICR)

Assume: Two or more stakeholders who currently disagree regarding a preferred decision option

→ **VOICR metric = "preposterior probability of consensus"**

= PC(i) = probability that a scientific study will lead to a result that allows the different stakeholders to reach consensus on the preferred decision option

Small, M.J., Güvenç, Ü. and DeKay, M.L., 2014.

When can scientific studies promote consensus among conflicting stakeholders? Risk Analysis, 34(11), pp.1978-1994.

http://onlinelibrary.wiley.com/doi/10.1111/risa.12237/abstract

Application to Further Information Needs for Shale Gas Development

Recent studies identifying research needs

Perceived risks and benefits

Perceived trust in accuracy and objectivity of proposed studies

Recent Studies Addressing Current Shale Gas Knowledge and Needs for Additional Study

1. **US National Research Council (NRC) Committee on Risk Management and Governance Issues in Shale Gas Development**: Organized two workshops to examine the range of technical, social and decision-making issues in risk characterization and governance for shale gas development

    14/8/2014 special issue of ES&T: http://pubs.acs.org/toc/esthag/48/15

2. **US HEI Strategic Research Agenda on Potential Impacts of 21st Century Oil and Natural Gas Development in the Appalachian Region and Beyond** (15/10): http://www.healtheffects.org/UOGD/UODG-Research-Agenda-Nov-4-2015.pdf

Recent studies addressing current knowledge and research needs (Cont.)

3. **Joint US (NSF) –UK (NERC, Royal Society of Chemistry) Workshop on Improving the Understanding of the Potential Environmental Impacts Associated with Unconventional Hydrocarbons:**
http://www.nerc.ac.uk/funding/application/currentopportunities/us-ukworkshop/final-report/

4. **US EPA Study of Hydraulic Fracturing for Oil and Gas and Its Potential Impact on Drinking Water Resources (External Review Draft, 6/2015):**
https://www.epa.gov/hfstudy

Principal Risk Domains and Issues

1. Operational: mishap occurrence and detection (accidents and leakage events), induced seismicity
2. Water Quantity and Quality: source drawdown, well leakage, return flow wastewater management
3. Air Quality: local criteria pollutants and air toxics, regional ozone and PM, global methane
4. Global Climate: life cycle emissions, fuel price/substitution effects
5. Ecological: habitat & connectivity impacts, air & water toxicity
6. Human Health: worker safety, pollutant exposure and effects, stress (traffic, light, noise)
7. Community/Social: economic impacts, boom-bust cycles, equity of benefit-cost distributions, community conflict and trust

Synthesis of Hazards, Mitigation Options and Research Needs (Operational)

Risk Domain	Principal Hazards	Mitigation Options	Research Needs
1. Operational Leaks, accidents	- Low probability explosions and other accidents - Undetected leakage -Improper well closure at completion of gas recovery -Induced seismicity (wastewater injection)	- High standards for well design and construction - Maintained or improved corporate safety culture - Liability, taxes, fees, and bonds to ensure proper closure -Seismic characterization, avoidance, monitoring	-Advances in low-cost ubiquitous monitoring -Advances/standardization of SCADA* systems for automated reporting of malfunctions -Behavioral studies of factors influencing individual and firm safety knowledge and behavior

*Supervisory control and data acquisition (SCADA) is a system for remote monitoring and control

Synthesis of Hazards, Mitigation Options and Research Needs (Socioeconomic)

Risk Domain	Principal Hazards	Mitigation Options	Research Needs
7. Socio-economic	-Boom-bust economic cycles -Increased housing costs **-Impacts on preexisting local industries** -Requirement for new community infrastructure, police and social services -Uneven distribution of private benefits, costs, and externalities -Community conflict and mistrust	-Coordinated planning with community participation -Community sharing and investment of income (e.g., schools, libraries, renewable energy projects) -Transparency in operations, with all monitoring and operating data available on company or State website.	-Studies to evaluate the extent of sustainable capture of wealth by drilling communities **-Long-term studies of shifts in local economies and sectors** -Long-term studies of community impacts and responses, including support for active participation of communities in these studies

Comprehensive Development Plans

Proposed Maryland Regulation Requiring Comprehensive Gas Development Plan (CGDP)

- **5-year plan for the locations of all planned well pads, roads, pipelines and supporting facilities.**
- **Reviewed by state (MDNR and MDE) and local agencies to ensure compliance with all location requirements . . . planning tools provided**
- **Extensive baseline monitoring**
- **Required public participation program**

May be implemented, maybe not . . . .

Application of Conflict Resolution Approach to Decision Support for Shale Gas?

→ **Location specific (action research)**

→ **As part of a Comprehensive Gas Development Plan?**

→ Stakeholders elicited for their current beliefs regarding

-benefits, costs, risks and risk management needs
-key uncertainties that should be resolved
-their perception of the ability of current and proposed science to reduce these uncertainties
-relative valuation of benefits and losses associated with alternative outcomes

→ **Opportunities for benefit and cost sharing in CGDP?**

Take Aways*

- Progress made in understanding the risks and effective risk management for shale gas development
- Key areas of technical, economic and social impact uncertainty remain
- In many cases we are "learning by doing" . . . OK, but not adequately institutionalized in terms of information collection, sharing and utilization
- Comprehensive shale gas development plans provide promise, recognizing need to:
  - address distribution of (real and perceived) benefits, costs and risks; and
  - active stakeholder participation to identify and conduct studies with high information value (conflict resolution)

* Not to be confused with "Flybuys"