Approaches to Risk & Portfolio Analysis:
A Work In Progress

Risk Working Group
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DRAFT; WORK IN PROGRESS
Frameworks

- Projects ➔ Programs ➔ Offices ➔ Departments ➔ WH ➔ Congress

- Components ➔ Technologies ➔ Systems ➔ Markets ➔ Economy

- R&D Risk Elicitation ➔ Technology Model ➔ Economic Model

- Strategic Vision: Transportation; Industry; Buildings; Power

- Doing the Right Things.

- Doing Things Right.
Why Do Risk Analysis?

• **EERE supports R&D in a wide variety of technologies:**
  – How useful are those investments in advancing the particular technology?
  – What is the likelihood that current budgets/R&D pathways will achieve their goals?
  – If the project’s budget or schedule changes, how will results change?

• **Where should the next dollar of R&D investment be made?**
  – What are the best R&D pathways to pursue to achieve program/portfolio goals?
  – What are realistic estimates of the resources required for the R&D?
  – When should R&D investment be cut, or alternative pathways explored?
  – What are the risks/consequences of NOT investing in a research pathway?
  – To increase the likelihood of success, is it better to do (1) fewer projects with more resources or (2) a wider range of projects? Under what circumstances?
  – What is the “right” level of investment in a technology system?
  – What is the potential impact of basic science R&D on achieving goals?

• **How should the R&D budget be allocated across programs? How should a portfolio be balanced over risk, return, time, technologies, markets?**

• **How can scoring of risk be made reasonably consistent across projects, programs, portfolios, markets, experts, over time?**
  – How can this be validated? Are the results repeatable, auditable?
  – How can gaming/bias in risk estimates be identified, controlled, minimized? Who should do the risk analysis? How should they be identified, selected?
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• **How can actionable information be developed?**
Potential Value-Added

• Improve Project, Program, and Corporate Portfolio design, performance, and likelihood of success.

• Clarify issues associated with accepting, managing, or rejecting risks:
  – Clarify technology cost and performance goals.
  – Frame the range of the possible; constrain the imposition of arbitrary “stretch” goals.

• Quantify the risks/benefits of pursuing additional research paths at critical bottlenecks:
  – Contributes to the case for appropriate levels of R&D funding.

• Link science research opportunities with applied energy R&D.

• Increase decision-maker confidence in the work.

• Assist private sector involvement in RDD&D.
Background

OSTP
• PCAST
  – Anchored Scales; challenges of framework; baselines; etc.

DOE
• Literature Review and Interviews.
• Review of Industry and Agency Best Practices.
  – Identified quantitative, physically base-lined approach from wind program
• Conducted initial pilot studies and experiments.
• Programs conducted pilot studies.
  – Pilot test using outputs of Program R&D Risk Analyses in NEMS, MARKAL, SEDS.
• Programs conducting analyses of key R&D activities.
  – Outputs of Program R&D Risk Analyses for NEMS, MARKAL, SEDS.
• Re-Drafting Risk Guide; next--external peer review.
Current Risk & Benefits Analysis

- For GPRA benefit estimates based on R&D Goals, if there is no treatment of risk and uncertainty in attaining R&D outputs and outcomes, then this raises the possibility that the “Best Goal” wins in comparisons.
  - Consideration of risk changes benefits estimates, re-orders comparisons.
  - Consideration of risk highlights importance of balanced portfolio of R&D.

- Goals and milestones may be set without sufficient consideration of bottom-up technical estimates—sometimes driven by long-term political desirability, or “stretch goals that are not funded; milestones sometimes set on the basis of near-term ability to meet tracking requirements. The establishment of goals is not done consistently across programs.

- Review of program goals found some at the high end of their estimated range—stretch goals!
Goals/Design of Risk Analysis

• GOALS:
  – Provide Risk Analysis methodologies and tools that are useful to Staff, Team Leaders, Program Managers, and Portfolio Managers in systematically identifying, quantifying, evaluating, managing, monitoring, documenting, and communicating technology development risks and benefits, and in assisting project, program, and portfolio decision-making that aligns and balances the portfolio with strategic goals.

