Integrated Resource Planning Training for Decision Makers

Day 9, Session 18 Decision making under uncertainty

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Content

- ▶ **Project evaluation**

  - ● **Decision making process**
  - ● **Typical investment decision criteria**

- ▶ **Factors of uncertainty for development planning**

- ▶ **Tools that can help to plan under uncertainty**

Shaping the decision-making process

▶ Decision-making is a process that involves rational analysis as well as social, policy, and environmental factors.

▶ The classic model of decision-making found in most business textbooks goes something like this:

- Identify the problem or opportunity.
- Gather information and analyse the problem.
- Define criteria for evaluating solutions.
- Generate alternative solutions.
- Weigh the costs and benefits of each option.
- Select the option with the highest expected value.
- Implement the decision.

▶ A good decision-making process has the following:

- Quality. It involves careful, rigorous analysis of the problem and a thoughtful comparison of the options.
- Executability. It creates collective buy-in and increases the odds that the decision will be executed well.
- Timeliness. It is neither too early nor too late.

▶ An IRP is a tool that brings together all these elements

- Involves careful and rigorous analysis
- It creates collective buy-in by developing it with key stakeholders
- Tells you when you need to invest under different pathways and estimates the impact.

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Evaluating investment proposals

▶ The objective is to select investments (or projects) that will add value (economic, financial, etc.)

▶ This involves answering the following questions

- Which investments should we consider?
- Which investments should we accept?

▶ In order to answer these questions we must define some investment criteria. The most commonly used criteria are:

- Net present value (NPV)
- Profitability index
- Internal rate of return (IRR)
- Payback period
- Real options (NPVext)

What do most companies use?

How frequently does your firm use the following techniques when deciding which projects to pursue?

	US (%)	UK (%)	Nether-lands (%)	Germany (%)	France (%)
Internal rate of return	75.6	53.1	56.0	42.2	44.1
Net present value	74.9	47.0	70.0	47.6	35.1
Payback period	56.7	69.2	64.7	50.0	50.9
Sensitivity analysis	51.5	42.9	36.7	28.1	10.4
Discounted payback	29.5	69.2	25.0	30.5	11.3
Value at risk	13.7	14.5	4.3	23.7	29.8
Real options	10.8	14.1	8.2	7.8	14.6
Profitability index	11.9	11.9	8.2	16.1	37.7

Source: D. Brounen, A. de Jong and K. Koedijk, 2006, Corporate finance in Europe: confronting theory and practice, Journal of Banking and finance.

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Some factors of uncertainty during the planning process

▶ **Some factors of uncertainty during the planning process**

- Demand – it is uncertain how much will demand grow and how the load shape might change

- Timing – development of new power plants, contractual arrangements, actual, construction times

- Fuel prices – are volatile and fluctuate over the years.

- Capital costs and financing – battery costs, Solar PV costs, steel costs, exchange rates, interest rates, etc.

- Power plants availability – RES resources (hydro, Solar, Wind, etc.), outages, maintenance

- Policy targets – new policy targets may emerge, or existing policy targets may change

