

# DEPARTMENT OF ENERGY



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# Integrated Resource Plan

An introduction for  
stakeholder consultation



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# Contents

- Context
- Generic Inputs
- Formulation of the problem
- Modeling Method
- Integrated Resource Planning Process
- Fact Base



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# Context

- The Integrated Resource Plan in the South African context is not the Energy Plan – it is a National Electricity Plan.
- It is a subset of the Integrated Energy Plan.
- The IRP is also not a short or medium-term operational plan but a plan that directs the expansion of the electricity supply over the given period.



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# Context



- The Long-term Electricity Planning goal is to ensure sustainable development considering:
  - Technical constraints
  - Economic constraints
  - Social constraints
  - Externalities
- What is its purpose?
  - In theory, identification of the requisite investments in the electricity sector that maximize the national interest.
  - In practice - identification of the investments in the electricity sector that allows the country to meet the forecasted demand with the minimum cost to the country.



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# Context – Why a long-term plan

Electricity Availability is directly correlated with the economic growth (GDP) and social welfare of a nation (especially for developing countries)

- Industry, services, communications, airports
- Education, health, safety, food..

- Electricity cannot be effectively stored
- Electricity demand must be met instantaneously
- Requirement of several years for new supply commissioning
- Linked to other infrastructure development

## Anticipation is Essential

- Anticipation of the needs: future demand of the customers must be projected.
- Anticipation of the supply: facilities must be prepared to supply at the right time with the right amount of energy at the right quality of service and at the right price



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# The IRP needs to answer the following questions

- What are the electrical energy requirements for South Africa to achieve the aspiration of sustainable economic growth?
- By when is the capacity needed?
- What is the appropriate mix of technologies to meet these needs that ensures South Africa can meet its commitments to climate change initiatives, ensures adequacy of supply, impacts the local manufacturing base, maintains a competitive position in the global arena and ensures sustainable use of local and regional resources?



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# The IRP needs to answer the following questions



- What are the linkages and dependencies on other resources such as water, primary energy sources, skills, sorbents, transmission infrastructure and land?
- What will it cost to meet these needs and how will it be funded? What will be the impact on future electricity prices and will they remain competitive?



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# The IRP needs to answer the following questions

- What will it cost to meet these needs and how will it be funded? What will be the impact on future electricity prices and will they remain competitive?
- What is required to implement this plan, what is the level of confidence in achieving this, what are the commitments required and who are these required of?



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# Formulation of the Problem

- PRIME OBJECTIVES OF THE ELECTRICITY GENERATION SYSTEM:
  - To satisfy the demand instantaneously for each eventuality
  - Within a defined level of reliability
    - Loss of Load Probability (LOLP)
    - Cost of Unserved Energy
  - At the least cost
    - Expansion plan Min [NPV (Investments +fixed cost variable cost+ cost of failure+ cost of externalities) ]



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# Decision making under uncertainty

- Since the plan is about making decisions about the future state. It is a plan developed with a degree of uncertainty.
- This requires at least 2 approaches:
  - A STATIC APPROACH
  - A DYNAMIC APPROACH (PROBABILISTIC)
    - Two main Techniques
      - Convolution
      - Monte Carlo simulations



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# Multi-criteria decision-making

- MCDM incorporates more than one criteria to resolve trade-offs and objectives outside the traditional least (direct) cost approach
- The approach applies the four criteria to each plan resulting from the scenarios
  - Develop partial value functions for each criteria
  - Apply the partial value functions to the metrics for each criteria (measuring different aspects of the plans)
  - Determine swing weightings for the criteria
  - Select an optimal plan based on these weightings and value functions



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# Current Models

- Load Forecasting

- SO: A time series analysis of historic trends at individual customer and/or sector level, adjusted for non-repeatable events, is adjusted through expert knowledge and judgement for known and assumed parameters that will impact future electricity consumption.
- CSIR: An econometrics model utilising economic and demographic parameters has been constructed that calculates the forecast based on algorithms that utilise these parameters in the input function.

