The Economics of Renewable Energy in the Caribbean

THE BARBADOS LIGHT & POWER COMPANY LIMITED

The Institute of Chartered Accountants of the Caribbean
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Roger Blackman
Barbados Light & Power Company

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Introduction

- Several factors affect the economics and rate of development of Renewable Energy (RE):
  - **Resource Availability**: Natural resources vary by country and location.
  - **Technology Availability**: Is hardware technically proven and commercially available?
  - **Technology Cost:** What does it cost to build and operate?
  - **Energy Cost:** Impact on electricity prices and how does it compare with competing technologies?
  - **Financing Options:** What financing mechanisms and terms are available?
  - **Transmission Issues:** How close is the resource to the grid and what will it cost to connect?
  - **Environmental Issues:** What impacts will the RE options have on the environment?
  - **Land-use policies:** Is the required land available and what are the competing interests?
  - **Policy & Legislative Framework:** Is there a supporting policy and legislative framework?
  - **Regulatory Framework:** Is there a supporting regulatory framework?
  - **Social acceptance:** What are public attitudes toward specific RE technologies?

- There is no 'one-size-fits-all' solution

Objectives

- Review factors that affect RE development
- Review best-practices in electricity planning for achieving ‘optimal’ energy mix
- Discuss some of the critical success factors:
  - Integrated Resource Planning Approach
  - Supporting Policy & legislative Framework
  - Independent Regulatory Framework

Presentation Overview

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- Energy Basics
  - Definitions and Concepts
- Energy Supply Options & Characteristics
  - Overview of Energy Sources
  - Firm & Intermittent Energy Resources
- Economic Evaluation of Renewable Energy
  - Levelised Energy Costs
  - Integrated Resource Planning
- Conclusion
  - Critical Success Factors

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Energy Basics

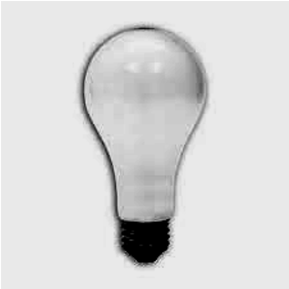
Common Energy Units

- Electrical energy typically measured in kilowatt-hours (kWh)
  - Power (Watts) x Time (hours)

- Fuel energy typically measured in millions of British Thermal Units (mmBTU)
  - 1 BTU is the amount of energy required to heat 1lb of water by 1 degree F
  - 1 BTU = 3,412 kWh
  - Approximate present cost of fuels commonly used in Caribbean:
    - Heavy Fuel Oil – US$19/mmBTU
    - Diesel – US$24/mmBTU
    - Natural Gas – US$4 to 14/mmBTU

- Efficiency of Electricity Production
  - 'Electrical Energy Output / Fuel Energy Input' expressed as a percentage; or,
  - 'Fuel Energy Input / Electrical Energy Output' expressed as BTU/kWh

Energy Consumption in Everyday Life



40W light bulb (continuous operation): ≈ 1kWh per day

Average Barbadian home: ≈ 8 kWh per day

2,500 Calories per day = 3 kWh per day

30 kWh per day (30km per day @10 km/litre)

<u>Conventional Car</u>
Gasoline cost in B'dos – US$1.60 per litre
Fuel consumption – 10 km per litre
} US$0.16 per km

<u>Electric Car</u>
Range – 121 km per charge
Battery capacity – 24 kWh
Electricity cost (in Barbados) – US$0.36 per kWh
} US$0.08 per km

How is Energy Valued?

- Energy sources traditionally valued based on:
  - Availability
  - Ease of storage and transport
  - Efficiency of conversion to useful energy
  - Energy Density

1 lb Oil

≡

3 lbs Wood

≡

5 lbs Bagasse

≡

21,000 AA-batteries

Energy Density

1 lb
Uranium-235

≡

1.8 million lbs
Oil

Energy Density (cont'd.)