- PPA prices – they are subject to negotiations

- Climate change – availability of resources, environmental costs

- *What other factors you have recently phased in your business?*

Projected cost reduction for batteries

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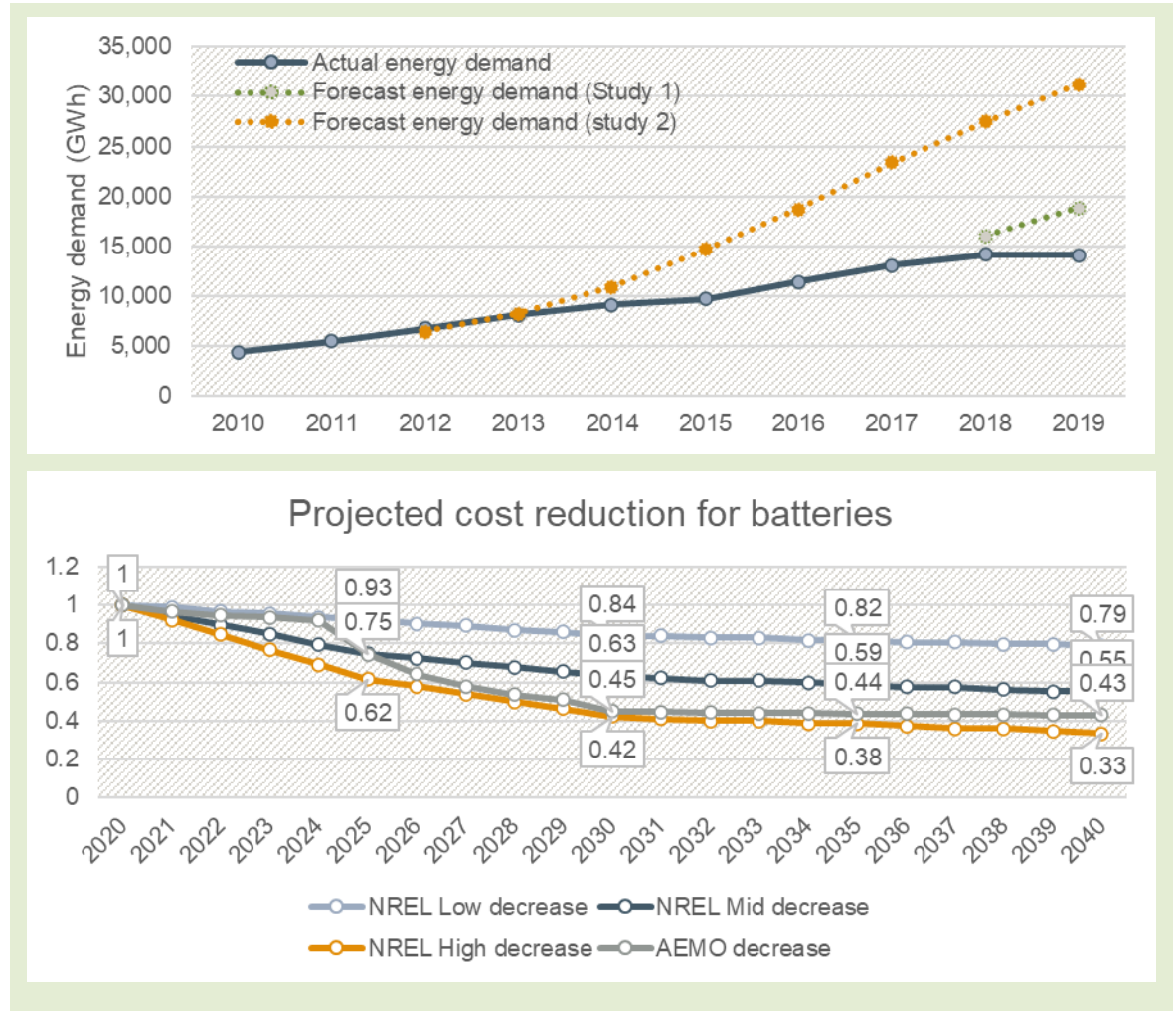
Tools for decision making under uncertainty

▶ **Scenarios**

▶ **Sensitivities**

▶ **Stress tests**

▶ **Probabilistic assessment**

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Scenarios in an IRP help to identify the least cost plan under different market conditions

- Scenarios can be used in an IRP to model uncertainty

  - It can show the least cost plan under different market outcomes

    - Demand, pricing, timing, costs, available options, costs of externalities, etc.
    - A Utility can prepare to react to possible market outcomes

  - It can show the impact from different policy decisions

    - Renewable energy targets, security of supply, national targets

- For example, a power plant selected as a least cost option in several scenarios (for example in the low, base and high demand scenarios) is more likely to be a good investment irrespective of the evolution of the demand.