- Expansion planning model

- Plexos:
  - Capable of doing static and dynamic (Convolution and Monte Carlo)
  - Can include additional requirements such as emission constraints



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# Key IRP Outcomes

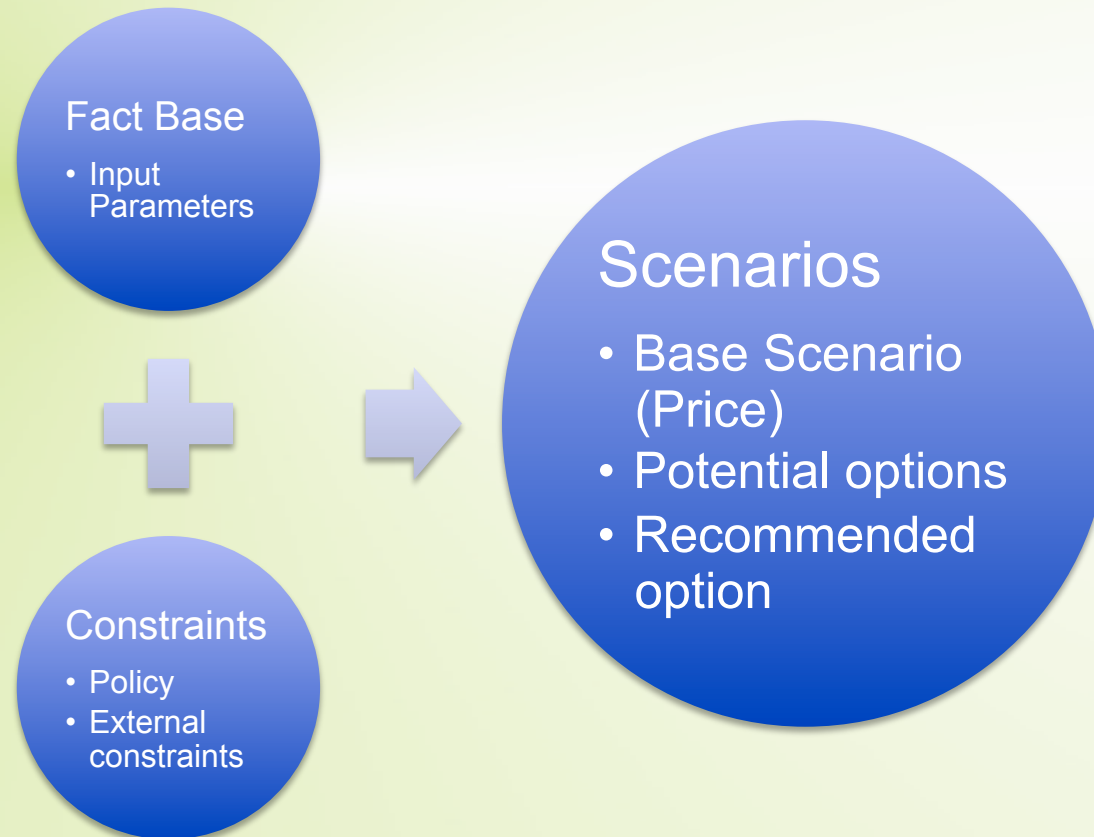
- **Price Cone**
  - RSA Ave Price Cone
  - Gx Price Cone
- **Carbon Impacts and effects**
  - Emission Constrained
  - Cost of Carbon
- **Security of Supply**
  - Adequacy
  - Cost of Unserved Energy (used to estimate the economic impact on customers of planned and unplanned outages)
- **Generation Mix**
  - Technology



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# IRP Process Diagram



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# Reviewing Output and making recommendations

- Review each Scenario modelled
  - Output needs to be scrutinised to:
    - Find potential modelling and input errors
    - Unrealistic expansion options
    - Review Reserve Margin, (Reliability Criteria)
    - Review load factor (Gas turbines – fuel logistics), pumped storage operations, energy limits
    - Review practicalities – Expansion Plan is a simplification of the problem
      - (Time between units commissioning, Is CCGT load profile practical/ day not night - continuous).
- Test the plan with a production study