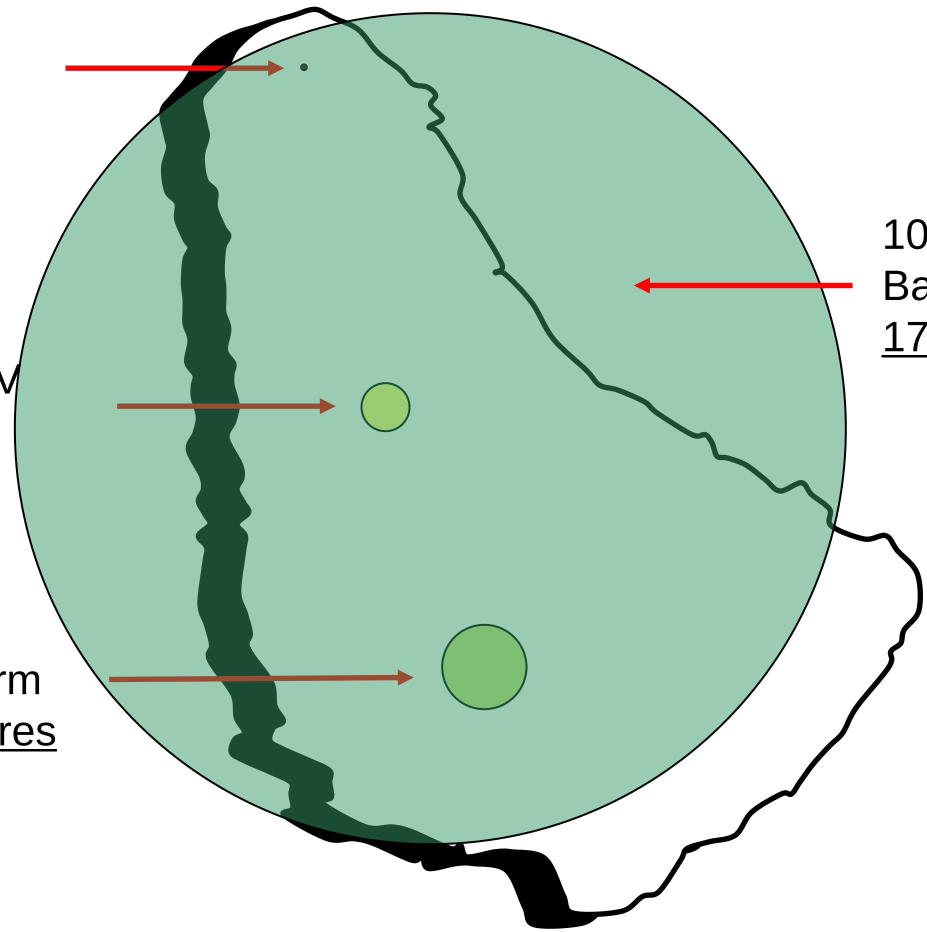
Technology Footprint

100 MW
Conventional Power Plant
<u>10 acres</u>

100 MW
Bagasse Power Plant
<u>170, 000 acres</u>

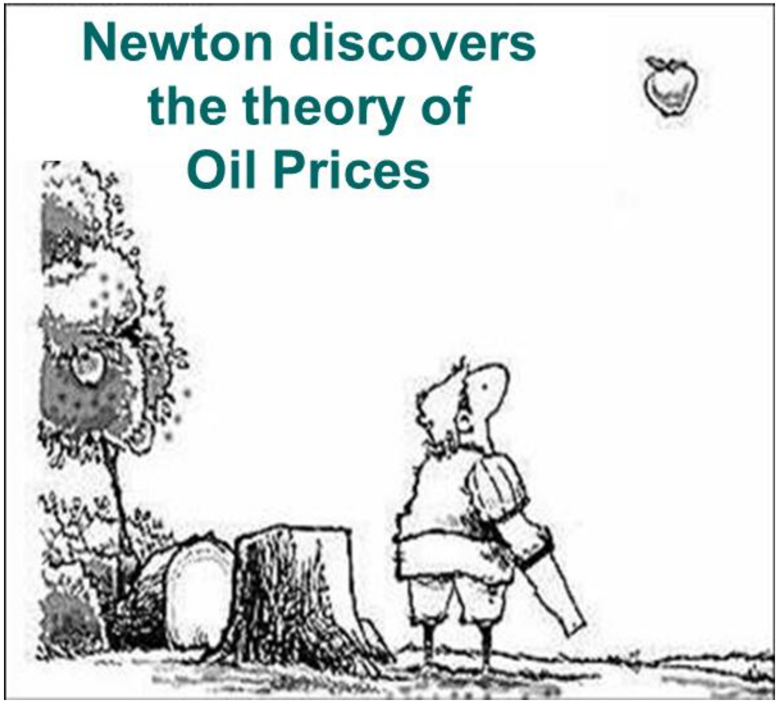
100 MW Solar PV
<u>550 acres</u>

100 MW
Wind Farm
<u>1,720 acres</u>



Value of Renewables

- RE technologies address several challenges posed by fossil fuels:
  - Energy Security
  - Environmental Impact
  - Depleting Resource
  - Price Volatility



Energy Supply Options & Characteristics

Energy Supply Options

- Renewable:
  - Wind
  - Solar PV / Thermal
  - Biomass
  - Geothermal
  - Hydro
  - Landfill Gas-to-Energy
  - Waste-to-Energy
  - ***Energy Efficiency***

