Kazakhstan Power Sector
Master Plan

USAID Power The Future
Capacity Building Program, Module 1
November 2018
Topic 2: Investment appraisal

20 November 2018
Contents

1. Relationship between objectives and methodologies
2. Cost-Benefit analysis, Financial and Economic evaluation
3. Time preferences and the discount rate
4. WACC and the CAPM
5. Risk Analysis and other indicators
1. Relationship between objectives and methodology
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1. Relationship between objectives and methodologies
2. Cost-Benefit analysis, Financial and Economic evaluation
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Objectives and methodologies

- A key objective of Master Planning is to develop a least cost expansion path for new capacity over the planning period.
- An implicit assumption is that at “least cost” each plant owner can at a minimum recover its costs incurred, including a return on its investment.
- If not, the Plan is not sustainable as many identified actors will not invest.

What is the process for investment appraisal?
Objectives and methodologies

• Any investor in an electricity asset will have a reasonable idea of upfront costs but high uncertainty over the future

• A difficulty in the investment decision is the nature of electricity costs:
  • Long lead times
  • Most large costs arising early in a project e.g. from construction
  • At the same time, the stream of benefits from a project occur over a much longer period of time and may be highly unclear.

How can these costs and benefits be evaluated and weighted?
2. Cost Benefit Analysis, Financial and Economic evaluation
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Cost Benefit Analysis

• CBA is a tool for evaluating between various projects or alternatives
• Considers costs of implementation and benefits
  • Can be economic or financial in nature
  • Reflects timing of costs and benefits
• Minimum number of potential projects or scenarios is 2
• Do-nothing or Business-as-usual
  • Introduce the project
• CBA does not avert the need for prior technical analysis
• However, it provides a means to assess project viability
Cost Benefit Analysis and electricity infrastructure

• CBA has increasingly important role in decisions related to the development of electricity infrastructure

• Number of factors support its use
  • Costs are highly loaded in the early years, while benefits arise over time
  • A wide range of benefits may apply
  • Benefits are spread across various participants
  • Benefits are highly uncertain
  • Many benefits are social and economic in nature, and won’t be captured by a private investor
  • Functionality and benefits are interlinked
  • Certain forms of investment aim to change consumer behaviour
Financial and Economic assessment

- Two key ways of developing a CBA
- Economic assessment
  - Cost and Benefits occurring to the economy, including all members in society
  - Measurements are done in terms of resource costs saved and willingness to pay for units of increased consumption
- Financial assessment
  - Cost and Benefits accruing to the relevant agents (e.g., generators, transmission company)
  - Measurement are done using actual prices and the resulting financial revenue

For a private investor the financial assessment is undertaken
Financial assessment – what costs are typically included?

- All relevant capital expenditure costs ✔
  - Feasibility study and Design ✔
  - Construction costs ✔
  - Supervision ✔
  - Interest during construction ✔
- Annual operating and maintenance expenditure ✔
- Taxes and import duties ✔
- And what is not included? ✗
  - Depreciation ✗
  - Cost of capital ✗ (or not directly)
Economic assessment – what costs are typically included?

• All relevant capital expenditure costs ✔
  • Feasibility study and Design ✔
  • Construction costs ✔
  • Supervision ✔

• Annual operating and maintenance expenditure ✔

• And what is not included? ✗
  • Depreciation ✗
  • Capital costs ✗
  • Taxes and duties ✗
Benefits – notional example of large solar PV generation

- Allow system meet higher demand
- Export potential
- Security of supply
- Reduced outages
- Environmental
- Storage potential
### Stylised example of valuing benefits - generation project

<table>
<thead>
<tr>
<th>Benefit</th>
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<th>Financial evaluation</th>
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<td>Meet consumption growth</td>
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<td>Reduced outages</td>
<td>WTP or alternative resource costs</td>
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<td>Environmental costs or benefits</td>
<td>Various approaches depending on the issue</td>
<td>Excluded unless financial scheme (e.g., for emissions)</td>
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<tr>
<td>Social cost or benefits</td>
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<tr>
<td>Export volumes</td>
<td>Typically export price</td>
<td>Export price</td>
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</table>
Simple example – generation project

