SDG Approac:
New Nuclear Strategy
and Risk Management

Nuclear Construction Summit

Presented by:
Christopher Dann
Partner and Director, Energy and Environment
cdann@sdg.com

October 26-27, 2009
A comprehensive, rigorous approach to strategic decision making and risk management is critical to the nuclear renaissance.
For nearly 30 years, SDG has been supporting energy clients in evaluating the value and risk of investments in nuclear power.

- We have been actively engaged with nuclear industry and societal decisions in the US and globally, supporting investor/owners, suppliers, and regulators.

- SDG is developing the strategy and risk management programs for several new nuclear plant developments in the US as well as abroad.

- SDG has performed the economic analyses for over half the major nuclear PWR steam generator decisions in North America.

- We have conducted hundreds of evaluations of some of the world’s largest capital investments and megaprojects.

- We have extensive knowledge of the US energy markets and the commercial, political, and regulatory context for nuclear power.
Demonstrating a comprehensive risk analysis and mitigation strategy is critical for nuclear developers for securing financing, political and regulatory support.

- Successful execution of these projects will require a robust decision making process that explicitly incorporates risk and uncertainty, considers alternatives and engages and aligns all of the stakeholders

- Risk management is central to this process and must go beyond traditional “weighting and rating” (e.g. heat maps) methodologies

- We have identified several “traps” that traditional risk management can exacerbate:
  - Failure to incorporate pervasive risk and the interrelationships among key risk factors – especially between schedule risks and cost risks
  - Failure to challenge the data and remove biases in risk assessments
  - Over-reliance on detailed data and analytical methodology at the expense of the big picture

**SDG has been successfully employing our decision-analytic approach to large capital project risk analysis and management for nearly 30 years.**
What goes wrong with large capital projects?

- **Insufficient advance planning and analysis**
  - Underinvesting in the "set-up" pre-construction period and taking short-cuts in planning and preparation
  - Advance planning and procurement to deal with supply chain/manufacturing capacity constraints as well as labor shortages
  - Inadequate understanding of the critical risks to cost and schedule and insufficient risk mitigation strategy development

- **Not completing advanced detailed design engineering**

- **Not building a unified owner/contractor team**: effective coordination and alignment of incentives among members of the consortium: OEM, developer, contractors and subcontractors
  - Ineffective change order management/administration
What goes wrong with large capital projects? (cont’d)

• Organizational bottlenecks on fast track projects:
  – Concurrent scheduling of interdependent tasks causes supervision and coordination information processing backlogs
  – This “hidden work” can trigger delays, cost overruns and quality meltdowns

• Governance failures on large projects:
  – Contracts—no matter how complex—are not adequate to allocate all material risks among project stakeholders over an extended planning, design, construction and operation period.
  – Contracts must be augmented with governance mechanisms that can smoothly and legitimately realign costs and benefits for all key stakeholders over time, as project context changes in ways that could not have been predicted.
What makes the problem complex?

Three primary dimensions:

Organizational: Alignment and commitment to an answer
- Values, desires, and motivations
- Fundamentally different frames and beliefs
- Group dynamics
- Habits and personalities
- Organization structure

Content: Trustworthy inputs and insight
- Data overload or lack of data
- Constantly evolving information
- Many alternatives or none
- Biases
- Access to subject matter expertise

Analytical: The right logic to get the answer
- High uncertainty
- Complex dynamics and inter-relationships
- Many independent drivers
- Consistency in risk assessment
How do you capture the opportunities and manage the risks of large complex projects?

1. Robust decision making process
2. Integrated analysis of cost, schedule and economics
3. Identifying optimal contract structures
4. Building downstream flexibility
5. Organizational simulation
6. Robust governance
A decision making process that engages diverse stakeholders and fosters alignment around project execution and risk management is essential.

<table>
<thead>
<tr>
<th>Steering Committee</th>
<th>Decision Making Executives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides oversight and guidance</td>
<td>e.g. Director level, VP level or higher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Core Team</th>
<th>Project Managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manages cost &amp; schedule</td>
<td>Project managers, project evaluation team, EPC lead</td>
</tr>
<tr>
<td>risk analysis effort</td>
<td></td>
</tr>
<tr>
<td>Maintains economic evaluation models</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extended Team</th>
<th>Internal Subject Matter Experts + External Experts on Megaprojects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides expertise in all risk areas</td>
<td></td>
</tr>
</tbody>
</table>

Dialogue – Monthly updates

Dialogue – Workshops & Interviews
Removing human bias is essential in risk assessment.

- Selective memory
- Framing effects
- Selective attention
- Anchoring effects

- Affective forecasting
- Overconfidence
- Hindsight
- Illusion of control
- Escalation of commitment
- Sunk cost fallacy
- Discounting opportunity costs
- Wishful thinking
- Positive illusions

- Nonregressive predictions
- Primacy and recency
- Inability to reason probabilistically
- Attribution errors
- Confirming evidence
- Status quo

- Decision styles
- Comfort zones
- Habitual frames
- Content selectivity

- Premature harmony
- Obedience
- Conformity

- Anonymity
- Attention to shared evidence
- Psychological safety

- Perceptions
- Reasoning
- Motivations
- Personality Traits
- Group Dynamics
An *integrated* simulation of the cost, schedule and economics of a project is required to quantify risks and evaluate execution alternatives.

Analytic Structure of Project Evaluation

Value Map

Deterministic Sensitivity

Probability Distributions

- ... on Schedule
- ... on Cost
- ... on Value (NPV), Profit, etc.
Our approach identifies key risk drivers and builds probability distributions over cost, schedule and economics.