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# Reviewing Output and making recommendations

- Cost the plan and estimate the tariff impact
  - Even if the costs are benchmarks (or not final)
- Review if Policy objectives are met
  - Competitiveness, Social development issues, localization etc
- Review against the broader picture of infrastructure development
- Recommend the most suitable plan
  - Develop a decision making framework



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# Key Policy Areas

- Energy Policies and Strategies:
  - Nuclear Policy
  - Renewable Energy Policy (Climate Change)
  - Imports (Regional Development) Policy
  - Diversity of energy sources (Mix)
  - Energy Efficiency Policy/Strategy
  - Adequacy (Reliability) criteria for generation
  - Industrial Development Policy



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# Key Scenarios

- Scenarios that require investigation
  - Demand scenarios
  - Supply scenarios
  - Economic scenarios
  - Climate change scenarios
  - Import & Export scenarios (Regional Development)



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# IRP 2010 Scenarios

- Baseline / Reference
- Carbon - emission constrained
- Carbon – carbon taxed
- Generation diversity
- Policy, Risk & Constraint adjusted

(IRP 2010 recommended)

This scenario will include sufficient detail on issues for immediate policy implementation such as:

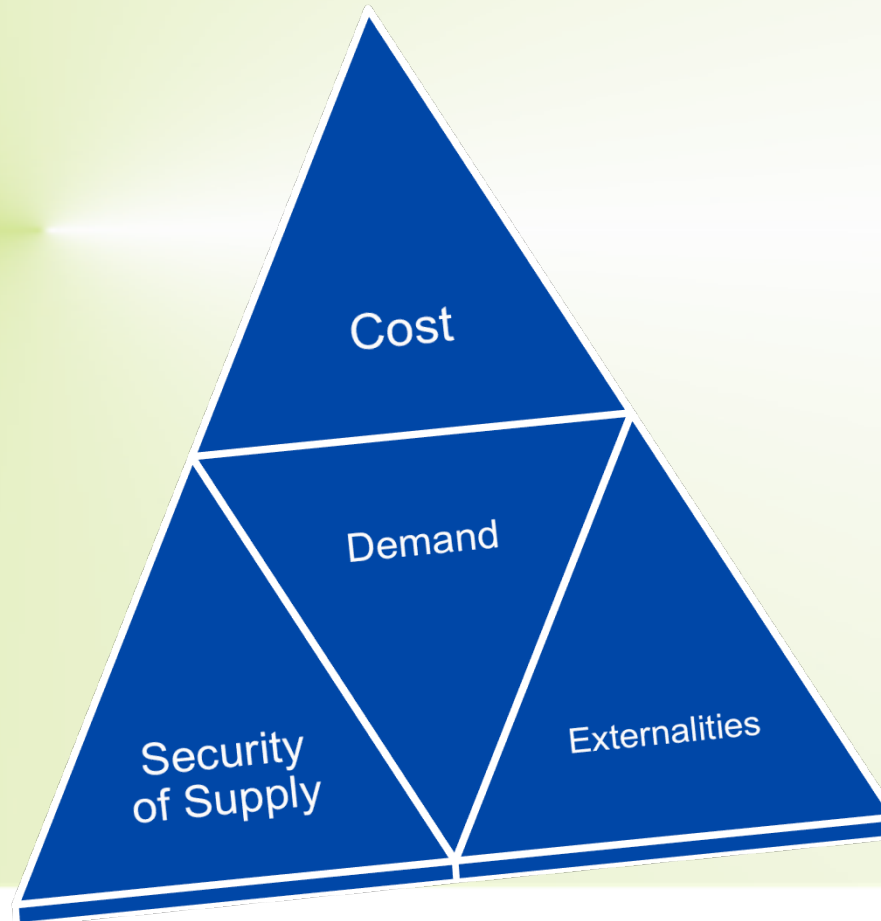
- Non Eskom generation
- Critical decision milestones
- Critical actions for the ministries
- Inputs to national planning