• Suppose an investment decision where a generation project has the following costs:
  • Capex of $100 million (inclusive of taxes) spread over 2 years
  • Opex of $4 million per annum
• And the following outputs/benefits
  • Average annual output of 500GWh
  • Average generation tariff of 3c/kWh
• Asset life of 25 years

Is it a good decision to invest in the plant?
## Notional Project cashflows

Costs and Revenues ($ million) by year

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How do we compare the costs now with the future benefits?
3. Time preference and the discount rate
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Value of time

• Would you rather have 1000 of income today or 1000 of income in the future (say in 3 years?). The answer is probably now, because 1000 in three years time is unlikely to buy as many goods and services as it does now (because of inflation). And also because 1000 put into a savings account today will yield interest.

• Discounting reflects this by reducing all future costs and benefits to express them as today’s values.

• However, what if you were offered 1000 today or 1050 in 3 years?
Value of time

• The value of time has a huge impact in planning.
• High discount rates discourage more capital intensive plans with long periods of construction.
• Social vs. private discount rates
  • Social discount rates consider time value from the point of view of society
  • Private discount rates consider the value of money for an investor
• For an investor, the key benchmark is its Weighted Average Cost of Capital (WACC)
Value of time – economic assessments

• There are many different views as to how to set an economic benchmark
• Asian Development Bank adopt a value of 10-12% proxying the cost of equity capital
• Others argue that for certain projects (e.g., those affecting climate change) a time-reducing discount rate is appropriate to capture the needs of future generations
• Most discounting approaches place greater weight on the present
• Issue also arises in nuclear decommissioning – while costs are huge, as they only arise in 75-100 years the discounted cost is trivial in project evaluation
Return to previous example (financial costs and benefits)

Costs and Revenues ($ million) by year

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Internal Rate of Return (IRR) = 9.4%

If the WACC is no more than 9.4% then the project is (prima facie) financially viable to the investor.
What does the IRR value mean?

• IRR is the annualized effective compounded return that sets the Net Present Value of all cash flows from the investment to zero

• This reflects the time value of money in that costs in the early years are given a greater weight than benefits in a later year

• The higher the IRR the more desirable the investment

• Where the IRR is at least as high as the financing cost to the firm then it is worth investing
Internal Rate of Return

- IRR Rule: The IRR is the interest rate that makes the value of the discounted cash flows equal to zero:

\[ 0 = -I_0 + \sum_{t=0}^{T} \frac{X_t}{(1 + IRR)^t} \quad \text{Accept if } IRR \geq R \]

- If the discount rate is higher than \( R \) and the discounted value is non-negative, the IRR rule is delivering a similar evaluation as NPV. If the cash flows are normal and the term structure is flat, then the IRR should give the correct evaluation for independent projects.

- Non-normal cash flows (cash flows that switch sign from year to year) generate problems when computing IRRs.

- The IRR rule can not distinguish between a $1 investment and a $1 million dollar investment.
## IRR as applied to previous example

**Costs and Revenues ($ million) by year**

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<td>Discounted revenue @9.4%</td>
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<td>7.0</td>
<td>1.1</td>
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</table>

Current costs/revenues have much greater weight in the decision making process.
Net Present Value

• NPV Rule: NPV is the dominant rule for ranking projects

\[ \sum_{t=0}^{\infty} \frac{X_{j,t} - I_{j,t}}{(1 + R)^t} > 0 \]

• In cases in which the revenues and the cost are mostly certain (small risk) it is possibly the best method.
4. WACC and the CAPM
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Weighted Average Cost of Capital

- The WACC is the required return on the firm as a whole. It is the appropriate discount rate for cash flows similar in risk to the firm.
- The WACC is calculated as:

$$\text{WACC} = \frac{E}{V} \times Re + \frac{D}{V} \times Rd \times (1 - Tc)$$

Where:
- Re is the cost of equity,
- Rd is the cost of debt,
- Tc is the corporate tax rate,
- E is the firm’s equity,
- D is the firm’s debt, and V = E + D.
Understanding the allowed rate of return

• Investors must at least recoup their cost of capital
• This is the amount they need to pay to attract finance
• That will depend on the return available to activities of similar riskiness
• So how do we define that amount?
• The weighted average cost of capital (WACC) is simply the sum of
  – The cost of debt, weighted by the share of debt in the firm’s capital base, and
  – The cost of equity, weighted by the share of equity in the firm’s capital base
• It is convenient to assume that the cost of debt is observable and that all the complexities relate to the cost of equity
• This is the “at risk” component, and it is here that the determination of the risk of the activity becomes relevant
Understanding risk I

