Project Portfolio Optimization

Boudewijn Neijens
2 July 2020
AGENDA

- Who is Copperleaf
- What have we learned so far
- Life cycles and economics
  - Capex, Opex and Totex
  - From long term plans to budgetary cycles
- Asset plans vs. Investment portfolios
- The concept of Value
- Asset Investment Planning & Management
- Prioritization vs. Optimization
- Conclusions
KEY COPPERLEAF CLIENTS

Over $1 trillion assets managed worldwide
WHAT WE HEARD SO FAR...

• You need a management system
• A SAMP should be dynamic & express what’s best for the company
• Risk and Levels of Service drive AMPs & Lifecycle Plans
• Every organization is different
• It’s about “What, When and If”
• Reasons to (re-)invest include:
  • Reliability (Lowest Economic Cost)
  • Cost savings
  • Safety / Regulatory
  • Strategic
• Include quantitative and qualitative factors in evaluations & prioritisation
• Projects that have the highest Benefit/Cost ratio must be prioritised
• Where should you invest your last R1000
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  • Strategic
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LIFE CYCLE COSTING & VALUE OPTIMIZATION

Inputs
- Ideas & Options
- Asset Data
- Strategic Business Requirements
- Business / Regulatory Environment
- Decision Making Criteria & Methodology
- Constraints

Analysis
- LCC & Value Estimation/Modelling
- Decision Support Analysis/Modelling

Decision Support Outputs
- Options
- Scenarios

Asset Management Decision Making

Stakeholder Consultation

Refine / Optimise

Review / Update / Optimise

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LIFE CYCLE PHASES

Life Cycle Value Realization

Capex | Opex | Capex

Acquire/ create decisions
Operation & maintenance decisions
Replacement, refurbishment, & life extension decisions

$  

Time
LIFE CYCLE ACTIVITIES
ASSET LIFE CYCLES

• A greenfield project
  • Decisions driven by future needs
  • Value-based
  • Cost of not doing = missed opportunity
ASSET LIFE CYCLES

- Ongoing operations and life cycle management
  - Many decisions are driven by existing assets & sustainment needs
  - Value-based and risk-informed
  - Cost of not doing = missed opportunity + asset liability
ASSET PLANS

- Asset Management Plan
  - Describes activities, resources, timescales
  - Often a mostly static view
  - Optimal per asset class
THE RIGHT LIFE CYCLE STRATEGY

- Replacement
- Refurbishment
- Maintenance

Forecast ($)

Risk

Time

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035

Time
ECONOMIC END-OF-LIFE

- PREMIUM PAID TO MEET RELIABILITY TARGET
- PREMIUM PAID TO MEET COST TARGET
- ECONOMIC END-OF-LIFE TIME

Graph showing:
- Total Cost
- Risk Cost
- Investment Cost
- O&M Costs

Time periods from 2010 to 2025.
ALTERNATIVES

- Refurbish
- Replace
- Upgrade
- Increase capacity
- Add redundancy
ALTERNATIVE: REPLACE

![Graph showing the comparison between replacing and refurbishing over time with risk and forecast costs.](image)
ALTERNATIVE: UPGRADE

Forecast ($)

Risk

Time

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035

Replacement
Refurbishment
Maintenance

Time

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
DIFFERENT POTS OF MONEY

- Opex + Capex = Totex

![Diagram showing different pots of money over time with categories like replacement, refurbishment, and maintenance.]
MORE CAPEX

[Graph showing forecast and risk over time with categories for replacement, refurbishment, and maintenance.]
MORE OPEX

Risk

Forecast ($)

Time

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035

Time

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035

Replacement

Refurbishment

Maintenance
ASSET PLANS

- Strategic Asset Management Plan
  - Guidance for all AMPs
  - The aggregate of all AMPs
DOES IT ALL ADD UP?

Optimal Life Cycle Plan 1 + Optimal Life Cycle Plan 2 + Optimal Life Cycle Plan 3 = ?
ASSET PLANS VS. INVESTMENT PORTFOLIOS

• Investment Portfolio
  • A real-world, constrained decision-making environment
OPTIMIZE PORTFOLIOS

- FINANCIAL
- TOTAL RISK
- RESOURCES
- OUTAGE CONSTRAINTS
- RENEWABLE TARGETS
- ASSET REPLACEMENT TARGETS
- ALL
OPTIMIZE PORTFOLIOS