  - Ocean Thermal Energy Conversion
  - Wave
  - Tidal

Technically & Commercially Proven ↕ Under Development

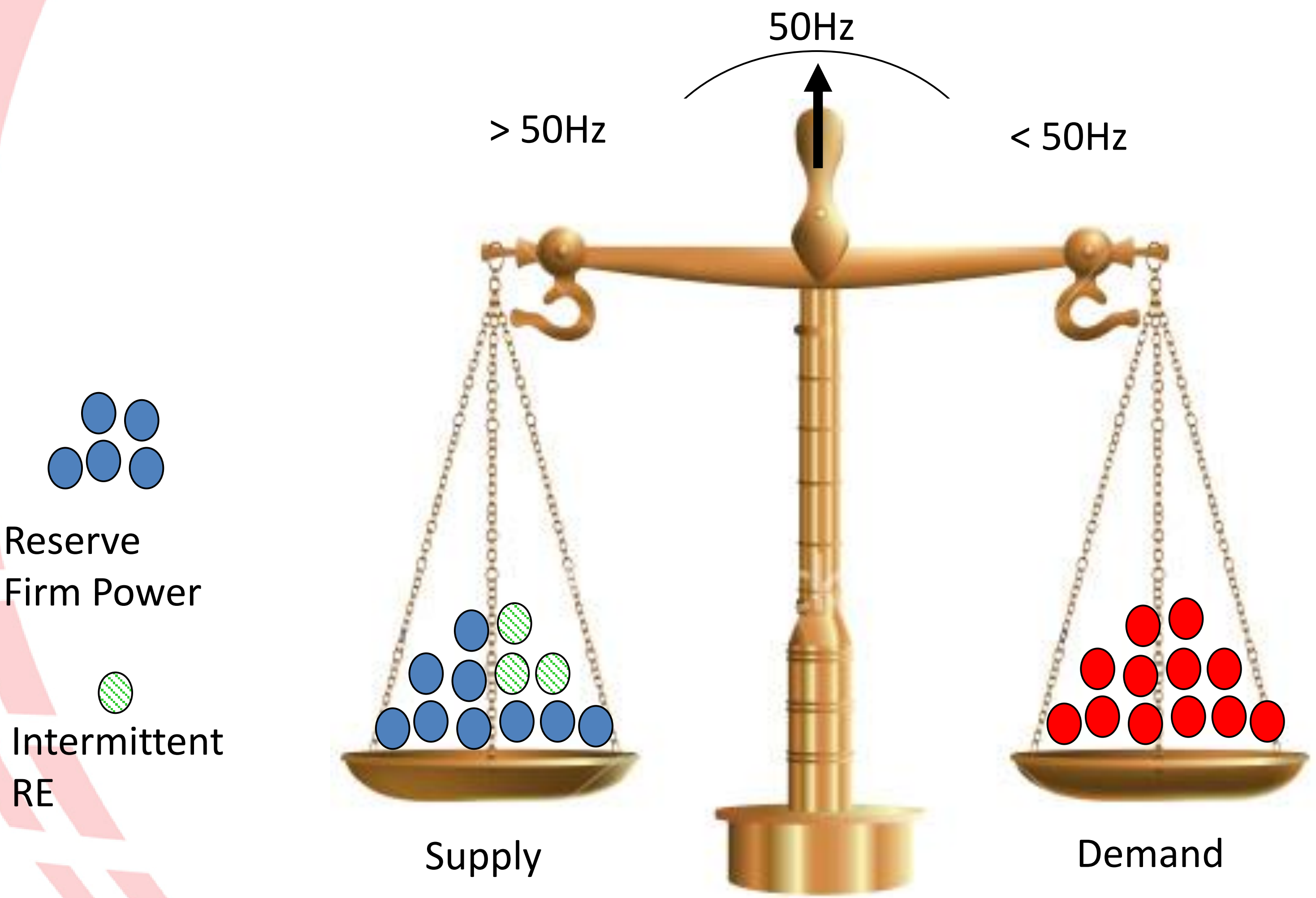
- Non-Renewable:
  - Use Conventional Fuel more efficiently
  - Natural Gas
  - Coal / Pet Coke