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# Balancing the equations



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# The Models require the following Inputs for each scenario



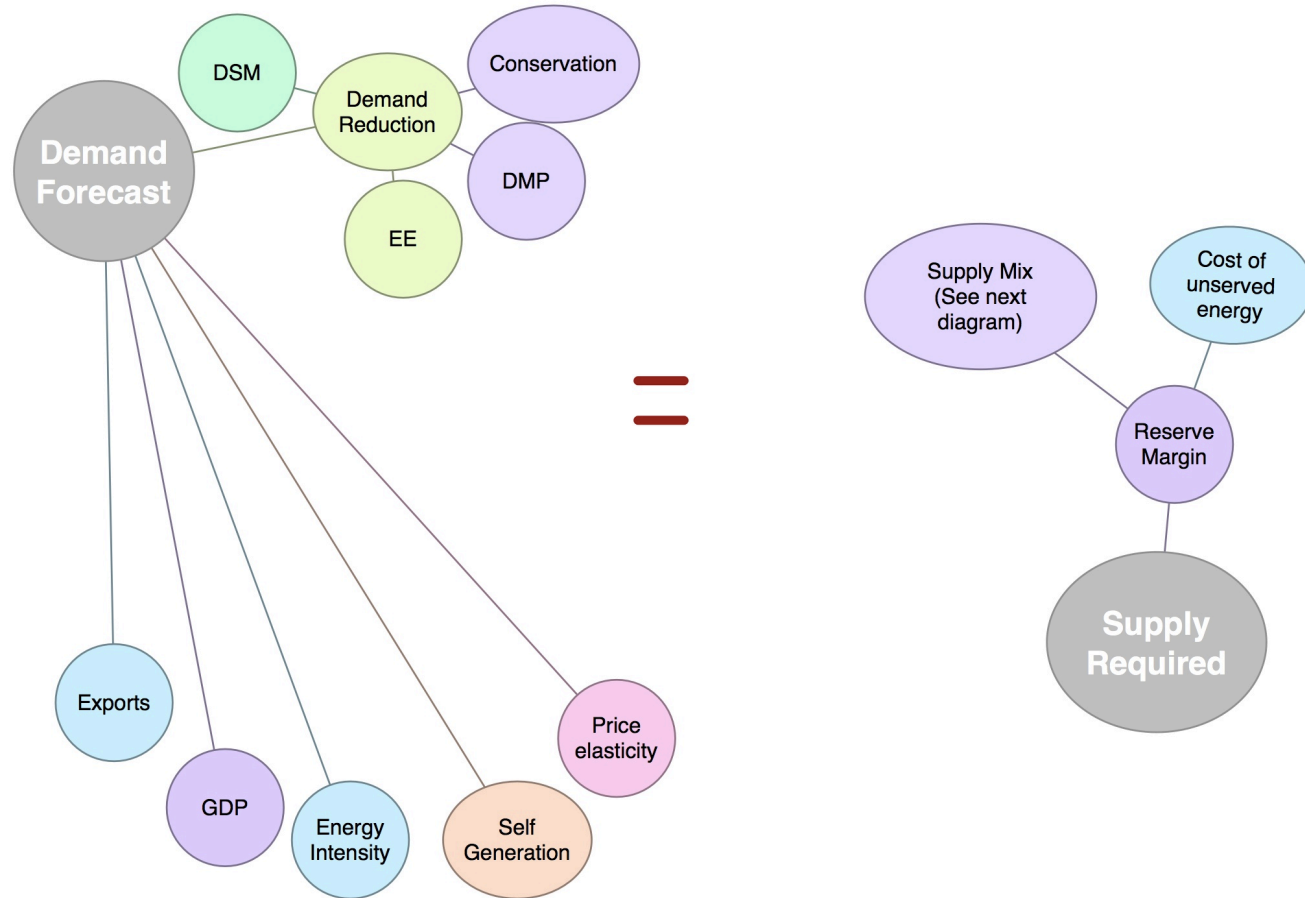
- General Inputs
  - Discount rate
  - Cost of unserved energy
  - Reliability criteria
- Demand Inputs
  - Demand forecast
- Supply Inputs
  - Levelised costs
  - Load factors
- Externalities
  - Cost of carbon



