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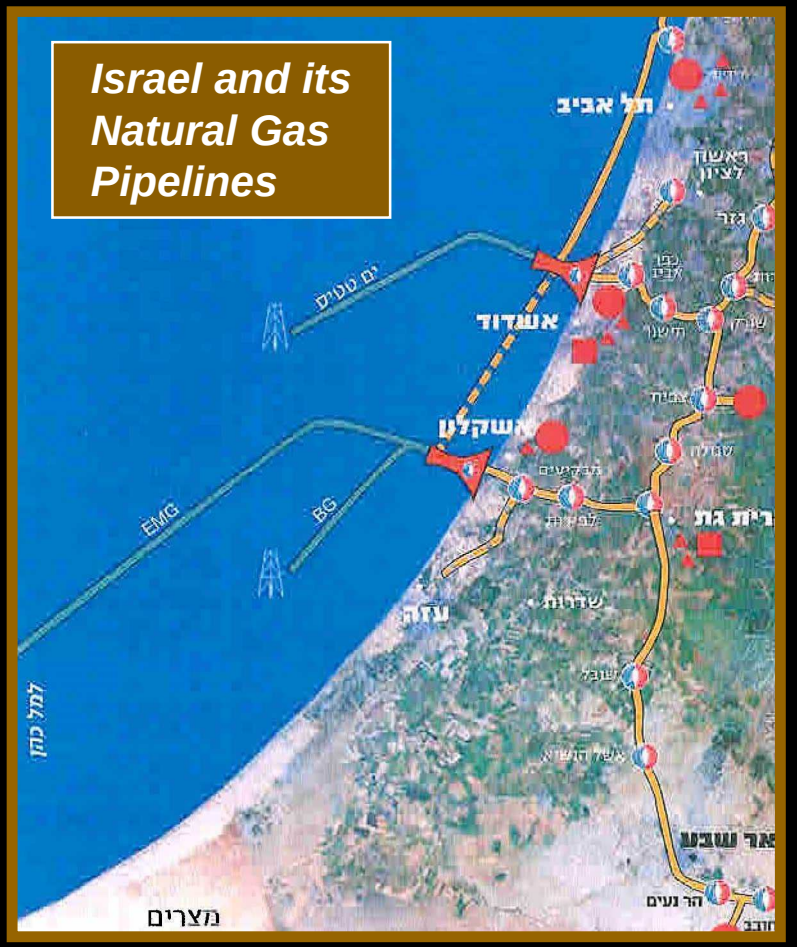
Environment, Energy, and Economic Development

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

Natural Gas and Israel's Energy Future:

Near-Term Decisions from a Strategic Perspective



Steven W. Popper

"*IQ SCENE*" Workshop

University College London-CIRED

26 March 2014

2006: Israel Was A Small Energy 'Island'… …Facing a Quiet Electricity Crisis

- **Uncomfortable race between electricity demand and supply**
  - **Traditional reliance on imported fuel: oil, coal, natural gas**
  - **Growing demand, driven by population and economic growth**
  - **Need for large investments to produce more electricity**
- **National concern about energy-related issues**
  - **Environment and health**
  - **Economics and cost stability**
  - **Supply security**
  - **Land use**

Choices would affect at least two generations of Israelis…

…and the political system had not been able to choose

Our Goal Was Not Better Forecasts

We wanted to show several things:

- **Prediction: neither credible nor reliable for complex problem with many unknowns**
- **Instead, ask:**
  - ***"What actions today will be likely to achieve long-term goals across many plausible futures?"***
- **Demonstrate a planning approach built on flexibility**
- **Encourage adoption of robust adaptive posture toward an uncertain future**
- **Potential for capacity building**

Our Work Was Framed in Line with the Project's Broader Objectives

- **Maximize process contacts with end-user communities**
  - **Periodic meetings with government steering committee**
  - **Extensive interviewing and engagement with professional staff**
  - **Several workshops with important stakeholder or analytical communities**
- **Maintain accessibility, transparency, visibility**
  - **As much as possible use models, data already familiar**
  - **Use off-the-shelf software environments**
  - **Seek to understand rhetoric of argumentation and judgment**
- **Ensure multiple points of entry**
  - **Begin from the end: who needs to know what -- and why?**
  - **Lead with final form visualizations with drill-down capability**

"XLRM" Format Lays Out Model Design

EXogenous Uncertainties

Price path for coal
Price path for natural gas
Cost of carbon dioxide (CO2) emissions
Cost of fossil-fuel technology
Cost of non–fossil fuel technology
Availability of non–fossil fuel technology
Demand for electricity
Cost of efficiency improvements
Administrative limits on GHG emissions
Cost of capital
Supply from foreign pipelines
Discovery of new domestic reserves
Fixed cost of LNG installation
Variable cost of LNG supply
Fixed cost of new domestic natural gas
Variable cost of new domestic natural gas
Cost of storage capacity

Levers Under Control

New plant type and primary fuel
National infrastructure construction
Level of reserve generation capacity (policy)
Share of generation capacity from coal and nonfossil fuel (policy)
Dispatch order of electricity generation
Administrative control of GHG emission levels
Administrative control of land use
Imposition of price on carbon emissions
Adoption of non–fossil fuel technology and capacity
Energy-efficiency enhancement
Target level of reserve capacity
Rate of domestic reserve depletion
Level and timing of LNG capacity
Fuel storage types
Fuel storage levels

Relationships

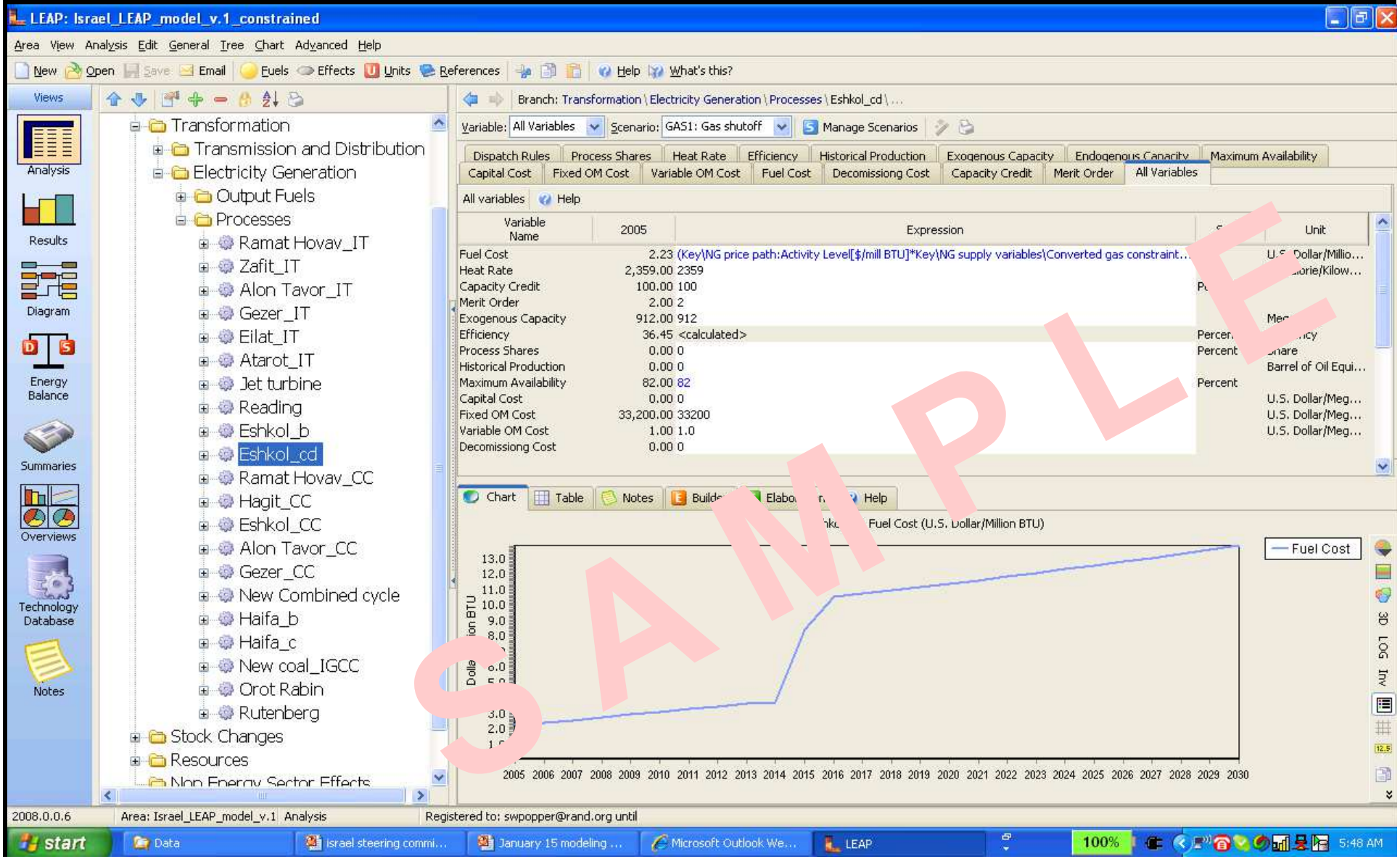
WASP package
MAED
RAND Israel energy sector model
- LEAP
- Excel