- **Project 1:** To build a football field at a cost = $10,000
  - Net Return $ 1,000 if Kazakhstan wins the 2022 World Cup (prob $\frac{1}{2}$)
  - Net Return $ 200 if Kazakhstan fails to qualify (prob $\frac{1}{2}$)
- **Average Return $ 600 , Variability $ 400**
Understanding risk II

- Project 2: Investment of the $10,000 in Long Term U.S. Bonds
  - Average Return $ 300 , Variability $ 0
Understanding risk III

• It is easy to compare:
  – Average Return $600, Variability $400
  – Average Return $600, Variability $100

• It is easy to compare
  – Average Return $300, Variability $0
  – Average Return $200, Variability $0

• But how does one compare
  – Average Return $600, Variability $400
  – Average Return $300, Variability $0

• An investor may be willing to accept risk if the average return is higher

• There is an “indifference curve” between risk and return
Understanding risk III (cont)
Diversification I

• Suppose you invest x% of the initial $10,000 in the football field project, and the remaining (100-x) % in the US Bonds.
  – Example: if x=50%, Average Return $ 450 , Variability $ 200
• Let’s increase x from 0 to 100%
Diversification II

• Project 3: To build an ice hockey ring at a cost = $10,000
  - Net Return $100 if Kazakhstan wins the 2022 World Championships (prob ½)
  - Net Return $1,300 if Kazakhstan fails to qualify (prob ½)
• Average Return $700, Variability $600
• Suppose you invest y% of $10,000 in the football field project, and the remaining (100-y) % in the ice hockey ring
# Diversification II

<table>
<thead>
<tr>
<th>Share of the Football Project</th>
<th>State 1</th>
<th>State 2</th>
<th>Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Ice-hockey Project</td>
<td>Football Project</td>
<td>Ice-hockey Project</td>
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<tr>
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<td>1000</td>
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<tr>
<td>20%</td>
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<td>50%</td>
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<td>70%</td>
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<td>100%</td>
<td>1000</td>
<td>100</td>
<td>200</td>
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</tbody>
</table>
Diversification II

![Diversification II Diagram](image)
Diversification III

• The previous figure exhibits a characteristic feature: it slopes in
• The explanation is directly related to the effect of diversification
  – Especially with negatively correlated assets, a major part of the risk is cancelled out by the opposite reactions of returns to states of the world.
  – Therefore, moving away from the 100% football-field project has positive consequences both for return and risk.
• The consequence is that there are portfolios that are inefficient on the risk/return relation – every portfolio below E, that is where the line slopes in
Market Portfolio

• An efficient market will not pay for the risk of ill-diversified portfolios.
• Let’s analysis the simplest diversification: \( y = 50\% \)
  – Average return = $650, variability = $360
• Remember that for the football-project,
  – Average return = $600, variability = $400
• This simplest diversification gives a higher return and lower risk; the market compensates investors only for taking risks that cannot be diversified away.
• The portfolio (i.e. collection of assets) which effects this diversification is referred to as the market portfolio; it is a theoretical concept.
• It is a portfolio consisting of every risky investment available weighted proportionality to the total market value of that investment.
  – For example, if we considered the US economy only, then a market capitalization weighted S&P 500 index fund could approximate the market portfolio
• It is the reference used by the market to price the risk.
Summary of Modern Portfolio Theory

- The price of risk is set with reference to a rational investor.
- That investor’s decisions are twofold (and clearly distinct):
  - To diversify her risky investments in order to replicate the market portfolio, and then, and only then,
  - To adjust her risk level by borrowing or lending that portfolio with positions in the risk-free asset.
Using portfolio theory to price equity

The Capital Asset Pricing Model (CAPM)

• The CAPM is often used to estimate the cost of equity.

• Where the assumptions underpinning the CAPM are met, it will measure the compensation equity-holders require.

• Under the assumptions of the CAPM model, investors only require compensation for exposure to systematic risk.