Example of scenarios and sensitivities in an IRP						
Scenario	NPV Capex	NPV Fixed O&M	NPV variable costs	NPV Wheeling	NPV total costs	Average costs
	(m$)	(m$)	(m$)	(m$)	(m$)	($/MWh)
Scenarios						
Unrestricted (no policy targets)	212	21	585	104	921	101.5
Base (50% domestic capacity and 30% RES)	283	38	591	88	1,000	108.0
Force regional-scale solar PV	310	45	579	83	1,016	110.1
Imports availability is delayed	286	37	573	126	1,022	110.2
Force CCGT (LNG) in the mix	321	44	608	71	1,045	115.0
Domestic energy >=50%	338	46	621	57	1,062	117.2
High import costs	331	55	739	19	1,144	124.4
Full independence	390	60	713	11	1,175	127.5
Low demand	193	26	461	60	741	109.0
High demand	341	44	682	116	1,184	109.3
High fuel prices	293	40	777	102	1,212	130.9
Battery costs rapidly decrease	273	39	590	88	990	107.1

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Sensitivities can be used to identify the robustness of the least cost plan under different market conditions

- ▶ Sensitivities can be used to identify the robustness of the results
  - ● Demand forecast, fuel costs, investment costs, national targets, emission costs, discount rates, etc.
- ▶ Sensitivities will reveal the impact from a specific change
  - ● The impact on investment plans
    - ○ Is the power plant still selected if fuel prices increase?
    - ○ What would be the impact if battery costs reduce significantly?
  - ● The impact on costs
    - ○ What will be the operating costs if demand increases?
    - ○ What would be the operating costs if emission prices are introduced?

Example of scenarios and sensitivities in an IRP						
Scenario	NPV Capex	NPV Fixed O&M	NPV variable costs	NPV Wheeling	NPV total costs	Average costs
	(m$)	(m$)	(m$)	(m$)	(m$)	($/MWh)
Base case	283	38	591	88	1,000	108.0
Sensitivities on the base case						
WACC 8%	353	52	645	106	1,155	106.3
WACC 12%	230	29	531	78	869	109.6
Low demand	193	26	461	60	741	109.0
High demand	341	44	682	116	1,184	109.3
High fuel prices	293	40	777	102	1,212	130.9
Battery costs rapidly decrease	273	39	590	88	990	107.1

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Stress tests

▶ Stress test can also be conducted to reveal the impact of decisions

- What if I invest for the high demand scenario and demand turns out to be low?
  - ○ Estimate the impact on costs and the economic value by adopting the investments of the high case and simulating the costs with low demand.
- What if I invest for the low demand scenario and demand turns out to be high?
  - ○ Estimate the impact on costs and the economic value by adopting the investments of the low case and not being able to meet the high demand.

Example - Direct economic value by scenario
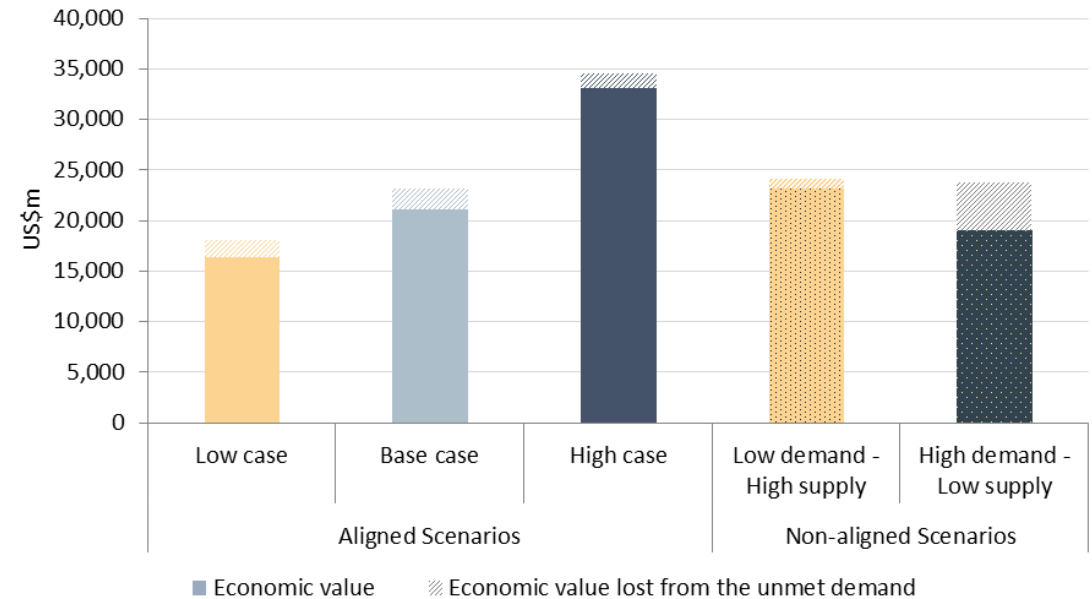
Probabilistic assessment

▶ Probabilities can be assigned to possible market outcomes to come up with a solution weighted by the probability of occurring

▶ Probabilistic models can also be deployed to evaluate flexibility

- In the following slides we will introduce Real options
- Other probabilistic models to evaluate investments also exist to deal with uncertainty.