RAND natural-gas supply model:
- Excel

Measures of Outcomes

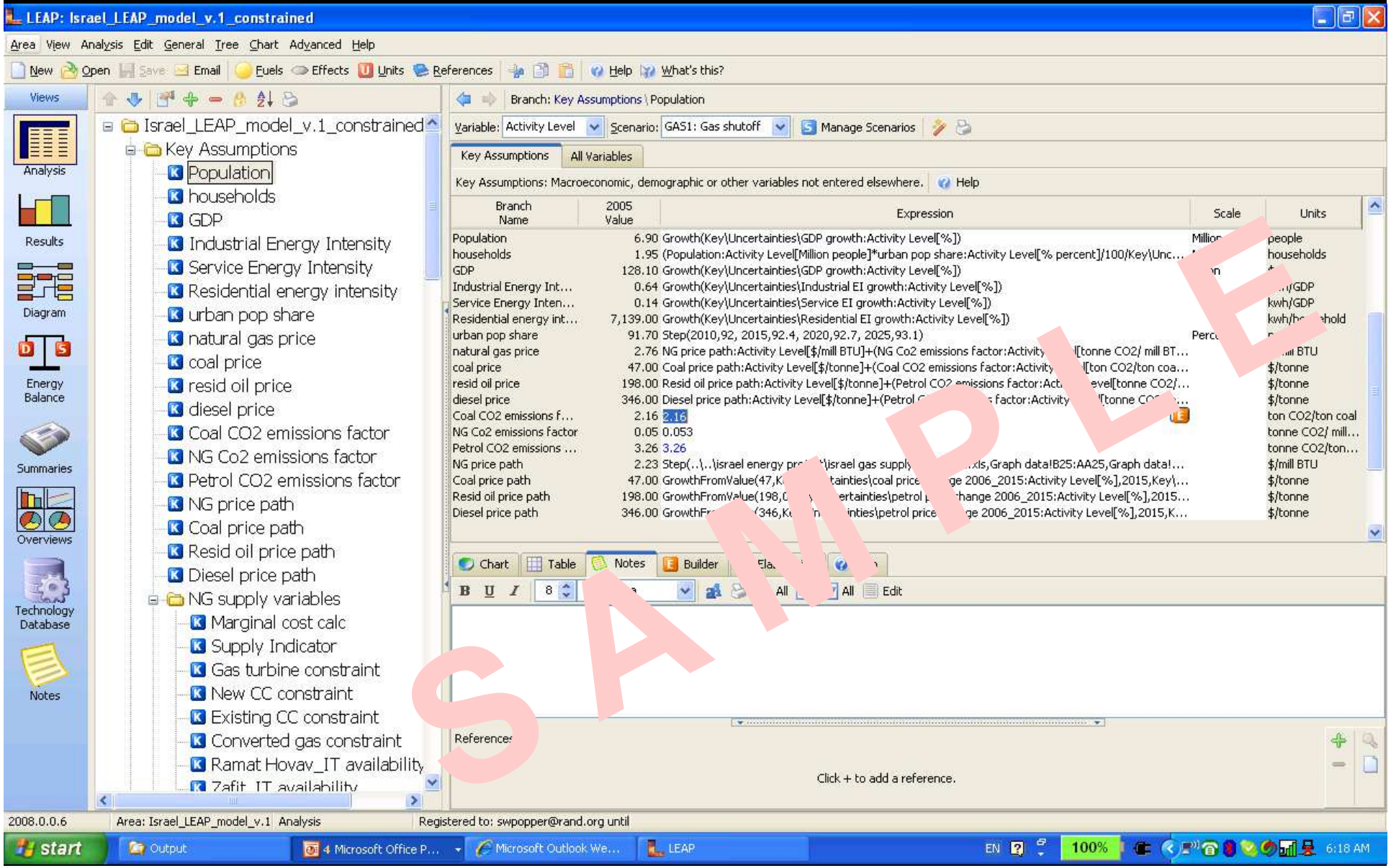
Total system costs
Total fuel costs
Balance of cost-sharing over generations
Annual natural-gas supply requirement
GHG emissions
Land-use requirements
Level of reserve generation capacity (actual)
Share of generation capacity from coal and nonfossil fuel
Depletion of domestic reserves (actual)
Cost of providing a given level of supply insurance
Cost of implementing supply insurance
Potential unmet demand for electricity