FINANCIAL

TOTAL RISK
RESOURCES
OUTAGE CONSTRAINTS
RENEWABLE TARGETS
ASSET REPLACEMENT TARGETS
ALL

2019  2025  2031
OPTIMIZE PORTFOLIOS

- Financial
- Total Risk
- Resources
- Outage Constraints
- Renewable Targets
- Asset Replacement Targets
- All
OPTIMIZE PORTFOLIOS

- Financial
- Total Risk
- Resources
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- Renewable Targets
- Asset Replacement Targets
- All

2019
2025
2031
ASSET PLANS VS. INVESTMENT PORTFOLIOS

• Assets and market conditions evolve over time
  • AMPs should be dynamic
  • Every decision should be taken full knowledge of how it affects the AMPs
ASSET INVESTMENT PLANNING & MANAGEMENT

- Asset Needs
  - Predict
  - Asset Risk Updates
  - Asset Life Cycle Strategy (~20 Years)

- Candidate Investments
  - Assess Value

- Business Needs
  - Expand/Growth

- Operating Needs
  - Manage
  - Operating Updates
  - Budgeting (~2 Years)

- Investment Plan (~5 Years)

- Bottom-Up

- Top-Down
WHAT IS “VALUE”? 

• Depends Who You Ask…
**AN EXAMPLE...**

![Car Image]

The table below compares different transportation options based on various criteria:

<table>
<thead>
<tr>
<th>Value</th>
<th>Repair</th>
<th>Replace</th>
<th>Upgrade</th>
<th>Carpool</th>
<th>Limo</th>
<th>Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordable</td>
<td>$</td>
<td>$$</td>
<td>$$$</td>
<td>$$</td>
<td>$$$</td>
<td>$</td>
</tr>
<tr>
<td>Look</td>
<td>★</td>
<td>★★</td>
<td>★★★</td>
<td>★</td>
<td>★★★★</td>
<td>★</td>
</tr>
<tr>
<td>Speed</td>
<td>★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★</td>
</tr>
<tr>
<td>Safety</td>
<td>△</td>
<td>△△△</td>
<td>△△</td>
<td>△</td>
<td>△△△△</td>
<td>△△</td>
</tr>
<tr>
<td>Convenience</td>
<td>★★☆</td>
<td>★★★★☆</td>
<td>★★☆☆☆</td>
<td>★☆☆☆☆</td>
<td>★★★★☆</td>
<td>★☆☆☆☆</td>
</tr>
<tr>
<td>Space</td>
<td>★★★★★</td>
<td>★★★★★</td>
<td>★★★★★</td>
<td>★★★★</td>
<td>★★★</td>
<td>★★★★☆</td>
</tr>
</tbody>
</table>

The table uses icons to rate each option: ★ for excellent, △ for moderate, ★☆ for fair, and ★★★ for outstanding. The options are: Affordable, Look, Speed, Safety, Convenience, and Space.
VALUE-BASED DECISIONS ALIGNED WITH STRATEGY

Make decisions that drive the organization’s strategy.
RISK AND VALUE OVER TIME

Present Value
$5,036

Risk Value Measure
$5,036
# ALIGNING METRICS

<table>
<thead>
<tr>
<th><strong>Event Type</strong></th>
<th><strong>Negligible</strong></th>
<th><strong>Small</strong></th>
<th><strong>Minor</strong></th>
<th><strong>Moderate</strong></th>
<th><strong>Major</strong></th>
<th><strong>Extreme</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>On-Site first aid injury</td>
<td>Injury requiring medical attention / near miss</td>
<td>Injury requiring medical attention / lost time</td>
<td>Multiple injuries requiring medical attention / lost time</td>
<td>Permanent disability</td>
<td>Fatality / multiple fatalities</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>Minor impact / no remediation required</td>
<td>Minor impact / contained on-site / simple remediation</td>
<td>Minor impact / contained / moderate remediation</td>
<td>Limited impact offsite / contained / moderate impact on site</td>
<td>Detrimental impact / on or offsite / long term remediation</td>
<td>Catastrophic offsite / impossible to mitigate / uncontained</td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td>&lt; $100K</td>
<td>$100K → $500K</td>
<td>$500K → $1M</td>
<td>$1M → $5M</td>
<td>$5M → $10M</td>
<td>&gt;$10M</td>
</tr>
<tr>
<td><strong>Dx SAIDI</strong></td>
<td>&lt; 1.5 h</td>
<td>1.5 → 8 h</td>
<td>8 → 16 h</td>
<td>16 → 80 h</td>
<td>80 → 160 h</td>
<td>&gt; 160 h</td>
</tr>
<tr>
<td><strong>Tx Frequency of Outages</strong></td>
<td>&lt;17</td>
<td>17 → 85</td>
<td>85 → 168</td>
<td>168 → 830</td>
<td>830 → 1660</td>
<td>&gt; 1660</td>
</tr>
<tr>
<td><strong>Lost Generation</strong></td>
<td>&lt; 2 GWh</td>
<td>2 → 11 GWh</td>
<td>11 → 22 GWh</td>
<td>22 → 110 GWh</td>
<td>110 → 220 GWh</td>
<td>&gt; 220 GWh</td>
</tr>
</tbody>
</table>
Value-based Decision Making is an approach to making decisions that is focused on delivering the maximum value to an organization.