- **Commercial Operation Date for Unit 1**

  - Detailed engineering and design duration
    - Months
  - Delayed site prep start
    - No
  - Water rights shortfall
    - No
  - Impact of unknowns around pre-op testing
    - Months
  - Fuel load and startup to COD
    - Months
  - Lower elevation construction
    - Months
  - Mid elevation construction
    - Months
  - High elevation construction
    - Months
  - Political support
    - Strong
  - Building construction through overhead crane completion
    - Months

  ![Tornado charts list all risks from most critical to least critical](image)

  ![Cumulative probability distributions display the full range of possible outcomes](image)

  ![All of the analyses can be performed on any of the model’s outputs – important schedule milestones, major cost categories, economic value measures, etc.](image)

Integrated Analysis of Cost, Schedule and Economics
Probabilistic analysis of the critical path is required to understand and mitigate the most important schedule risks.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permitting</td>
<td>Detailed Design</td>
<td>Site Prep – Earthworks</td>
<td>Site Prep – Cooling Lake</td>
<td>Equipment Procurement</td>
<td>Reactor Building – Phase 1</td>
<td>Reactor Building – Phase 2</td>
<td>Turbine Building – Phase 1</td>
<td>Turbine Building – Phase 2</td>
</tr>
<tr>
<td>Fuel Load</td>
<td>Start-Up</td>
<td>Start of Commercial Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:
The colors convey how often the activity is on the critical path.
- 0% to 25%
- 25% to 50%
- 50% to 75%
- 75% to 100%
It is critical to account for interrelationships among key risk factors, especially between schedule risks and cost risks.

Schedule is often one of the main drivers of cost.
We develop and evaluate the impact and trade-offs of alternative risk mitigation strategies.

Cumulative Probability Distributions on Total Project NPV

<table>
<thead>
<tr>
<th>Cumulative Probability</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Illustrative</strong> Unmitigated Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected NPV = -$XXX B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fully Risk Mitigated Project</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected NPV = $XXX B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alternative Strategy Development
- Opportunity Capture
- Risk avoidance
- Risk mitigation
- Risk transference / insurance

Examples of risk mitigation areas:
- Technology / vendor selection
- Contractual terms
- Construction schedule optimization
- Procurement process optimization
The analysis can be used to determine what drives the difference between alternative project execution strategies.

**Technology Selection**

**Vendor A**

- Schedule
  - Schedule risk 1: Detailed engineering design
    - Schedule risk 2
    - Schedule risk 3
    - Schedule risk 4
    - Schedule risk 5

- Owner’s Costs
  - Owner’s costs 1
  - Owner’s costs 2
  - Owner’s costs 3
  - Owner’s costs 4
  - Owner’s costs 5

- EPC Costs
  - EPC costs 1
  - EPC costs 2
  - EPC costs 3
  - EPC costs 4

- Operations
  - Electric output
    - Operating costs 1
    - Operating costs 2
    - Operating costs 3

**Vendor B**

- Expected NPV of Nuclear Plant ($ B)

Illustrative
Allocating risk effectively between different scope areas is critical to optimizing contract structure.

**Scope A:** 84% chance of cost overrun

**Scope A:** Narrow risk but limited opportunity for cost reduction

**Scope B:** Wide distribution with significant risk and opportunity for cost reduction

Illustrative
In SDG’s experience, the most significant commercial terms can mitigate over a third of the risk around project cost.

Cumulative Probability Distributions on Total Overnight Project Cost

Illustrative

Critical Commercial Terms
$EV = $XXX / kW$

No Commercial Terms
$EV = $XXX / kW$

- Overall LOL and liability structure (e.g. joint and several v. wrap) and equity participation
- Fixed costs for supply scope
- Target costs for construction scope
- Schedule LDs
- Warranties and Performance Guarantees
Downstream flexibility is an important source of value in project evaluation.

Recognize downstream decisions and exit ramps

Build flexibility into execution plans to mitigate risk or capture opportunity

Assess option value and understand the value of information

“The things I could have done and didn't do have cost us billions of dollars.”

– Warren Buffett
SDG is a strategy consulting firm dedicated to helping clients create and deliver maximum shareholder and stakeholder value.

- **Diverse client experience** — in virtually every industry sector, including more than one-third of the world’s 100 largest companies (as measured by market capitalization)

- **What it takes to meet client goals** — capability to manage risk and uncertainty, creativity, analytical excellence, business knowledge, integrity, teamwork, and dedication to client service

- **A collaborative approach** — work with clients on project teams to transfer principles and processes for ongoing success

- **Broad reach** — Offices in North America, Middle East and India

SDG was founded in 1981 in Menlo Park as a spin-off from SRI (Stanford Research International) by partners with close ties to Stanford University’s schools of engineering and business.
SDG’s Energy & Environment practice has been at the leading edge of many of the critical strategic challenges facing the energy industry.

- **Generation Portfolio & Asset Strategy** – Support owners of the largest generation fleets to make decisions on asset investments, acquisitions, divestitures, retrofitting, and to address uncertainties arising from market volatilities, fuel risks, environmental and other regulatory changes.

- **Enterprise Risk Management** – Support many leading companies in energy and other industries in assessing the value and risk inherent in their businesses and in devising strategies for increasing value and minimizing risk in their portfolios.

- **Nuclear Renaissance** – SDG has been at the forefront of the nuclear renaissance and is supporting several developers of new nuclear plants in developing strategy and risk management for these massive investments.

- **Energy System of the Future** – Evaluate the potential market prospects and impact of emerging technologies and changing market needs on the energy system of the future.

- **Renewable Energy** – We work with manufacturers, developers and utilities in addressing strategic challenges in this highly uncertain market.

*SDG’s Energy and Environment practice’s clients represent more than 75% of the total electricity generated in the US.*