We Built a Detailed, Easily Modified Model of Israel's Energy Sector…



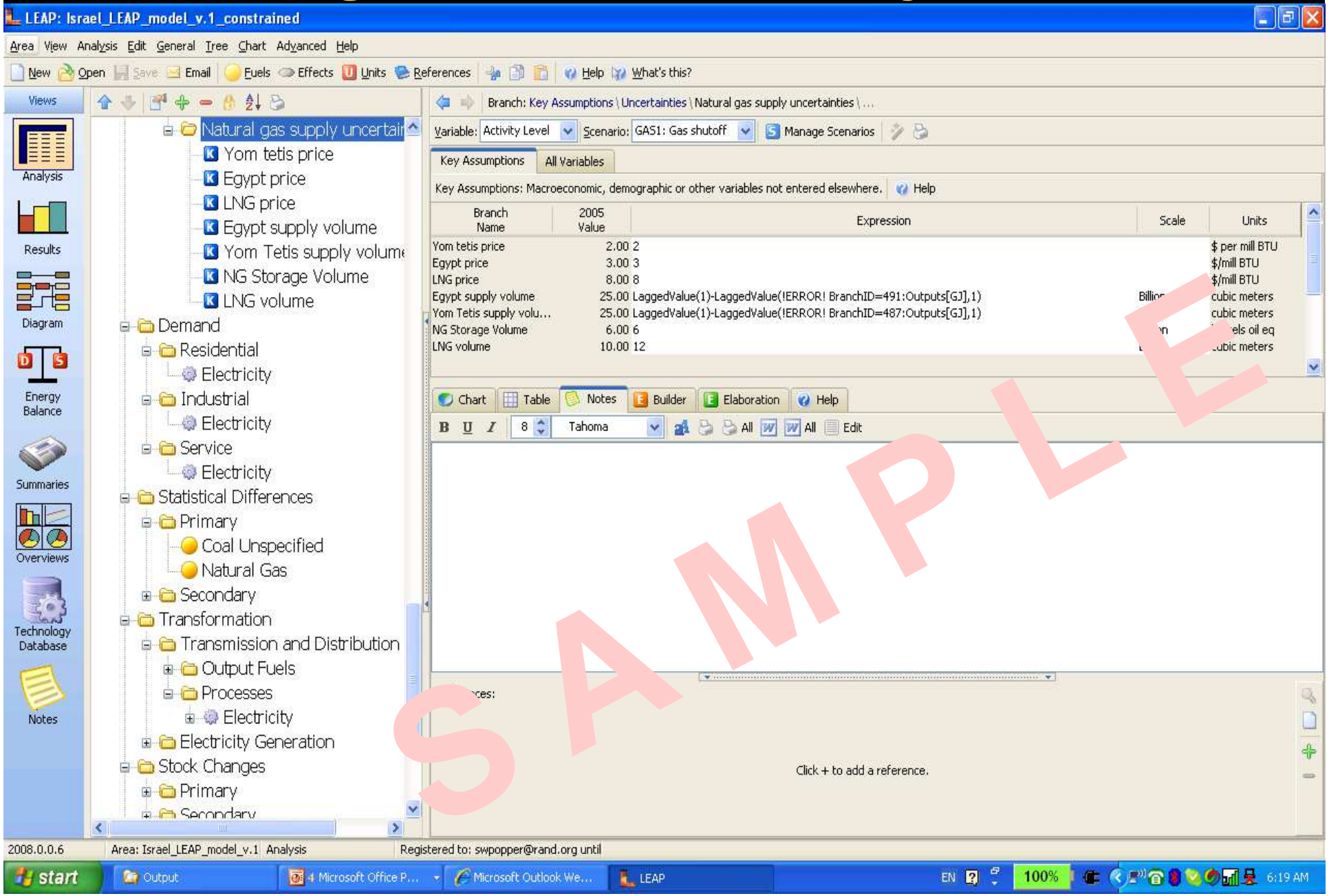
SAMPLE

...Within the LEAP Energy Accounting and Simulation Software...



SAMPLE

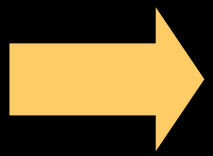
...Using Data from Ministry and IEC



SAMPLE

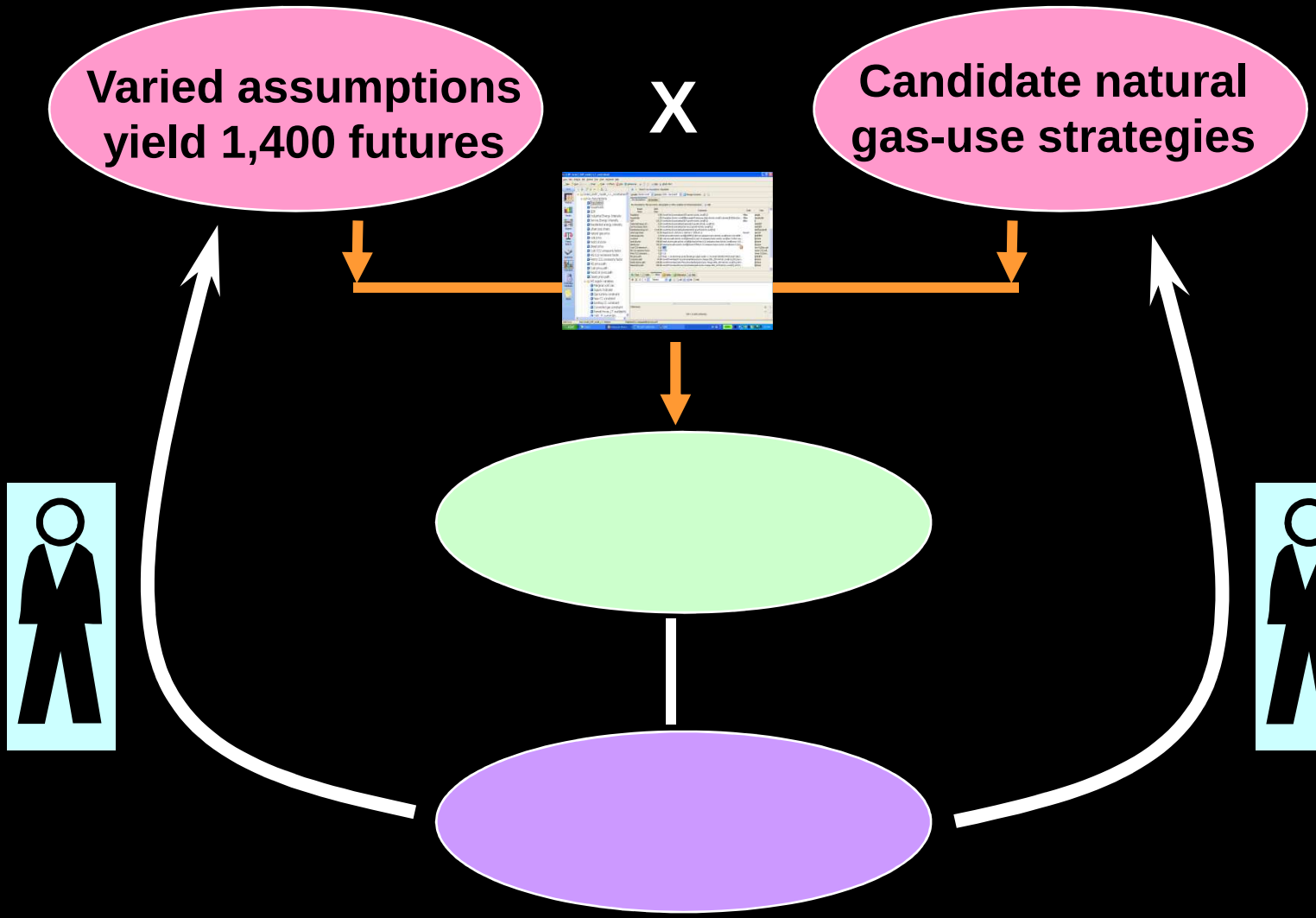
We Analyzed Strategies in Two Steps

Israel's needs and goals ; but also future uncertainties ...



- **Robust strategies for natural gas *utilization?***
- **Robust strategies for supply infrastructure?**

We Created Scenarios of Strategic Outcomes



We Identified Rule-based Candidate Strategies: Built Up from Simpler, More Vulnerable Versions

Name	Prefers to Build:	Will Build Coal Plant *IF*:	Builds Renewable Plants?	Invests in Efficiency?	Retires Coal Plants?	Always Follows Rules?
Less NG Rule	Gas CC	< 50% of generation; < GHG limit; & cost < gas cost -- or -- Coal and renewables < 40% of generation; & GHG < limit	If in scenario & cost ≤ cost of gas CT	If cost < cost of gas CT	No	Yes
Least Cost Rule	Least cost among coal, gas, and renewable	Least cost	Yes, if cost < gas CC or coal	If cost < cost of gas CT	1 in 2020 and 1 in 2025 if operating costs > replacement)	Yes
More NG Rule	Gas CC	One in 2020 & one in 2025 if cost < cost of gas or renewable	If in scenario & cost ≤ cost of gas CT	If cost < cost of gas CT	1 in 2020 and 1 in 2025 if operating costs > replacement)	Not if cost of gas CC > 130% of coal costs
WASP (Base-line)	According to plan	According to plan	According to plan	No	No	Yes