Firm & Intermittent RE

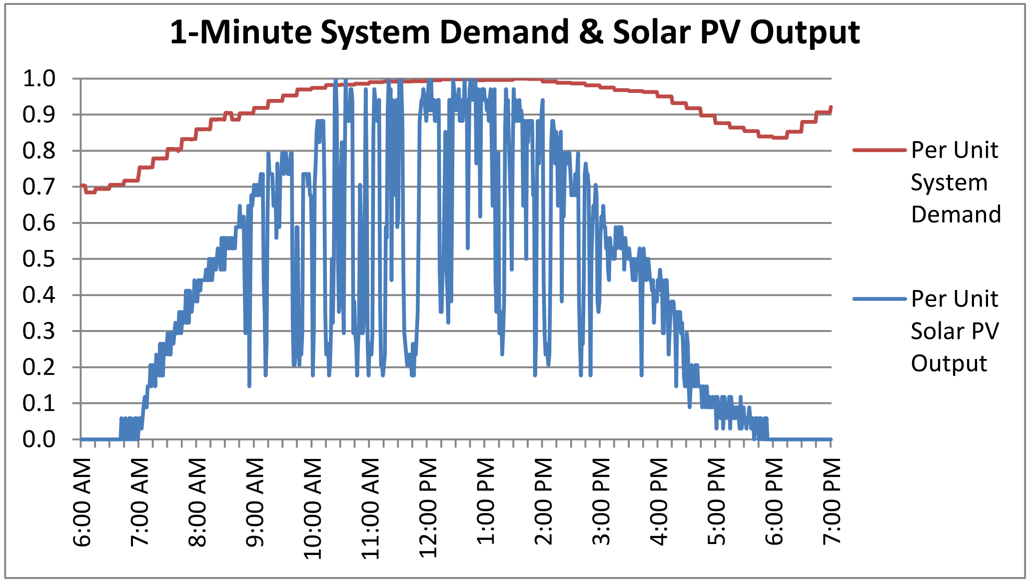
- Firm RE
  - Electrical output can be dispatched as required
    - Biomass
    - Geothermal
    - Hydro
    - Landfill Gas-to-Energy
    - Waste-to-Energy

- Intermittent RE
  - Electrical output cannot be dispatched, i.e. it is limited by the availability of the energy source
    - Solar PV
    - Wind
  - Special considerations required for grid interconnection of intermittent RE to maintain network stability and reliability

Supply & Demand Must Always be Balanced



Solar PV Example



- Potential Solutions:
  - Geographic diversity of distributed solar PV
  - Storage technologies
  - Operating reserve margins

- Intermittent RE Penetration Study should be conducted

Economic Evaluation of RE

Levelised Cost Of Energy

- Levelised Cost of Energy (LCOE) methodology compares the life-cycle cost of producing a unit of electricity from various technologies

LCOE = I + O&M + F Where, I = annualized investment cost (BDS$/kWh)
O&M = operation and maintenance cost (BDS$/kWh)
F = fuel cost (BDS$/kWh)

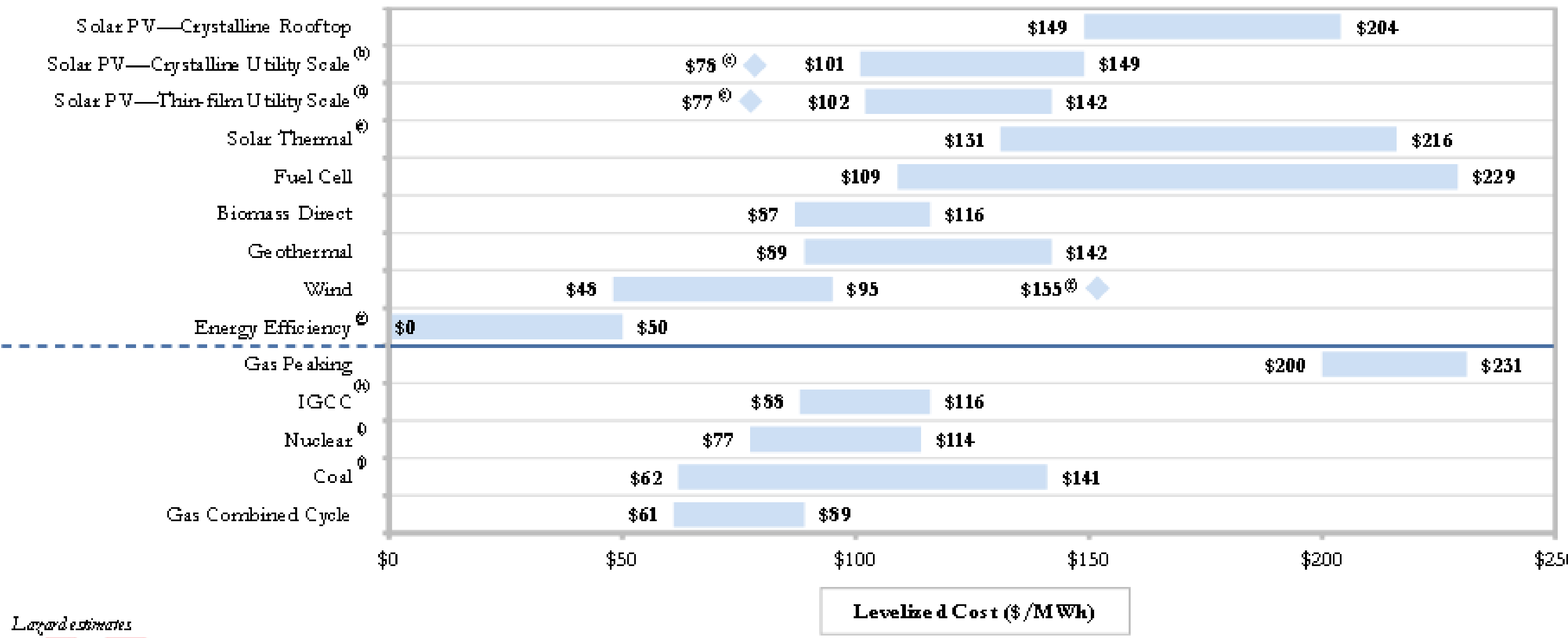
- Convenient summary measure of the overall competitiveness of different generating technologies