• METHODOLOGY DESIGN:
  – Provide value to and support decision-making by project leaders, program managers, and portfolio managers.
  – Provide scalable methodologies and tools for risk analysis that can be rolled up or drilled down as needed to enable consistent comparisons of risks across projects and programs.
  – Recognize and minimize biases, both internal and external.
  – Analyze and document risks in a manner that is objective, credible, fair, transparent, and auditable with all important assumptions and uncertainties clearly identified.
  – Minimize the cost of conducting risk analyses.

• PROPOSED MINIMUM PERFORMANCE REQUIREMENTS:
  – Risk analyses of key (critical path) program elements every two years
Representative Risks

- **Technical**: whether the technology meets specified levels of performance, reliability, cost, etc. due to scientific or technical limitations.
  - **Environment/Health/Safety**: whether a technology meets requirements.

- **Budget-Cost**: whether the R&D is completed at the planned budget.

- **Schedule**: whether program milestones or goals are met on schedule.

- **Market**: whether a technology that meets its goals is accepted in market.

- **Managerial/Organizational**: whether contractor management is effective in operations.
- **Financial/Economic**: whether a technology finds financial support; suffers economic shifts.
- **Political/Strategic**: whether R&D receives political support or provides strategic value.
R&D Risk Analysis

• Identify Technology Improvement Opportunities (TIOs).
• Select/characterize Technology Performance Measures (TPMs).
• Select external experts and estimate TPMs for the TIOs.
• Develop/Run Engineering-Economics Model for the energy system.
• Develop/Run risk-adjusted benefits model (Logit/SEDS) for system.

• **Baseline:** TIO TPMs (e.g. cost, performance, lifetime, O&M, reliability, etc.) in the future without public R&D
• **Probability of Advance:** The probability that the R&D will be successful in advancing the technology.
• **Triangular Distribution:** The triangular distribution of the TPMs that the technology advances to if the R&D is successful: (90%/Most Likely/10%)
• **Budget:** The needed and planned research budget and the triangular distribution of the expected earmark-free budget: Planned Budget; Low/Most Likely/Large Budget
• **Schedule:** The planned schedule for the planned research budget and the triangular distribution for the expected time required to achieve the R&D for the planned budget.

• **Scalability!**
Estimating R&D Risk distributions

- Technology Goals may be set with insufficient information on how challenging the goal will be to achieve, e.g., is the goal at #1 or #4 below? Different programs may set goals with different but unspecified levels of optimism. Cross-program interpretation is difficult.
- “Riskiness” of R&D performance improvement reflects in part how aggressive the Goal is. Technical risk for the same R&D project is higher for Goal 4 than for Goal 1.
- External experts estimate distribution of potential outcomes at different technology levels.
- Costing of R&D, as well as, in some cases, costing of technology.

![Graph showing the probability of occurring improvement from reference baseline to goal with easy and hard levels.](image)
Quantitative R&D Risk: Outputs
(illustrative values only)
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(illustrative values only)

- Risk Distribution
  - Likelihood of success
  - Risk of mission failure
  - Impacts of budget on schedule
  - Cumulative Risk

- Tornado Diagram Sensitivities
- Parallel Path Analysis
- Competitive? Market Impact?
Step 2: Define technology performance measures (TPMs) to assess, map their relationship to TIOs and associated R&D activities
  
  (Trade-off of link to physical baseline; complexity)
  
  (Scalability)

<table>
<thead>
<tr>
<th>EXPLORATION</th>
<th>RESERVOIR ENGINEERING</th>
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<tbody>
<tr>
<td>(hydrothermal &amp; EGS)</td>
<td>1. Well Stimulation Cost</td>
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<tr>
<td>1. Non-Well Exploration Costs</td>
<td>2. Production Well Flow Rate</td>
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<tr>
<td>2. Exploration Well Success Rate</td>
<td>3. Thermal Drawdown Rate</td>
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<table>
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<tr>
<th>WELL CONSTRUCTION</th>
<th>ENERGY CONVERSION</th>
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<tr>
<td>2. Production Pump Cost</td>
<td>2. Binary System O&amp;M Cost/Yr</td>
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<tr>
<td>4. Pump Horsepower</td>
<td></td>
</tr>
<tr>
<td>5. Wireline Tool Temperature</td>
<td></td>
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<tr>
<td>6. Permanent Equip. Temperature</td>
<td></td>
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<tr>
<td>7. Zonal Isolation Pressure</td>
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<tr>
<td>8. Zonal Isolation Temperature</td>
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*EGS Enabling Technologies
RISK ANALYSIS SCOPE – CSP Power Tower

a. Parabolic Trough & Power Tower- with 6 hours Thermal Energy Storage
b. Power Tower w/no Storage for side case analyses. Not in SEDS/NEMS distributions.