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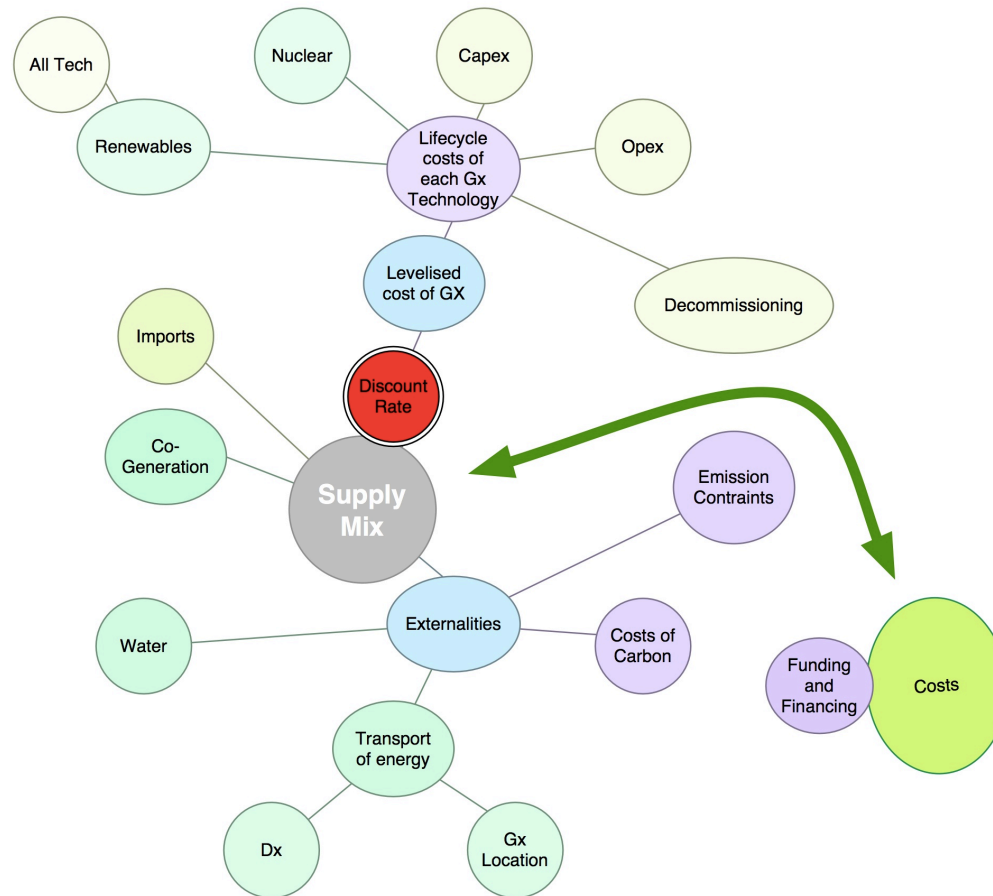
# Demand Parameters



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# Supply Parameters



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# Generic Inputs

In developing an IRP there are many variables which need to be exogenously determined (inputs). Most important ones are:

- Fuel prices projections
  - Crude oil barrel, ton of coal, m3 of Natural gas
- Description of the existing generation mix
  - Capacity, fuel, efficiency, FOR , POR, decommissioning date, CO2 emissions, fixed cost and variable cost, required reliability
- Investment criteria :
  - Discount rate
- Demand projection (s)
  - Annual peak load in MW & Energy in GWh



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# The critical consultation sheets