Example with a probabilistic assessment on the demand

A new industrial customer is expected to connect to the grid. It is still uncertain if he will invest and how much capacity he will need. His current estimation is that his maximum capacity will be 50 MW.

	Capacity (MW)	Probability of demand being materialised	Probability weighted demand (MW)	
Low demand	50	0%	0	*Decision not to invest*
Base demand	50	70%	35	*Invests but market conditions are not favorable for his industry.*
High demand	50	100%	50	*Invests and market conditions are favorable for his industry.*

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Introducing Real Options – what Real Options have to offer

▶ The typical DCF evaluation methodology ignores flexibility

- The typical DCF analysis assumes that once the investment decision is taken, there is no scope for managers to react to new information.

▶ Real options analysis seeks to value flexibility

- It attempts to assess and determine the value of flexibility in responding to new information.

- It attempts to increase the potential upside from the investment and decrease the possible downside.

What is a Real Option?

▶ Real option is the right but not the obligation to take a pre-defined action, at a predetermined cost (the cost of this action), for a predetermined period in time to react to changing market conditions.

- $NPVext = NPV\ of\ extended\ cash\ flows$ + flexibility or option value

  - Accept the project with the highest NPVext

- Real options embedded in projects:

  - Option to expand or alter operating scale
  - Time to develop/ Staged investment
  - Option to abandon
  - Option to switch inputs or outputs
  - Multiple Interacting Options

Example - Interconnector project

▶ Project: Demand is expected to grow incrementally to 1000 MW in 20 years' time. The proposed solution to cover the demand is to develop a 400kV double circuit transmission line.

Real Options embedded in the project

- Which factors affect significantly the project?
  - The capital costs and the demand
- What are the main factors of uncertainty?
  - In this example we will examine demand
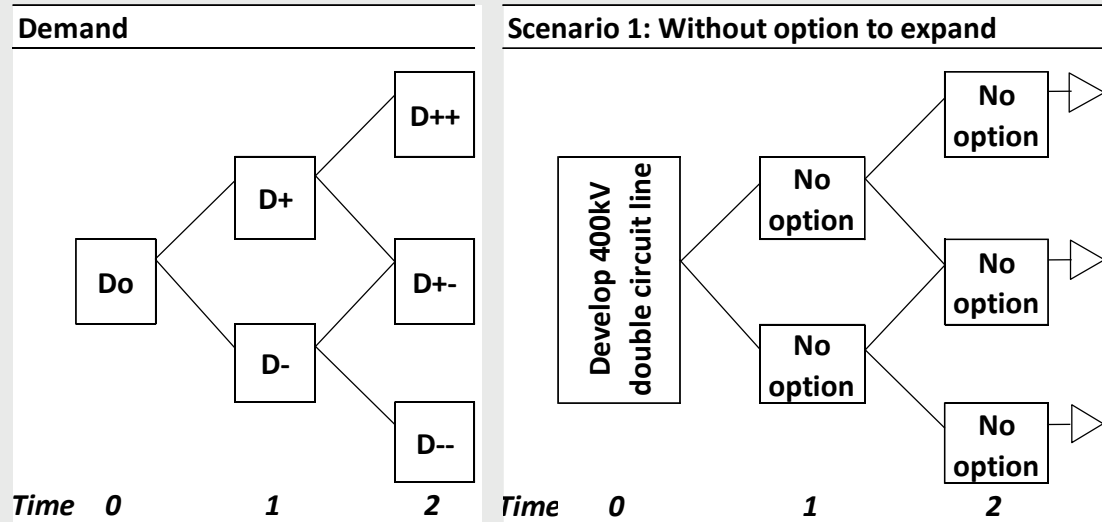- Can we do anything about it?
  - Develop the project in stages

Available solutions

▶ Scenario 1: Develop a 400kV double circuit transmission line.