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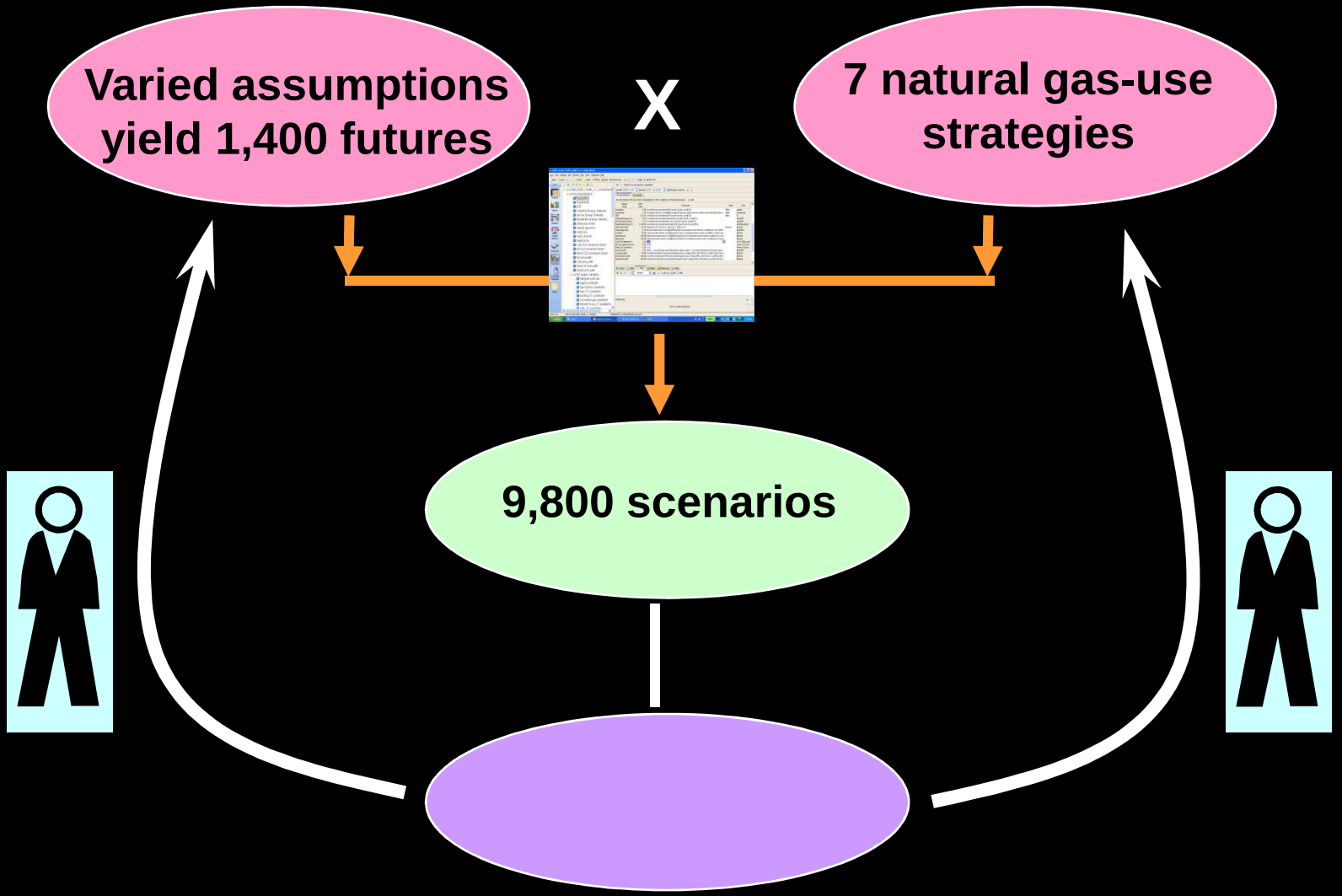
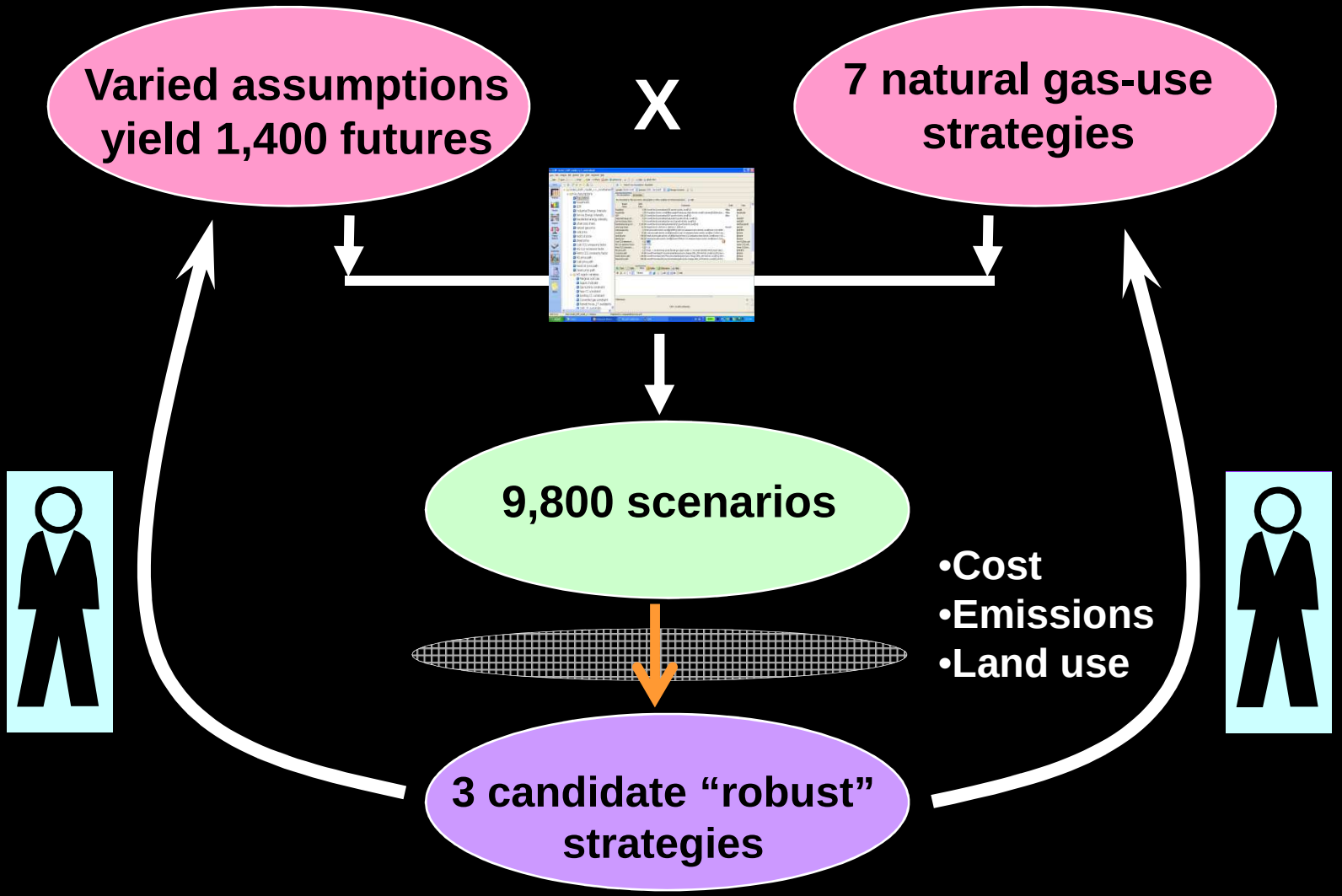
NB: "Cost" = levelized cost of electricity (LCOE)