- Useful tool for policy discussions

- Evaluates technologies on a 'stand-alone' basis and therefore cannot be used to determine expansion requirements

LCOE Comparison

(2012 analysis)



Source: Lazard Levelized Cost of Energy Analysis – June 2012

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Integrated Resource Planning (IRP)

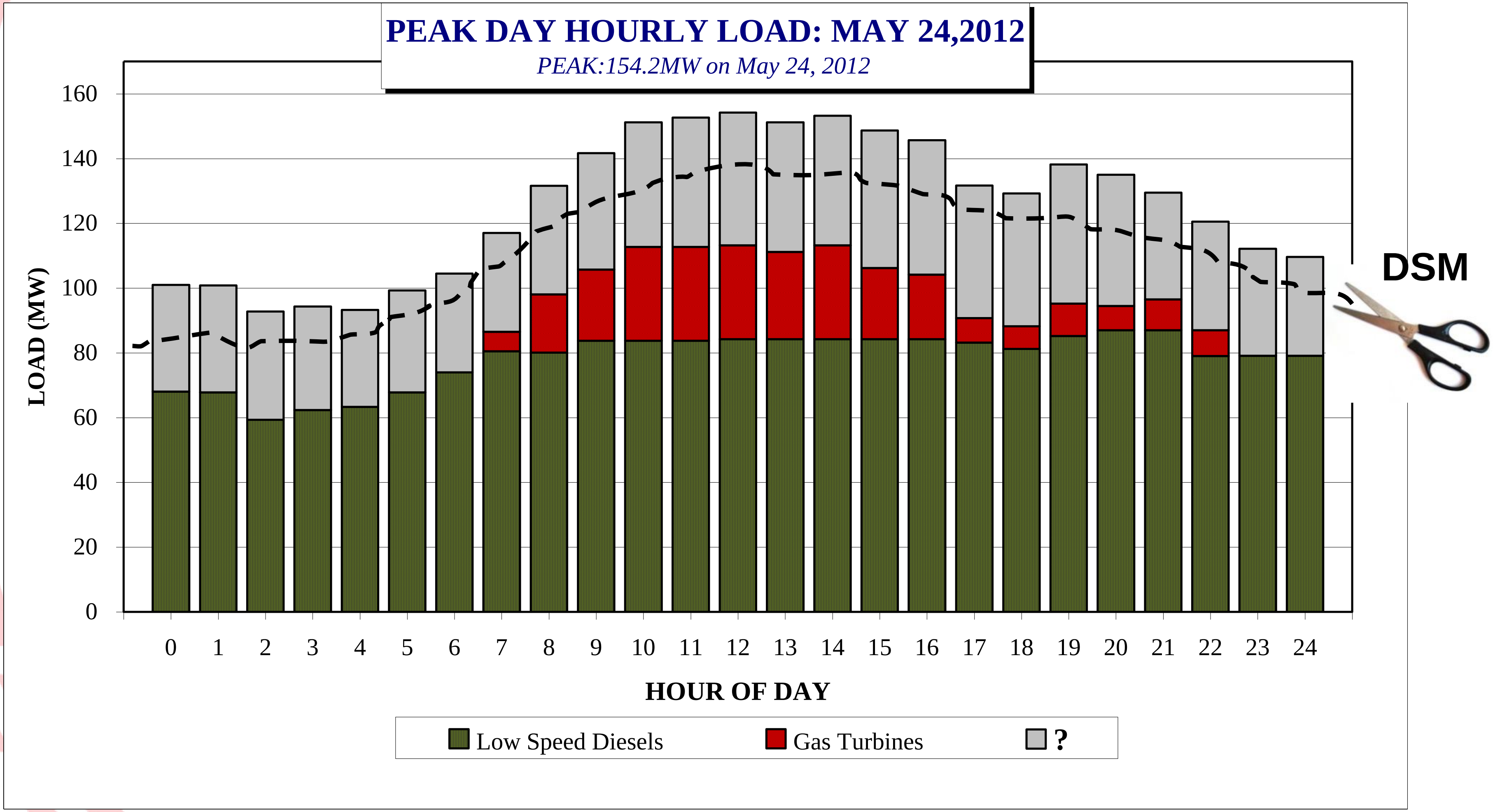
- Electricity planning best practice to determine long-term (20 to 30 years) 'road-map' for reliable least-cost electricity supply
  - Identifies 'optimal' mix of RE and conventional technologies