Parameter	I/O	Impacts
Discount rate	Input	Price cone, Mix
Demand Forecast	Input / Policy	Security of supply
Energy Intensity (Long)	Input / Policy	Security of supply
Energy Intensity (Short)	Input / Policy	Security of supply
Economic multipliers	Modelling	Key Outcome
Rate of Exchange	Input	Price cone
Inflation	Input	Price cone
GDP	Input	Price cone
Cost of energy not served	Input	Security of supply
Price Elasticity	Input	Price cone
DSM	Input / Policy	Security of supply
EE	Input / Policy	Security of supply
DMP	Input / Policy	Security of supply
Conservation	Input / Policy	Security of supply
Gx Mix Parameter	Output	Price cone
Cogeneration	Input	Price cone
Nuclear	Policy	Carbon
Funding / Financing	Output	Price cone



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# The critical consultation sheets



Parameter		Impacts
Gx Lifecycle Costs	Input	Price cone
Reserve Margin	Input	Security of supply
Own Generation	Input	Price cone
Imports	Input	Security of supply
Price cone	Output	Key Outcome
Renewables	Input / Policy	Carbon
Water	Input / Output	Externality
IRP 2010 Approach & Methodology Overview		Governance
IRP Consultation Plan		Governance
Carbon & Climate Change	Input / Policy	Carbon
Carbon taxes	Input / Policy	Carbon
Distribution	Input / Policy	Externality
Base Scenarios	Input / Policy	Key Outcome
Gx Location	Input / Policy	Externality



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# Demand Forecast

## Parameters



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# Demand Inputs

Different demand scenarios based on different assumptions:

- Explanatory variables (determinants of electricity demand)
  - Gross Domestic Product (GDP)
  - Output from specific industries, in particular manufacturing and mining (gold, PGM, iron, coal)
  - Electrification
  - Population
  - Energy intensity = relationship between production output and electricity demand.



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# Demand Inputs

Different demand scenarios based on different assumptions:

- Additional considerations:
  - Electricity Prices (elasticity)
  - Weather effects (especially temperature)
  - Viable substitutes to electricity
  - Technology impacts (Smart Grids & electric cars?)
  - Known large-scale projects
- Demand side management (DSM) programmes
  - Expected energy impact
  - Expected demand profile impact
  - Costs (fixed and variable)



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# Generation Mix

## Parameters



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# Supply Inputs

- Potential technologies
  - Coal, Nuclear, Gas: CCGT and OCGT, Renewable technologies (Wind, Solar, Biomass and Geothermal), Hydro and **Pumped Storage etc**
- Plant Costs (Exchange Rate required)
  - Investment (Total overnight costs, Expense schedule, Lead-times)
  - Refurbishment
  - Decommissioning



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# Supply Inputs

## – Fuel

- Cost in each year for economic life of plant or price at reference date plus expected escalation during economic life of plant
- Fuel energy content (where applicable) and availability (water)

## – Operation and Maintenance (O&M)

- Cost in each year for economic life of plant or price at reference date plus expected escalation during economic life of plant



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# Supply Inputs

- Plant Availability Data
  - Maintenance (or Planned Outage), Unplanned Outages
- Plant Technical Parameters
  - Plant Economic life, Efficiency(ies) and/or Heat Rate(s), Plant Load factor
- Plant Water Usage
  - The water usage per unit of energy output for each Plant Technology Type.
- Plant Sorbent Usage



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# Supply Inputs

- Plant Emissions

- The costs of pollution control equipment, waste management and any required health and environmental protection measures
- Pollution Control Technologies included in, and the impact thereof on
  - Plant cost, Plant availability and Plant technical parameters



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# Externalities

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# Externalities, constraints and Policy

- Emissions - Co<sub>2</sub>, other particulates
- Water
- Skills
- Transmission issues
- Finance / Funding
- Policy Directions on technology - Nuclear, coal and Renewables
- Plant Sorbent Usage restrictions