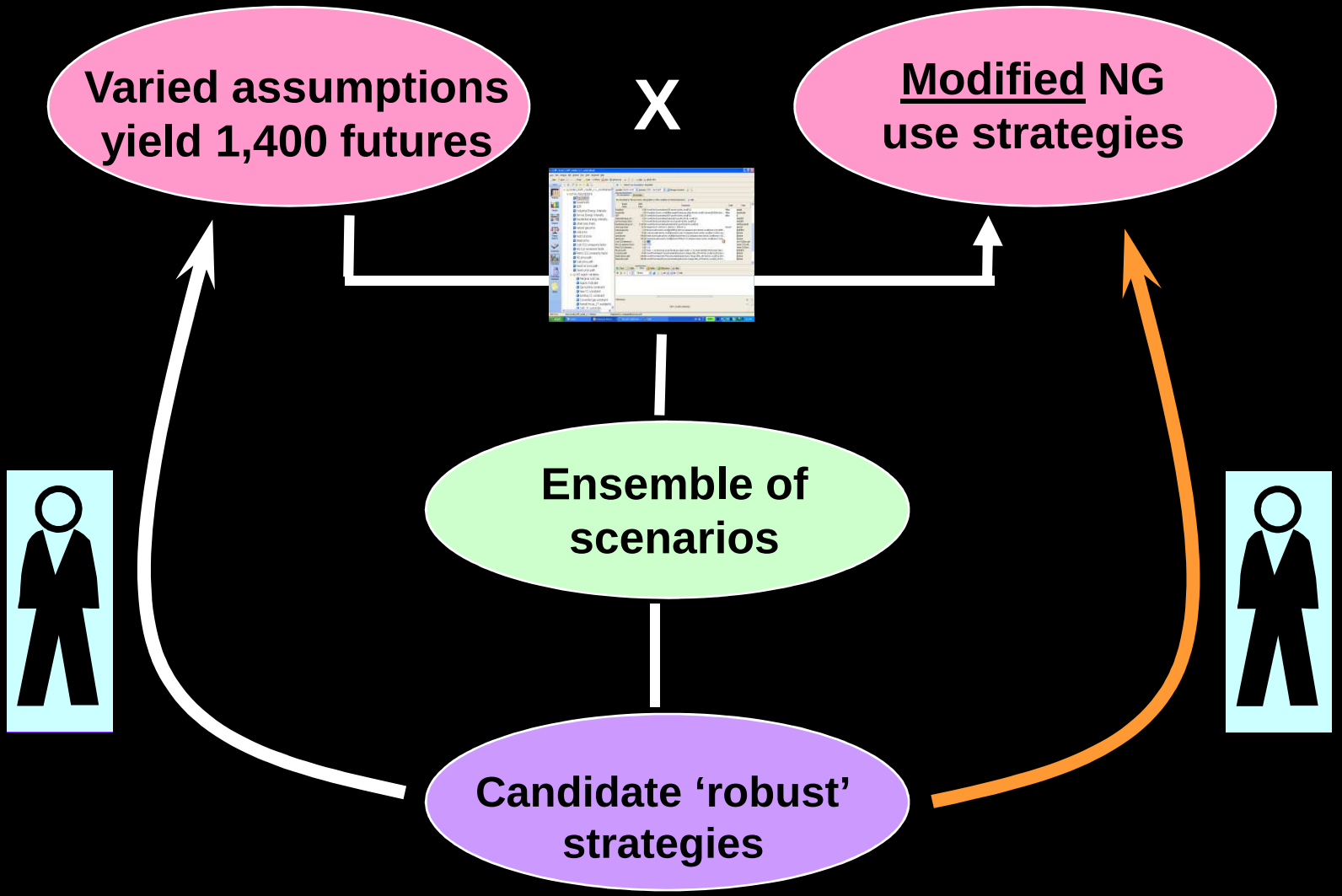
We Created Scenarios of Strategic Outcomes



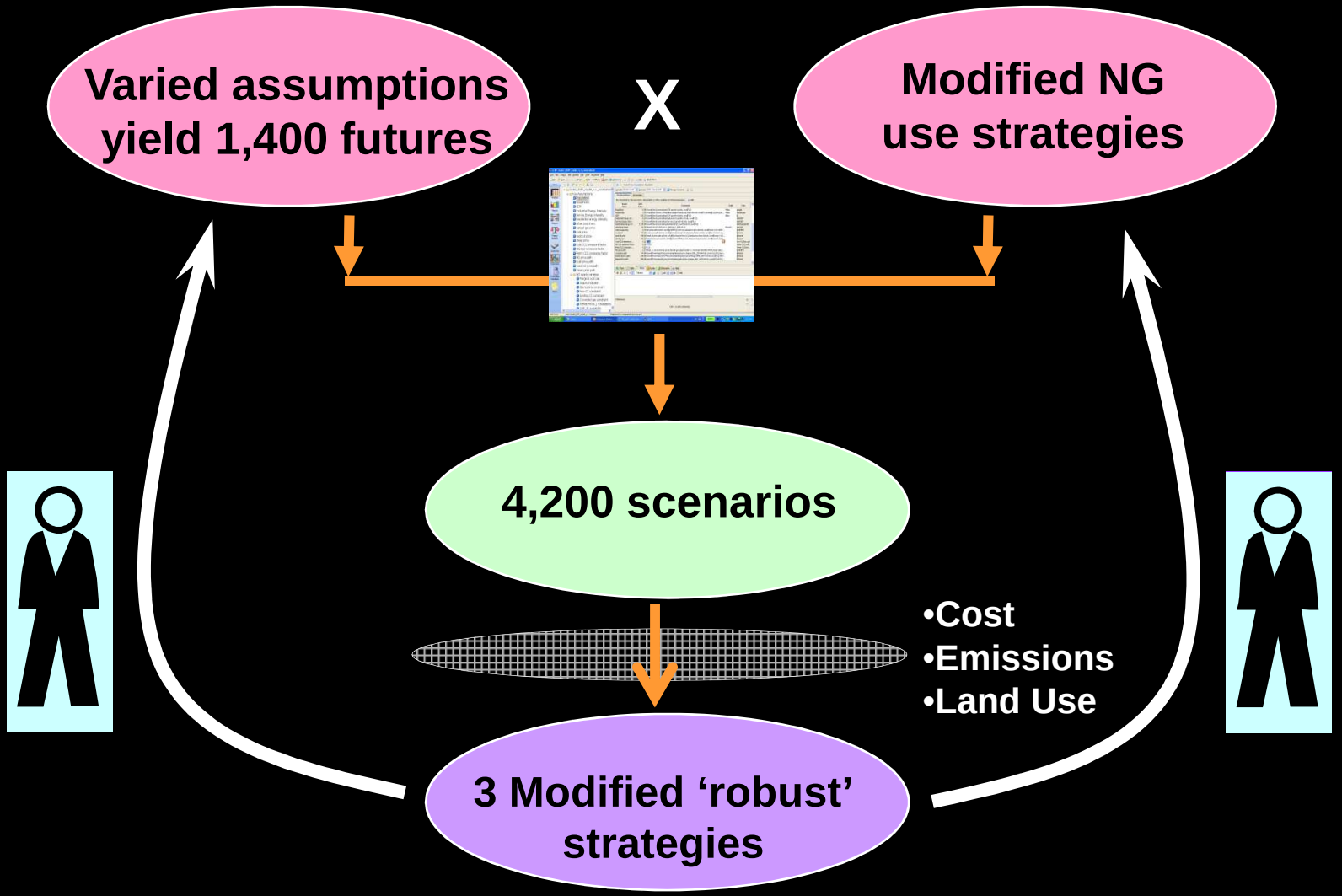
We Identified the Most Robust Strategies