- Considers trade-offs between financial and non-financial criteria e.g. environmental impacts and energy security

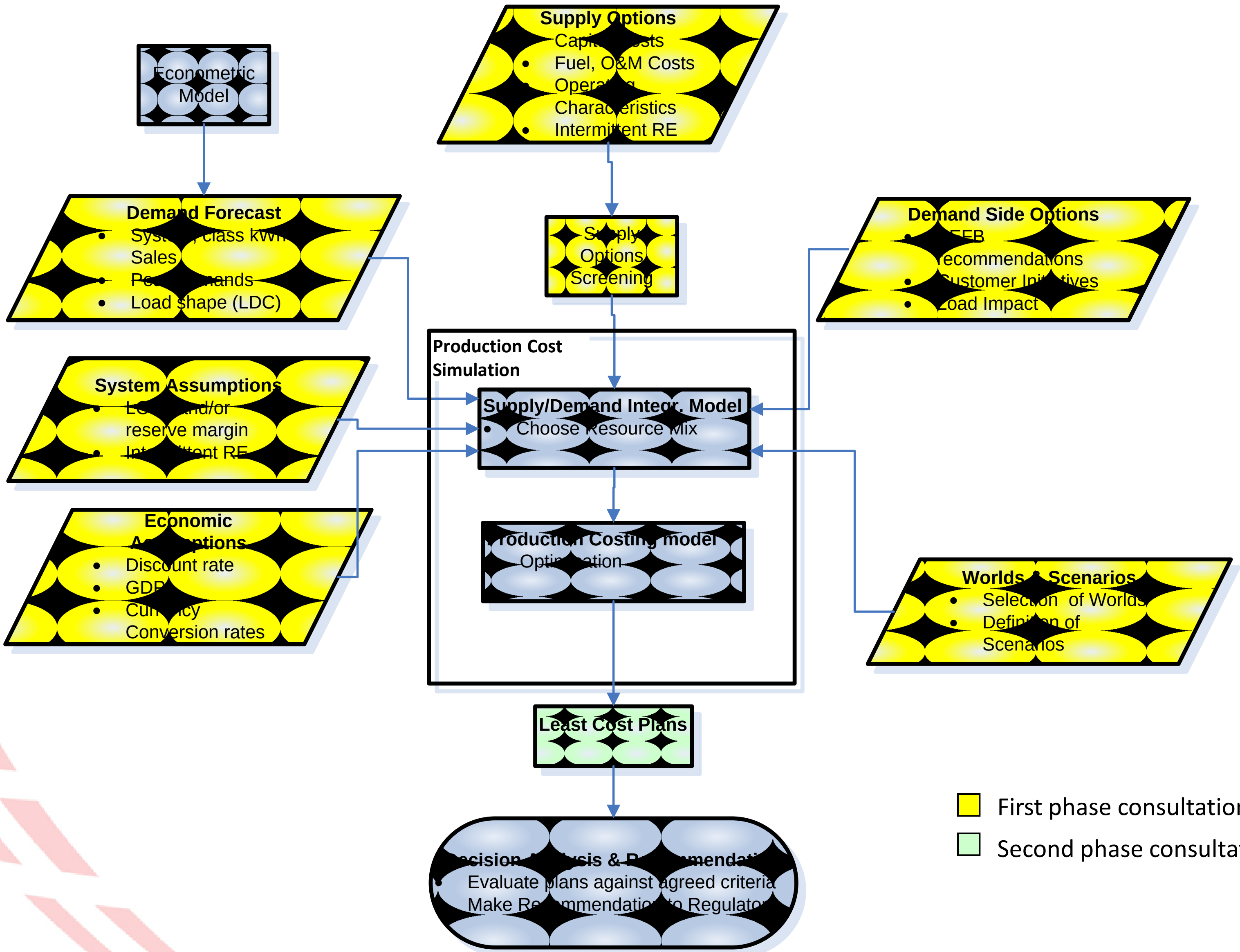
- Involves public participation

- Considers all resources
  - **Supply-side**: Electricity generating technologies
  - **Demand-side**: Energy efficiency or other measures which modify consumer demand