• Two types of risk:
  – **Systematic risk**: it affects the profits of all firms, but in a way that varies from one company to the next.
  – **Non-systematic risk**: also known as firm-specific risk, and tends only to affect individual companies (or industries)
**Systematic Risk**

- Examples include
  - the rate of growth of GDP
  - inflation
  - exchange rate movements
  - technology shocks
  - and many other macroeconomic variables

- In a CAPM world, only this is relevant for the pricing of risk;
  - It is the risk of the market portfolio

- However, firms/industries/regions are different in their reaction to systematic risk
  - An electricity firm’s income does not react to overall economic fluctuations in the same way that a bank does
  - This is accounted for by the “beta” factor
Beta

- Defined as the covariance between movements in the return on an individual stock and returns on a market portfolio, divided by the variance of returns on the market portfolio:

\[
\text{Beta} = \frac{\text{Cov} (r_i, r_m)}{\text{Var} (r_m)}
\]

- Beta measures the systematic risk of a specific equity portfolio:
  - It describes the sensitivity of the portfolio to broad market movements.
  - The market portfolio is, by definition, assigned a beta of 1.0.
The prices of Microsoft (and therefore returns) move up and down at roughly the same time the market (as approximated by the S&P 500 index) – but at a greater degree. This would suggest that it has a beta of greater than 1.
Market (or equity) risk premium

• Represents the return above the risk free asset that an investor with a diversified portfolio across the market will require

• Extremely difficult to estimate
  – What is relevant is the “ex-ante” market risk premium
  – However, most reliable data is on “ex-post” or historical MRP

• Can be large diversion between estimates

• In turn consensus in developed economies has revolved around 5% to 7%
CAPM formula - example

\[ r_i = \beta_i (r_M - r_f) + r_f \]

• \( r_i, r_M \) & \( r_f \) are the expected returns on the asset being measured, \( \alpha \) the market portfolio and risk-less asset respectively

• \( \beta_i \) is the asset beta of the asset being measured

• \((r_M - r_f)\) is often referred to as “the market risk premium”

Example:

• Risk-free rate = 7%
• Market risk premium = 6%
• Beta = 1.0

\[ \Rightarrow \text{Cost of Equity} = 13.00\% \]
• Cost of debt = 8.50%
• Taxation = 20%
• Debt/Equity ratio = 60/40

\[ \Rightarrow \text{WACC} = 9.04\% \]
Return to notional example

- IRR of Project estimated at 9.4%
- Assume previous WACC of 9.04% is for the project
- Hence the investment decision is supported
- However, what if there is uncertainty?
  - Over how much the plant will be dispatched?
  - Over the prices that can be obtained in the future?
  - Over potential future cost obligations

Is a return 0.36% above the WACC sufficient to reflect the uncertainty?
5. Risk analysis
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Risk analysis

• As we are dealing with future, neither revenues nor costs are perfectly known, therefore we need to incorporate the risk concept in our analysis.

• The simple NPV rule does not take into account the risks that in the future both revenues and costs change.

• The risk a cost that should be evaluated.

  • Sensitivity analysis examines how sensitive a particular NPV calculation is to changes in underlying assumptions

  • Scenario analysis examines how sensitive the NPV calculation is to changes in different likely scenarios
### Example of sensitivity analysis

**What happens if all costs increase by 10%?**

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**IRR falls below estimate of WACC**
Example of sensitivity analysis

What happens if benefits reduce by 10%

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IRR falls below estimate of WACC
Risk (scenario) analysis

• Real options - options available to management as part of the project that add value.
• For example, electric utility has choice of building a power plant that:
  • Burns oil
  • Burns either oil or coal
  • Plant (1) is cheaper to construct. Naive implementation of present value might suggest that plant (1) be constructed. But while (2) costs more, it also provides greater flexibility. Management has the ability to select which fuel to use and can switch back and forth depending on energy conditions
• Ignoring options usually causes undervaluation of projects
• Other kind of real option (deferral, spot, abandon, etc.)
• Real options are generally evaluated by binomial trees or Monte Carlo simulation
• Volatility of the revenues and costs is the key driver.
Value-at-Risk (VaR)

• Value-at-risk: The VaR is the maximum amount at risk to be lost from an investment over a given holding period, at a particular confidence level. As such, it is the converse of shortfall probability, in that it represents the amount to be lost with a given probability.