- 3 timeframes:
- 3 budget scenarios:
- Tech Breakout: Solar Field, Receiver, Working Fluid, Thermal Storage, Power Block, O&M.

Power Tower
1. Solar Field Cost & Performance (C&P)
2. Receiver C&P
3. Heat Transfer Fluid System C&P
4. Thermal Energy Storage C&P
5. Power Block & BOS C&P
6. Operations & Maintenance C&P

Scalability!
• **Total System Cost for Target funding level**

<table>
<thead>
<tr>
<th>Total System Cost ($/kW)</th>
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<tbody>
<tr>
<td>0.0%</td>
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<tr>
<td>0.0%</td>
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<tr>
<td>3.0%</td>
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<tr>
<td>31.5%</td>
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| 5.0%                      |
| 100.0%                    |
| 97.0%                     |
| 68.5%                     |

Values in Thousands

Current

2010

2015

2020
Total System Cost by Funding Level

<table>
<thead>
<tr>
<th>Funding Level</th>
<th>2010 Distribution</th>
<th>2015 Distribution</th>
<th>2020 Distribution</th>
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<tbody>
<tr>
<td>0.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>91.8%</td>
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<tr>
<td>8.2%</td>
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Inclusion of risk & uncertainty allows metrics to be put into comparable levelized technology cost & performance.

**Aggressive 2025 Goal Example** – less than XX% chance to achieve or do better than this value with **overtarget** R&D funding.

**Moderate 2025 Goal Example** – about XX% chance to achieve or do better than this value with **target** R&D funding.
Scale Example

36 technologies

4.5 av. quantities (TPMs) per technology, e.g.
  – Efficiency (%)
  – Capital cost ($/KW)
  – O&M cost ($/KW-y)
  – Capacity factor (%)

3 Program funding levels
  – Base: no DoE funding
  – Target: Current plan
  – Overtarget: 2 x target

2 goal years
  – E.g. 2015 and 2025

4 parameters per distribution
  – Probability of Advance (POA)
  – 10th percentile
  – Mode (most likely)
  – 90th percentile

XX experts

1304 quantities to assess
  (technologies x TPMs x Programs x goal years)

XX total assessments
  (quantities x experts)
Some challenges

- Proprietary concerns; competitiveness;
- Misuse of results & Program Risk; Personnel limits/overheads
- Establishing a consistent protocol among risk analysts and facilitators
- Finding and training enough qualified risk analysts and facilitators for such a large scale of the expert elicitation
- Selecting the appropriate level to evaluate TIOs-TPMs for assessment.
- Assessing and treating probabilistic dependence within TIOs and subsystems, over time, and between technologies.
- Avoiding motivational bias: Many US experts have or may hope to obtain DOE funding.
- Parsing costs, projected costs, learning curve costs, commodity price changes; etc.
- Limited pools of experts. Getting the most knowledgeable experts, especially from industry. In many fields, much cutting edge R&D is outside the USA.
- Clearly/consistently communicating definitions and application of methodology
- Correlation.
- Assessing learning by doing (LBD) after last goal years.
Deterministic Goal-based LCOE
Risked LCOE
Consumer Expenditures by Scenario

- BAU
- EIA CO2 Tax
- Double CO2 Tax
- High Oil Price

*0% discount rate used
Change in Capacity in 2030 due to R&D
NPV of Consumer Savings (2012-2030) due to R&D

• Discount rate of 3% used to calculate NPV
Savings to Investment Ratio (2012-2030)

- \( SIR = \frac{\text{NPV of Consumer Savings}}{\text{NPV of R&D}} \)

\((3\% \text{ Discount rate and 20 years of funding})\)