▶ Scenario 2: The selected infrastructure should allow to double the capacity of the line if needed.

- Phase I: Develop a transmission line to cover the capacity for the next 10 years. For example select a double circuit infrastructure and develop only a single line (400kV) in the first phase.
- Phase II: if conditions are favorable, develop the second line (400kV).

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Accept the project with the highest NPVext (probability weighted NPV including options)
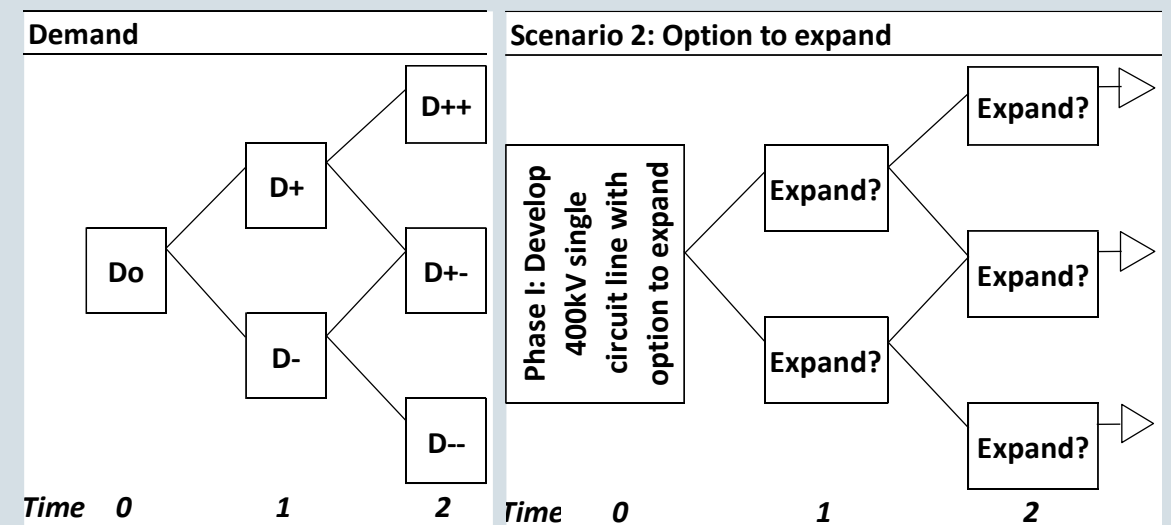
▶ **Scenario 1: without flexibility**

- Develop a 400kV double circuit transmission line.
- This scenario does not provide any flexibility, however, it doesn't have any extra costs for embedded options.

Demand

```
        D+      D++
Do
        D-      D+-
                D--
Time  0    1    2
```

Scenario 1: Without option to expand

```
                        No
                        option
Develop 400kV   No
double circuit  option
line                    No
                        option
                No
                option
                        No
                        option
Time  0    1    2
```