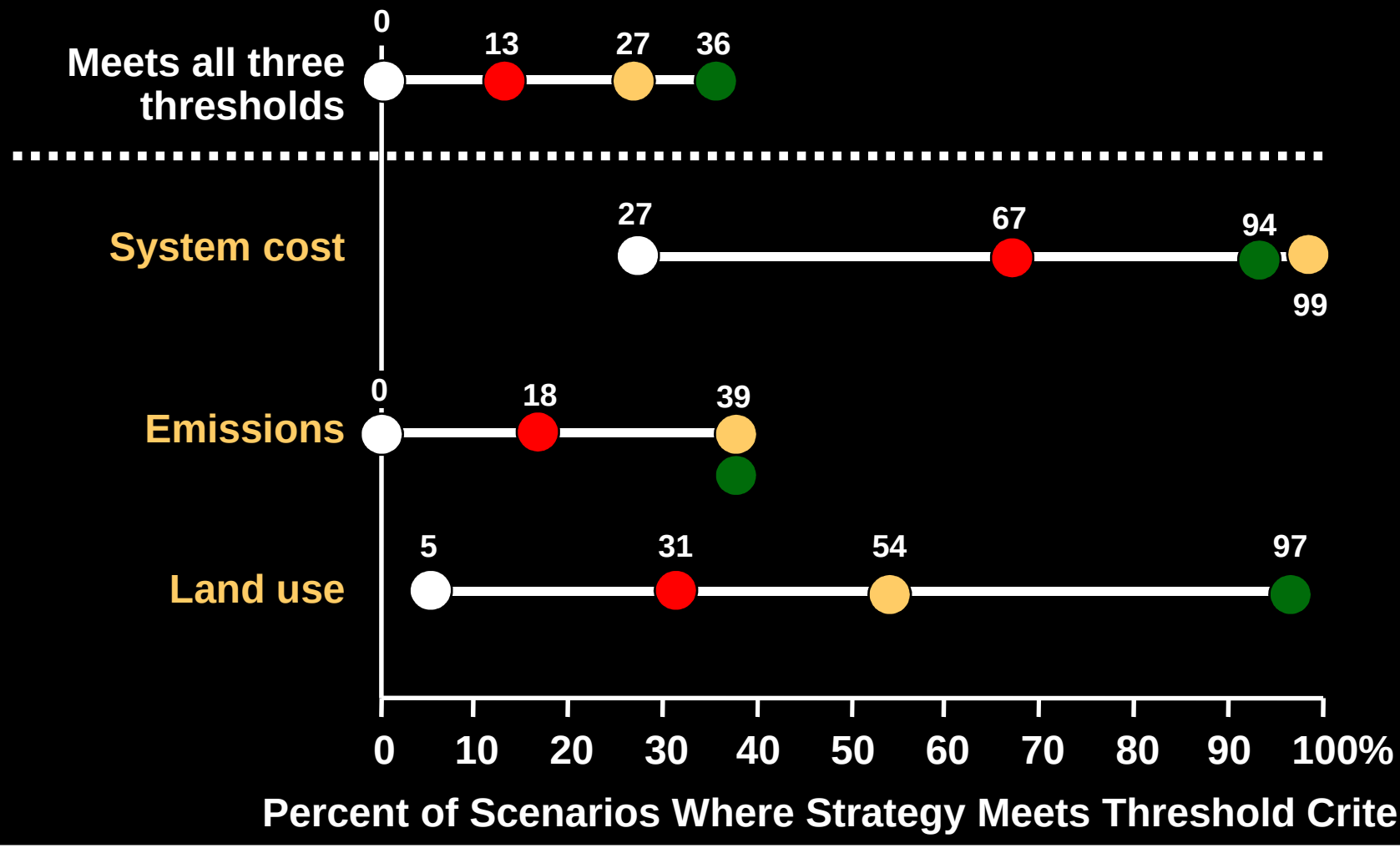
We Amended Strategies to Limit Weakness



Then, We Tested the Modified Strategies Again



"More Natural Gas" Appears To Be the Most Robust of the Candidate Strategies



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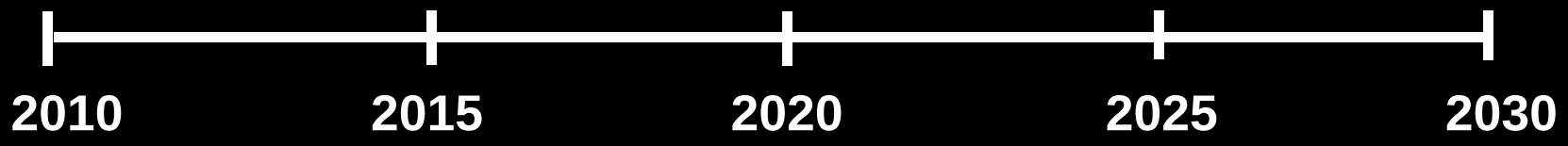
But What Are Reliable Sources for Future Additional Natural Gas Supply?

- **Strategies could draw natural gas from**
  - **Domestic deepwater (DDW) reserves**
  - **Liquid natural gas (LNG) terminal**



Analysis Suggests Joint DDW Might Be Most Robust for Additional Future Supply

- **Strategies could draw natural gas from**
  - **Domestic deepwater (DDW) reserves**
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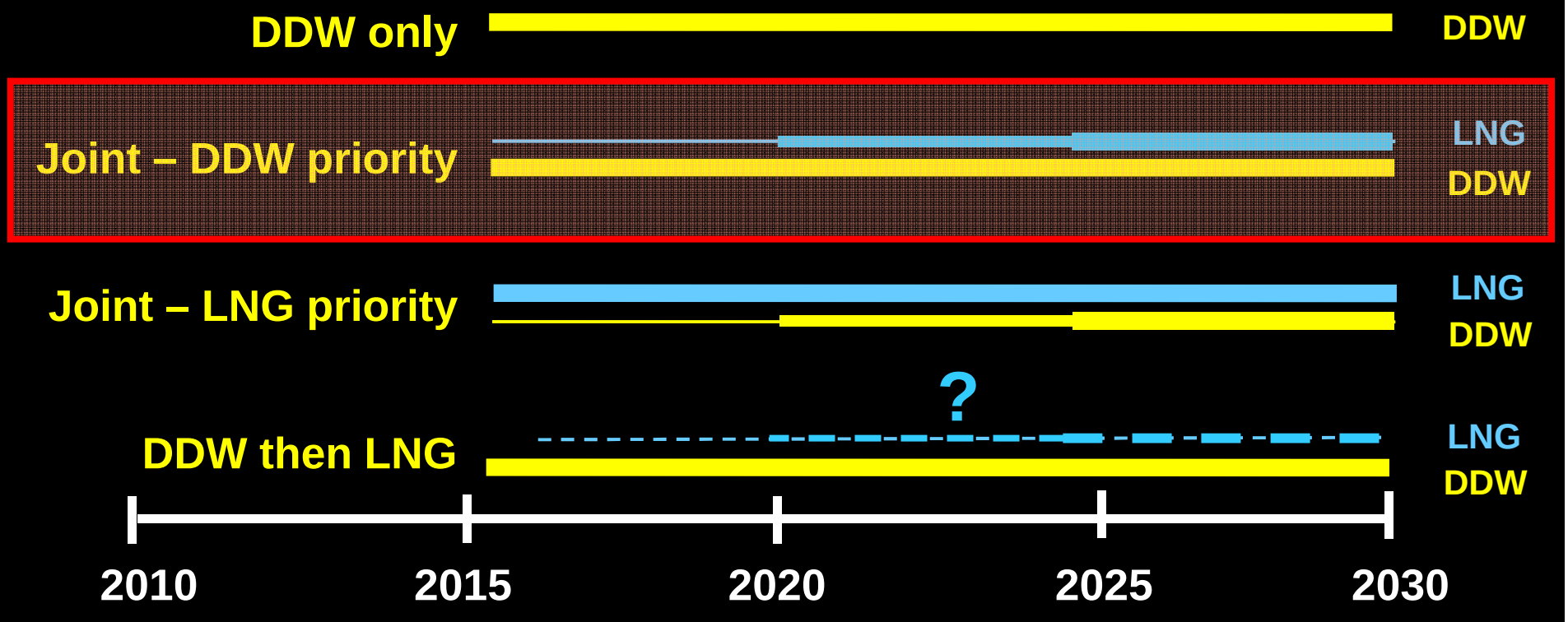
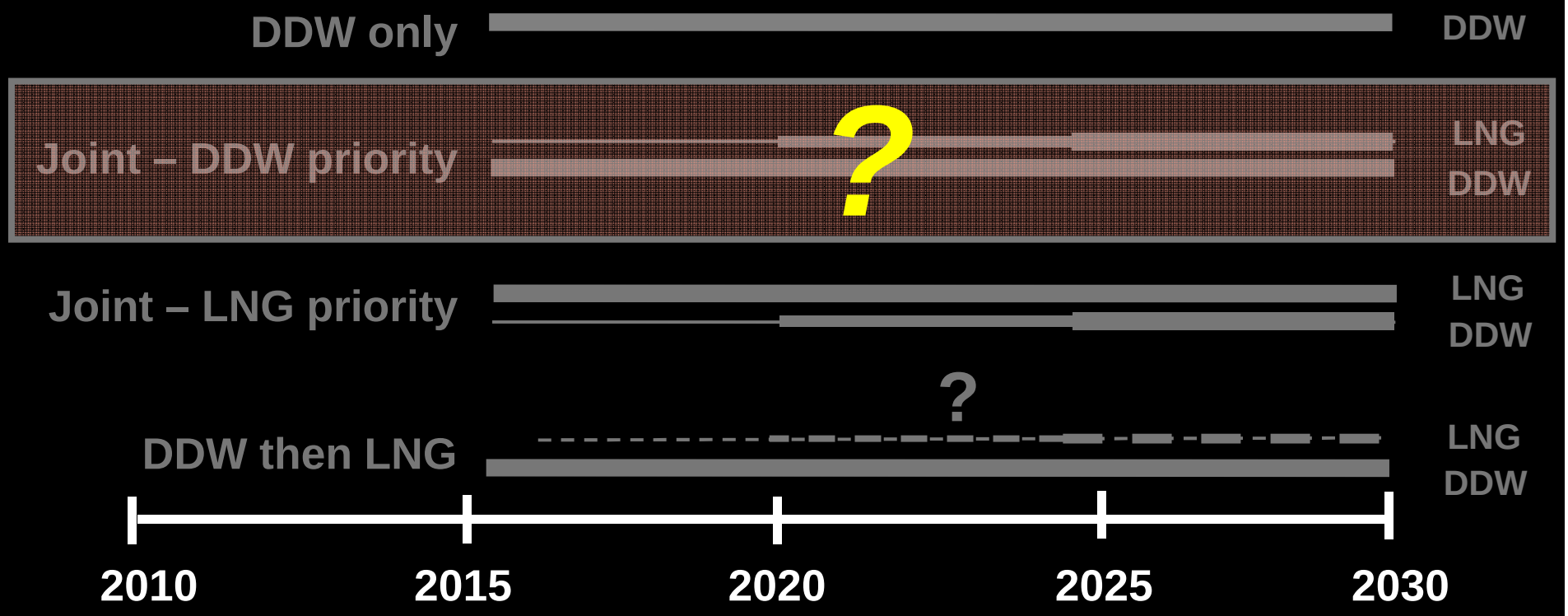