Demand Side Resources



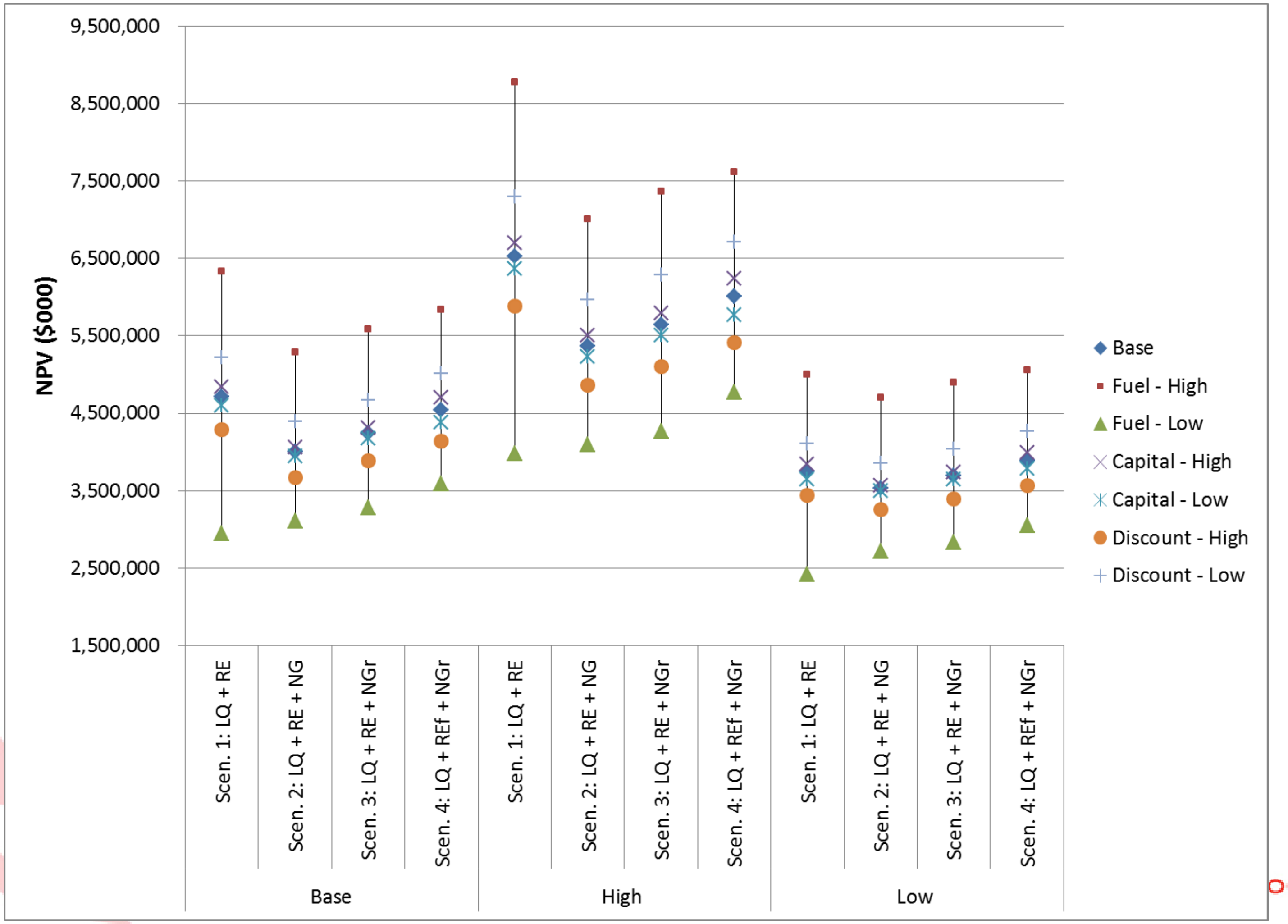
IRP Process



- First phase consultation
- Second phase consultation

Sample IRP Output

NPV & Sensitivity Analysis



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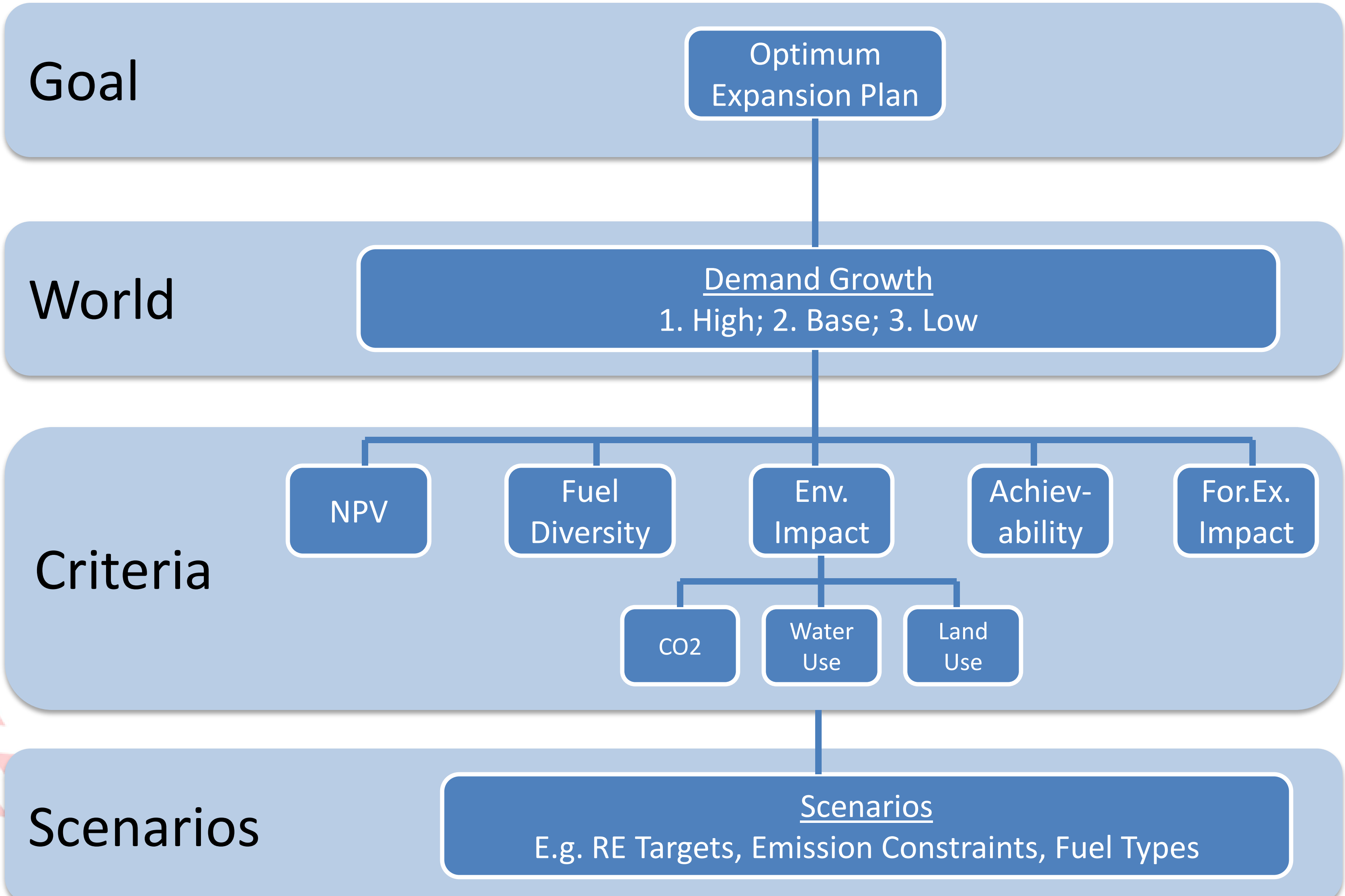
Sample IRP Output (cont'd.)

Decision Hierarchy



Sample IRP Output (cont'd.)

IRP Sample Criteria Achievement Table

Worlds	Scenarios	NPV ($000)	C02 (million MT)	Water (million Ga)	Land Use (acres)	Fuel Diversity	Foreign Exchange ($000)	Achievability	2017 Gas Interruption Cost ($000)
Base	LQ + RE	4,718,007	17,874	2,736	552	34.30%	4,192,718	High	
	LQ + RE + NG	4,003,169	13,513	4,475	385	37.28%	3,696,372	Medium	102,410
	LQ + RE + NGr	4,242,772	15,019	978	66	59.78%	3,856,238	Medium	59,236
	LQ + REf + NGr	4,539,107	12,614	2,948	1,026	71.95%	3,928,066	Low	43,345
High	LQ + RE	6,533,100	27,677	2,885	583	26.85%	5,906,882	High	
	LQ + RE + NG	5,370,996	13,847	6,471	767	65.90%	4,721,986	Medium	
	LQ + RE + NGr	5,647,944	24,273	1,952	773	67.10%	5,084,604	Medium	
	LQ + REf + NGr	6,009,076	20,751	4,646	1,045	75.58%	4,987,311	Low	
Low	LQ + RE	3,743,509	12,674	2,633	537	43.16%	3,263,432	High	
	LQ + RE + NG	3,527,547	10,785	3,066	14	43.87%	3,267,055	Medium	
	LQ + RE + NGr	3,691,844	11,428	837	34	48.14%	3,370,626	Medium	
	LQ + REf + NGr	3,890,652	9,506	2,735	196	74.13%	3,372,432	Low	

Conclusion

Critical Success Factors

for the cost efficient and sustainable deployment of RE

- Integrated Approach to Resource Planning
  - Consider both supply and demand resource options
  - Scenario planning: Identify least-cost solutions for a variety of plausible scenarios
  - Consider non-financial criteria – guided by Gov't policy e.g. environmental, energy security
  - Stakeholder consultation and participation

- Supportive Government Policy and Legislative Framework
  - Ensure reliable and cost-effective power supply
  - Maximise efficiency in production, distribution and end-use of electricity
  - Reduce dependence on oil where economically feasible
  - Balance economic, environmental and security priorities

- Independent Regulatory Framework
  - Free from undue political or other influences
  - Stakeholder consultation and participation
  - Consistent and transparent decision making processes

Thank you!

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