Methods for Developing Robust Climate Adaptation Plans in the Energy Sector

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Uncertainty underlies almost every aspect of climate adaptation planning

• How might the **climate** change?

• How might **other uncertain drivers** interact with climatic changes to impact society?

• How can we evaluate **many potential futures** objectively?

• How do we **balance across many objectives**?

• How do we **support public dialogue** over choices?
Traditional decision methods are fine if we don’t face much uncertainty

“Predict Then Act”

What will future conditions be? → What is the best near-term decision? → How sensitive is the decision to the conditions?

Works well when future:

• Isn’t changing fast
• Isn’t hard to predict
• Doesn’t generate much disagreement
Traditional decision methods can backfire in deeply uncertain conditions

- Uncertainties are underestimated
- Competing analysis can contribute to gridlock
- Misplaced concreteness can blind decisionmakers to surprise

Source: http://goo.gl/eG91C1
Planners require *innovative analyses* that *support deliberations*.
New methods work better under deeply uncertain conditions by running the analysis backwards.

“Predict Then Act”

What will future conditions be? → What is the best near-term decision? → How sensitive is the decision to the conditions?

Decision Making Under Uncertainty

Proposed strategy → Identify vulnerabilities of this strategy → Develop strategy adaptations to reduce vulnerabilities.
Analytic, interactive decision support tools facilitate new conversations between decisionmakers.
This approach has been applied across the globe…

See: www.rand.org/jie/centers/water-climate-resilience.html
...and across many different settings

Water Resources Planning

Community Resilience

Coastal Resilience

Flood Risk Management
The Colorado River Basin Study (2012) used this approach to evaluate climate vulnerability and adaptation options.
The Colorado River Basin is a vital natural resource

- Provides water and power for 40 million people in 7 states and 22 tribes
- Supports billions of dollars in economic activity annually
- Irrigates 15% of U.S. crops
- Is the lifeline for 24 national parks, wildlife refuges, and recreation areas
Climate change and other trends threaten its successful management

Source: US Bureau of Reclamation, 2012
Robust Decision Making supported evaluation of vulnerabilities and robust strategies

1. Decision Structuring
2. Case Generation
3. Vulnerability Analysis
4. Tradeoff Analysis

New options

Descriptions of key vulnerabilities

Robust strategies
Decision structuring: decision stakeholders work to define objectives/parameters

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Descriptions of key vulnerabilities
New options
Robust strategies
XLRM framework organized the analysis

<table>
<thead>
<tr>
<th>X: Uncertain factors and scenarios</th>
<th>L: Options and strategies</th>
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<tbody>
<tr>
<td>• Demand scenarios (6)</td>
<td>• Representative options (40)</td>
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<tr>
<td>• Supply scenarios (4)</td>
<td>- Demand reduction</td>
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<tr>
<td>• Observed resampled (103 traces)</td>
<td>- Supply augmentation</td>
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<tr>
<td>- Paleo resampled (1244 traces)</td>
<td>• Dynamic portfolios (4)</td>
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<tr>
<td>- Paleo conditioned (500 traces)</td>
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<td>- Downscaled GCM projected (112 traces)</td>
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<td>• System operations scenarios (2)</td>
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<tr>
<th>R: Relationships or models</th>
<th>M: Performance metrics</th>
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<tbody>
<tr>
<td>Colorado River Simulation System (CRSS)</td>
<td>Indicator Metrics</td>
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<td></td>
<td>- Water delivery (5)</td>
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<tr>
<td></td>
<td>- Electric power (3), Recreation (11), Ecological (5), Water quality (1), and Flood control (1)</td>
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Case generation: evaluate strategy in each of many plausible futures

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Robust strategies

Descriptions of key vulnerabilities

New options
We evaluated thousands of plausible futures

Key inputs: Strategy and plausible assumptions about future conditions

Each element shows performance of a strategy in one future
Vulnerability Analysis: Mine the database of cases to describe descriptions of key vulnerabilities

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Robust strategies

Descriptions of key vulnerabilities
Scenario discovery identified Upper Basin vulnerabilities

- Long Term Average streamflow < 13.8 MAF
- 8-year dry spell with average streamflow < 11.2 MAF
- Describes 85% of vulnerable traces, (coverage)
- 87% of traces in conditions are vulnerable (density)

(~24,000 traces)
Consistent with:
- Change in Temperature 2012-2060 > 2 deg F
- Average Precipitation 2012-2060 < 100% of Historical Average
Scenario discovery identified Lower Basin vulnerabilities

- Long Term Average streamflow < 15 MAF
- 8-year dry spell with average streamflow < 13 MAF
- Describes 86% of vulnerable traces (coverage)
- 72% of traces in conditions are vulnerable (density)

(~24,000 traces)
Consistent with:
- Change in Temperature 2012-2060 > 1.7 deg F
- Average Precipitation 2012-2060 < 104% of Historical Average
Portfolios of options were developed to address the vulnerabilities.

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New options lead to descriptions of key vulnerabilities.
Adaptive strategies were developed from quantitative assessments, expert judgment, stakeholder preferences.

**Quantitative analysis**
- Developed cost and yield estimates
- Defined prioritized lists of options based on cost effectiveness criterion and preferences (portfolio development tool)

**Stakeholder/expert judgment**
- Proposed and characterize individual options (~80)
- Defined “strategies” representing preferences over option types
  - A) Inclusive
  - B) Reliability Focus
  - C) Environmental Performance Focus
  - D) Common Options

**Specifications of alternative strategies**
Tradeoff Analysis: Allow decisionmakers to compare tradeoffs among strategies...

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Descriptions of key vulnerabilities
Robust strategies

New options
RDM highlighted key tradeoffs: vulnerability reduction vs. cost
...and helped define a robust strategy

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New options

Descriptions of key vulnerabilities

Robust strategies
Analysis identified high priority, near-term options to form foundation of a more robust strategy.
How did RDM inform the Colorado River Basin Study?

- Organized stakeholder input about uncertainties, metrics, options
- Identified key vulnerabilities to future uncertainty
- Structured design of alternative adaptive strategies
- Highlighted key tradeoffs among adaptive strategies
- Defined near-term actions for implementation

www.usbr.gov/lc/region/programs/crbstudy/finalreport/
Study report and interactive research brief available online

RAND Research Report
(www.rand.org/pubs/research_reports/RR242.html)

Adapting to a Changing Colorado River
Making Future Water Deliveries More Reliable Through Robust Management Strategies
David G. Groves, Jordan R. Fischbach, Evan Bloom, Debra Knapman, Ryan Keefe

RAND Interactive Research Brief
(www.rand.org/jie/projects/colorado-river-basin/interactive-brief.html)

Adapting to a Changing Colorado River
As water needs grow and climate conditions change, Colorado River managers and users look for ways to prepare for the future.
Water and Climate Resilience Center

www.rand.org/jie/centers/water-climate-resilience.html