Is This Really True?

- **Strategies could draw natural gas from**
  - **Domestic deepwater (DDW) reserves**
  - **Liquid natural gas (LNG) terminal**



What If Israel Actually Had a Supply Emergency?

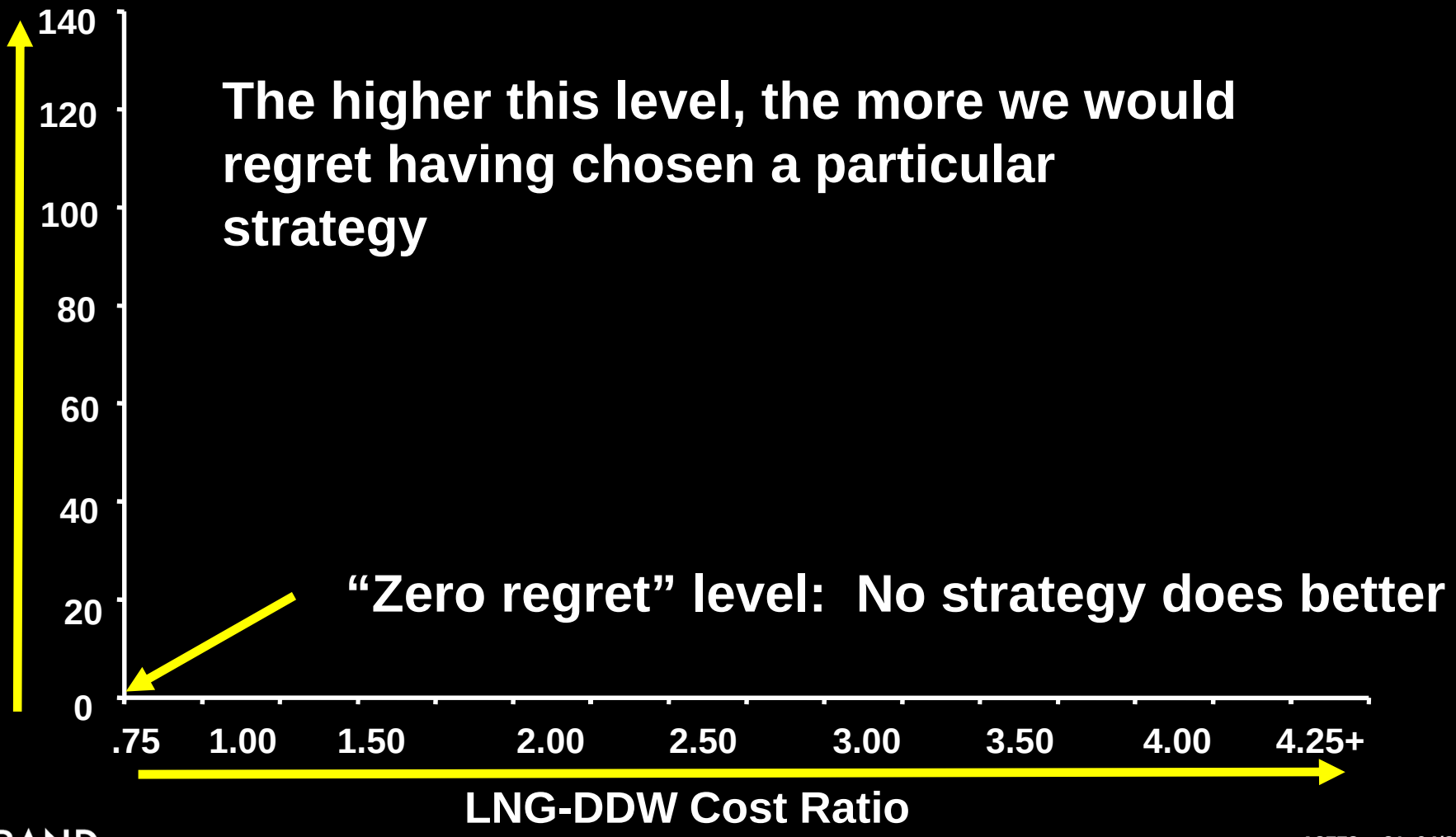
We anticipated current events by examining an especially vulnerable future year

- **In 2025, there is a one-year supply shutoff from existing foreign natural gas pipeline**
- **Each strategy must pay costs for implementing its policies; for example**
  - **Draw on diesel or natural gas storage**
  - **Draw more from LNG or DDW reserve capacities**
  - **Impose brownouts**

Which strategy performs best under these emergency conditions?