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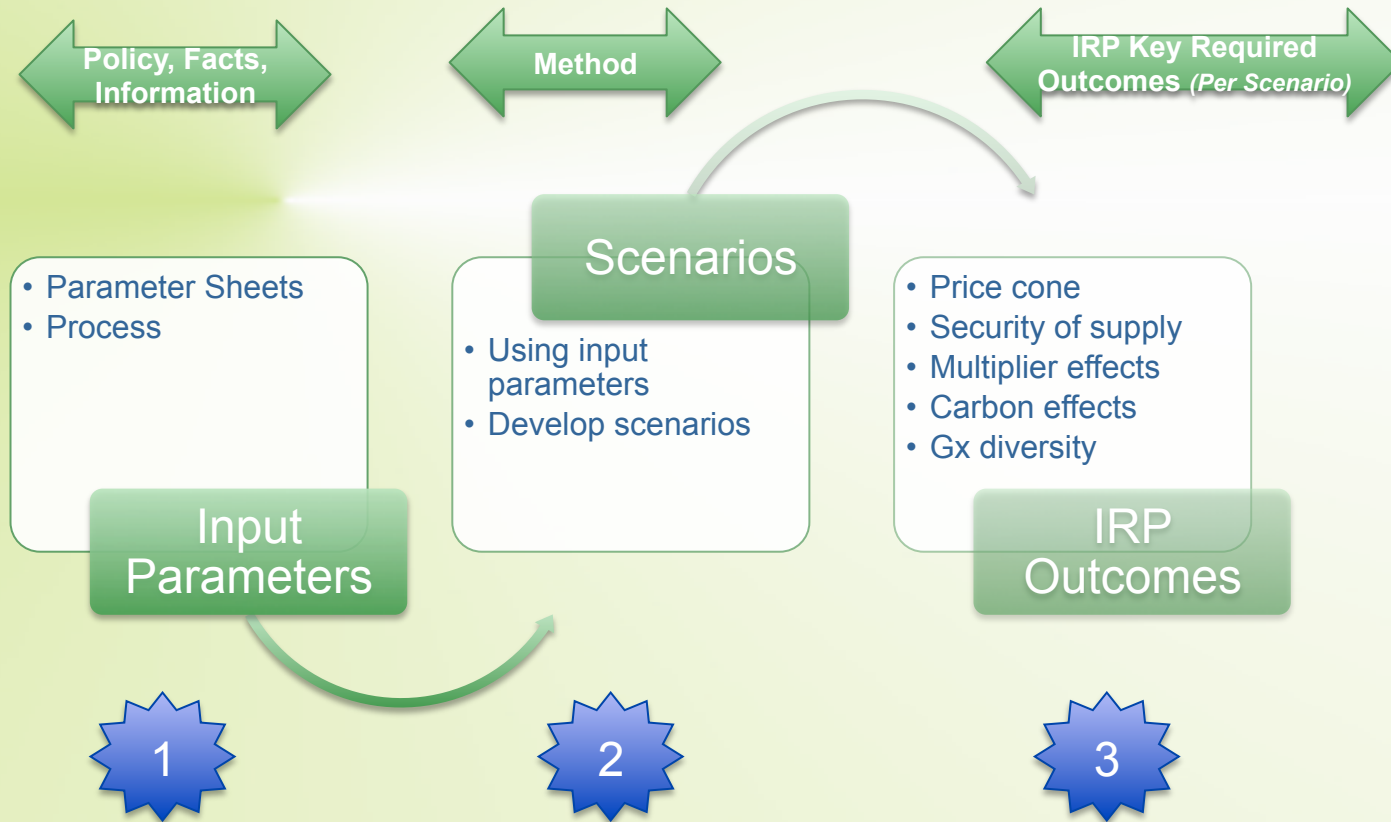
# Integrated Resource Planning Consultation Process



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# 3 Major IRP consultation points



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# Conclusion

- We need to complete the fact base before we can model
- The model produces scenarios which can then be interrogated
- At scenario point choices need to be made and those choices require explanation
- Scenario of choice is further developed into the plan.



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