▶ **Scenario 2: with flexibility**

- Allow to double the capacity of the line if needed.
  - The option comes with extra costs.
  - If conditions are favorable expand: upside potential gains
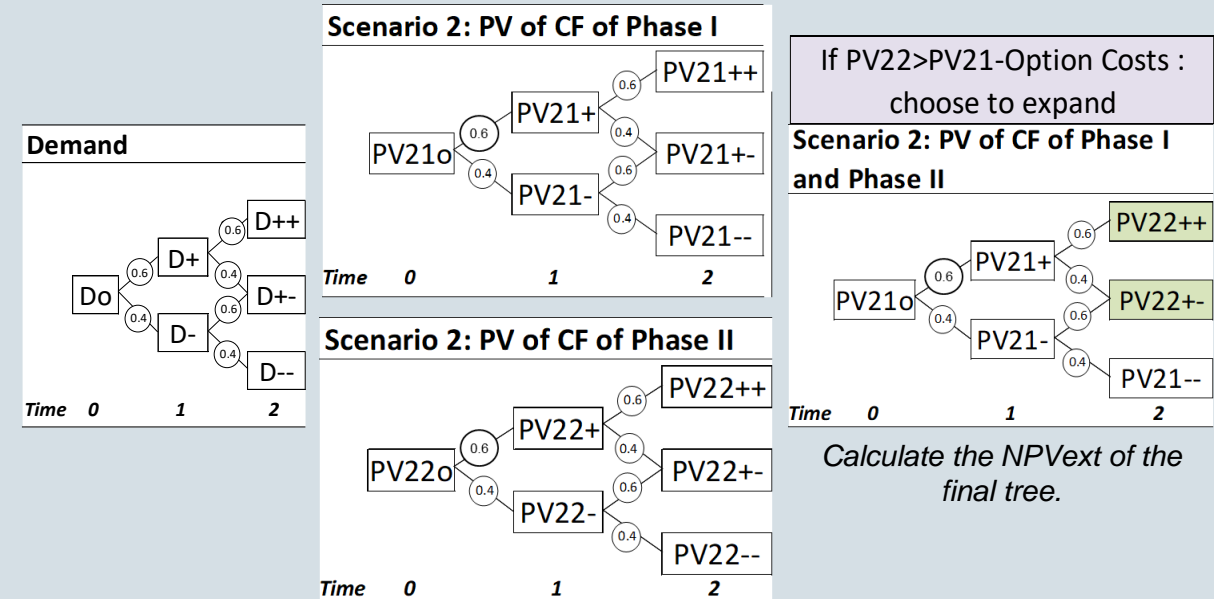 - Otherwise wait and see: protection from downside losses

Demand

```
        D+      D++
Do
        D-      D+-
                D--
Time  0    1    2
```

Scenario 2: Option to expand

```
                                        Expand?
Phase I: Develop        Expand?
400kV single
circuit line with                       Expand?
option to expand
                        Expand?
                                        Expand?
Time  0    1    2
```

Accept the project with the highest NPVext (probability weighted NPV including options)

▶ Calculate the NPVext of Scenario 1

Demand

Scenario 1: PV of CF
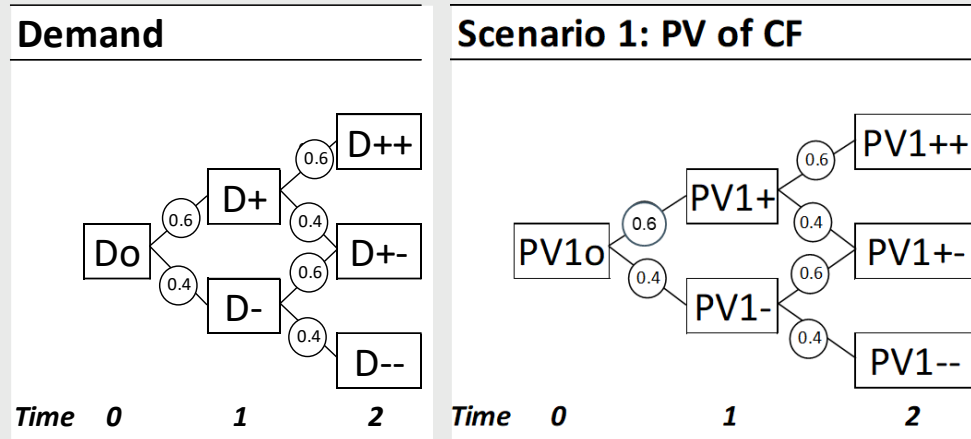
$NPV_{ext} = PV1_0 +$
$0.6 * [PV1^+ + (0.6 * PV1^{++} + 0.4 * PV1^{+-}) +$
$0.4 * [PV1^- + (0.6 * PV1^{+-} + 0.4 * PV1^{--})$

▶ Calculate the NPVext of Scenario 2

Scenario 2: PV of CF of Phase I

Demand

If PV22>PV21-Option Costs :
choose to expand

Scenario 2: PV of CF of Phase I and Phase II

Scenario 2: PV of CF of Phase II

Calculate the NPVext of the final tree.

$NPV_{ext} = PV21_0 +$
$0.6 * [PV21^+ + (0.6 * PV22^{++} + 0.4 * PV22^{+-}) +$
$0.4 * [PV21^- + (0.6 * PV22^{+-} + 0.4 * PV21^{--})$

▶ Compare the NPVext from Scenario 1 and 2

▶ Accept the project with the highest NPVext

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