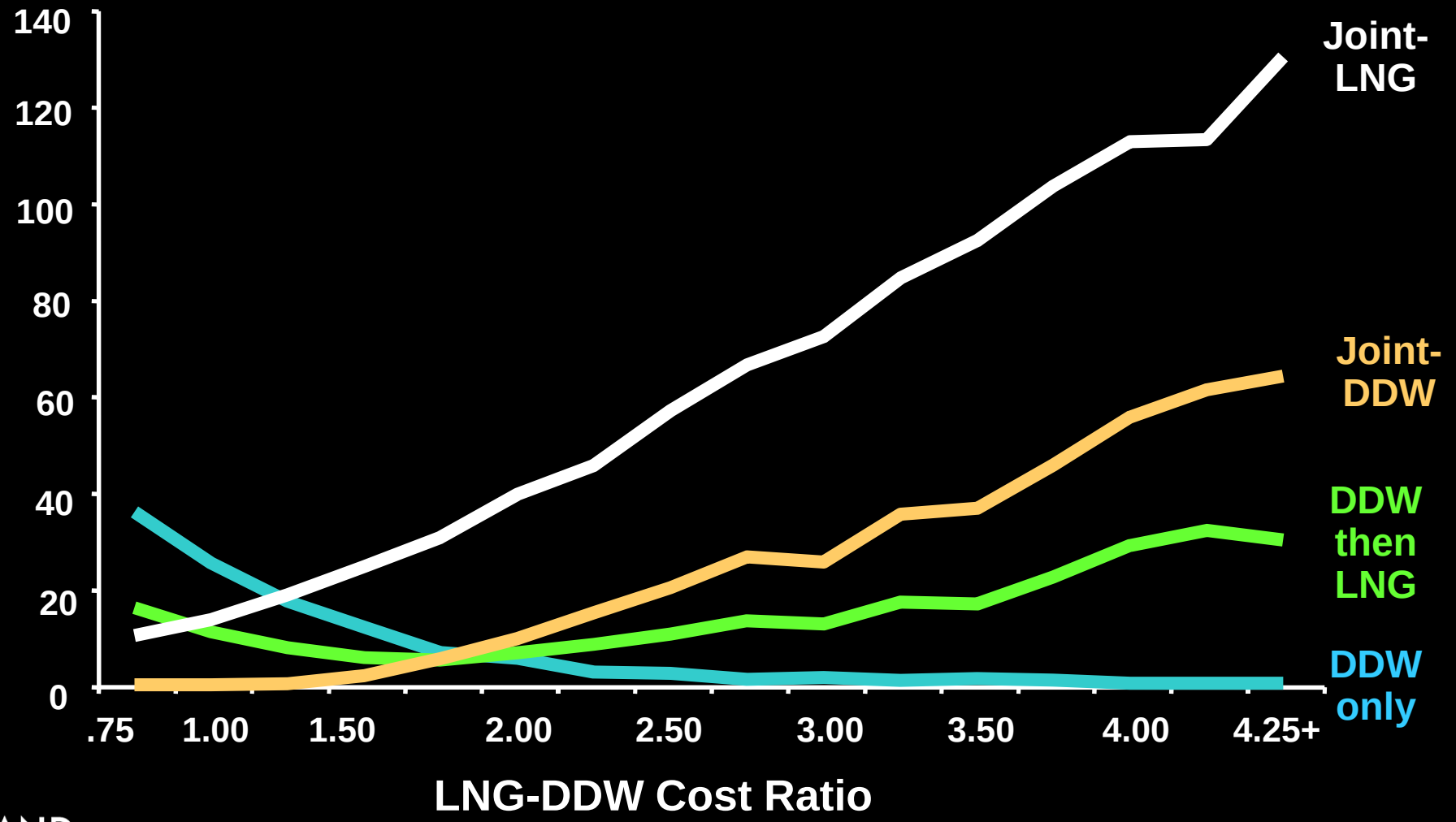
Without Prediction, We Want to Know Basis for Making Strategic Choices

Expected **costs above least cost for each scenario (%)**



Total Cost in Emergency Depends on Future LNG and DDW Natural Gas Costs

Expected **costs above least cost for each scenario (%)**



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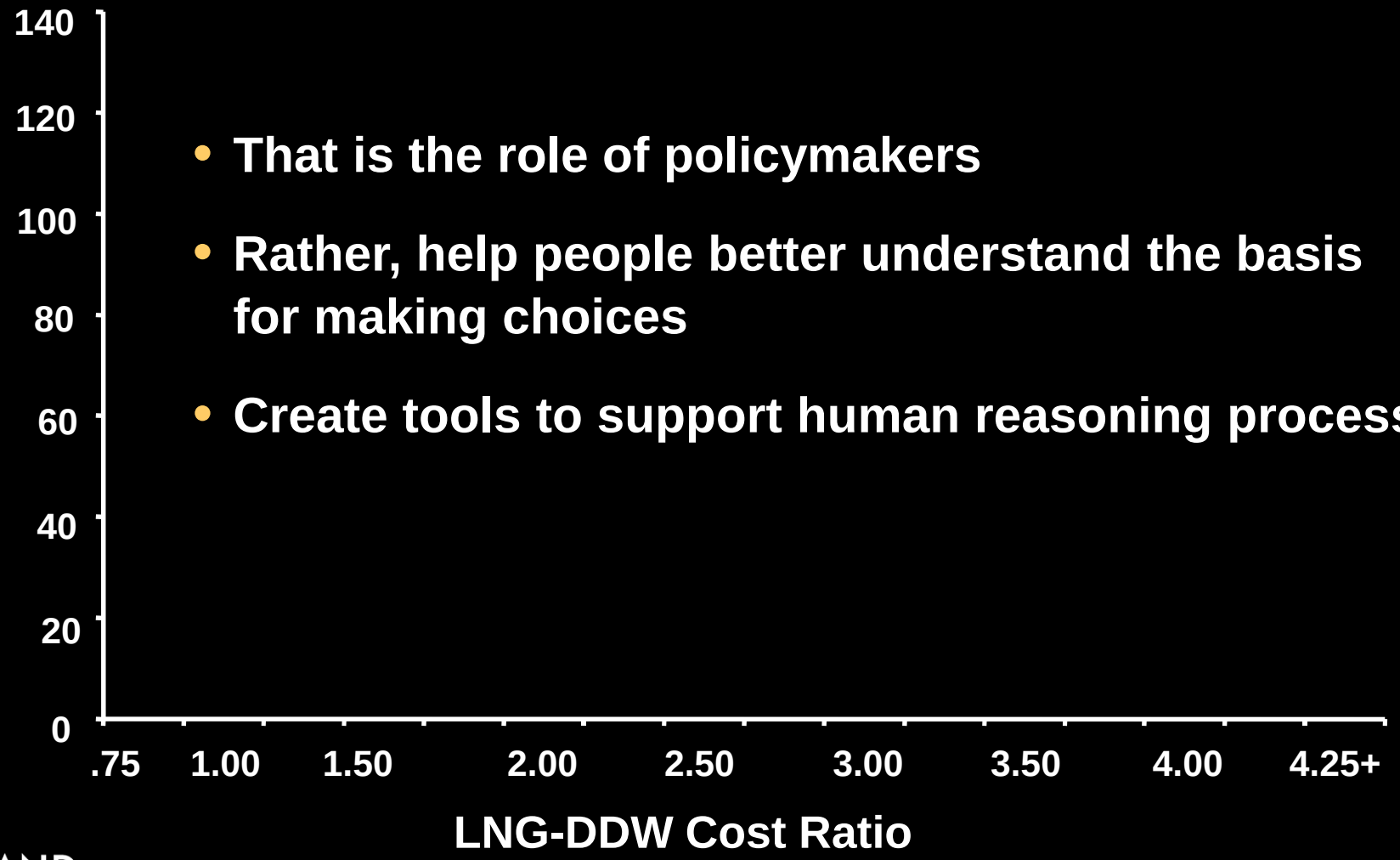
Goal Is Not to Have Computer Provide Answers

Expected **costs above least cost for each scenario (%)**



- That is the role of policymakers
- Rather, help people better understand the basis for making choices
- Create tools to support human reasoning process

Report Delivered in December 2009;

In 2010…

- **Israel's Ministry for National Infrastructures decides:**
  - **To completely redo the energy master plan for the State of Israel…**
  - **…based on the principles demonstrated in the RAND study**

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