• VaR has three parameters:
  • The time horizon (period) to be analyzed (i.e. the length of time over which one plans to hold the assets in the portfolio – In finance, typical holding period is 1 day to 10 days. In project evaluation depends on the case.
  • The confidence level at which the estimate is made. Popular confidence levels usually are 99% and 95%.
  • The unit of the currency which will be used to denominate the value at risk (VaR).
Value-at-Risk (VaR)

- Three potential methods for computation
  - Historical simulation: Not suitable for new projects
  - Variance-covariance method:
    - Assumes that the implicit distribution is known, generally normal.
    - This simplify the computations
  - Monte Carlo: computationally burdensome but can provide interesting results
In this case the worst five outcomes (that is, the worst 5%) were less than -15%. The Monte Carlo simulation therefore leads to the following VAR-type conclusion: with 95% confidence, we do not expect to lose more than 15% during any given time.
Value-at-Risk (VaR)

- An example for planning:
  - Traditional approach: Min E [NPV cost to meet demand]. Expected value because it is probabilistic (hydrology for instance, other inputs can be added stochastically fuel prices, demand, etc)
  - It could be also important to know how much is the NPV in the 5 % of the worse cases and find the projects that minimize the VAR.
  - Or we could be more pessimistic and find a planning that minimizes the maximum regret of all the alternatives. (Minimax regret criterion)
Other indicators - Payback

- **Payback** is the \( N^* \) that satisfies:

\[
I = \sum_{t=0}^{N^*} X_t \quad N^* < N^c
\]

where \( N^c \) represents the life of the investment project.

- Similarly, the payback rule says to accept the mutually exclusive project that has the smallest \( N^* \).

- The most obvious problem with payback is that it ignores the time value of money.
## Stylised example - payback

**Costs and Revenues ($ million) by year**

<table>
<thead>
<tr>
<th></th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>......</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capex</strong></td>
<td>-50</td>
<td>-50</td>
<td>-50</td>
<td>-50</td>
<td>-50</td>
<td>-50</td>
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<td>-50</td>
</tr>
<tr>
<td><strong>Opex</strong></td>
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<td>-4</td>
<td>-4</td>
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<td>-4</td>
<td>-4</td>
<td>-4</td>
<td>-4</td>
</tr>
<tr>
<td><strong>Revenue</strong></td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Cumulative cashflows</strong></td>
<td>-50.0</td>
<td>-100</td>
<td>-89</td>
<td>-78</td>
<td>-67</td>
<td>-56</td>
<td>-56</td>
<td>-1</td>
<td>10</td>
</tr>
</tbody>
</table>

Note that payback doesn’t consider time value of money
Other indicators – Discounted Payback

• The discounted payback is the $N^*$ that satisfies:

$$I = \sum_{t=0}^{N^*} \frac{X_t}{(1 + R)^t} \quad N^* < N^c$$

• It is better than simple payback but it is not considering the value of the project beyond $N^*$

• By using discounted payback, you may be excluding projects that have positive net present value
# Stylised example – discounted payback

**Costs and Revenues ($ million) by year**

<table>
<thead>
<tr>
<th></th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>22</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex</td>
<td>-50</td>
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<td>Opex</td>
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<tr>
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<td>15</td>
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<td>15</td>
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<td>15</td>
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<td>15</td>
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<tr>
<td>Discounted @ WACC</td>
<td>-50.0</td>
<td>-45.9</td>
<td>9.3</td>
<td>8.5</td>
<td>7.8</td>
<td>7.1</td>
<td>1.5</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Cumulative cashflows</td>
<td>-50.0</td>
<td>-95.9</td>
<td>-86.6</td>
<td>-78.1</td>
<td>-70.3</td>
<td>-63.2</td>
<td>-0.9</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>
Discounting with homogenous investment

• In many cases investment will be carried out by public bodies and private investors
• Recourse to finance and objectives will vary
• Moreover, recourse to contractual provisions that reduce uncertainty (e.g., take or pay clauses) will vary by plant
• So should the discount rate vary by plant and investor?
• For coherence of the Master Plan a single discount rate is applied consistently
  • However, it is common to model with a range of discount rates and see how capacity order changes
Thanks for your attention