**IDENTIFY**
- Identify the criteria that deliver the greatest value to the organization.

**ALIGN**
- Align criteria to a common scale to compare dissimilar investments (i.e. financial and non-financial).

**ASSESS**
- Assess the value of investments using a rational economic approach.

**OPTIMIZE**
- Optimize investments across the organization based on value and constraints.
OPTIMIZATION

- Simplex algorithm invented in the 40’s by G.B. Dantzig
- Large set of simple equations describing objectives & constraints
- Requires serious computing power
## Prioritization vs Optimization

**Prioritization**

<table>
<thead>
<tr>
<th>Name</th>
<th>Alt</th>
<th>Score</th>
<th>Cost</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>A</td>
<td>$50</td>
<td>$3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 2</td>
<td>A</td>
<td>$100</td>
<td>$3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 3</td>
<td>A</td>
<td>$75</td>
<td>$4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 4</td>
<td>A</td>
<td>$50</td>
<td>$2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 5</td>
<td>A</td>
<td>$25</td>
<td>$1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 6</td>
<td>A</td>
<td>$100</td>
<td>$2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 7</td>
<td>A</td>
<td>$50</td>
<td>$3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 8</td>
<td>A</td>
<td>$50</td>
<td>$1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Budget Constraint:** $10

<table>
<thead>
<tr>
<th>2020 Budget Process</th>
<th>Max. Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Consider only 2020 projects</td>
<td>$300</td>
</tr>
<tr>
<td>2. Rank by Value, then Cost</td>
<td>$225</td>
</tr>
<tr>
<td>3. Apply budget constraint</td>
<td>$250</td>
</tr>
<tr>
<td>4. Manually adjust</td>
<td></td>
</tr>
</tbody>
</table>

**Optimization**

<table>
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<td>A</td>
<td>$50</td>
<td>$3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 2</td>
<td>B</td>
<td>$70</td>
<td>$2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 3</td>
<td>A</td>
<td>$70</td>
<td>$4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 4</td>
<td>A</td>
<td>$50</td>
<td>$2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 5</td>
<td>A</td>
<td>$22</td>
<td>$1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 6</td>
<td>A</td>
<td>$103</td>
<td>$2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 7</td>
<td>A</td>
<td>$50</td>
<td>$3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project 8</td>
<td>A</td>
<td>$52</td>
<td>$1</td>
<td></td>
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<tr>
<td>1. Automatically:</td>
<td></td>
</tr>
<tr>
<td>• Defer &amp; advance projects</td>
<td></td>
</tr>
<tr>
<td>• Select project alternatives</td>
<td>$325</td>
</tr>
<tr>
<td>• Iterate to optimum solution</td>
<td></td>
</tr>
</tbody>
</table>

**2020 Budget Process**

- Rank by Value
- Apply budget constraint
- Manually adjust

**2020 Budget Process**

- Consider only 2020 projects
- Rank by Value, then Cost
- Apply budget constraint
- Manually adjust
OPTIMAL DECISIONS OVER TIME

- Uncertainty increases in outer years
  - Both economically and asset behaviour
  - Explore multiple scenarios – “what if”
- Importance of dynamic AMPs
WHAT-IF SCENARIOS

Scenario Comparison

<table>
<thead>
<tr>
<th>Scenario(s)</th>
<th>Portfolio</th>
<th>Electrical Distribution</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Scenario(s)</th>
<th>Safety Risk</th>
<th>Electrical Delivery Capacity Risk</th>
<th>Compliance Risk</th>
<th>Total Investment Cost</th>
</tr>
</thead>
</table>

Scenario(s):
- 02_Optimized 2019 Plan
- 99_Cutline (for comparison)
- 99_Optimized 10% CAPEX
THE EFFICIENT FRONTIER

Expected Return

Lower Value

Expected Spend

Higher Spend

Higher Value

Efficient Frontier

Expected Spend

Lower Spend
THE COST OF NOT DOING

System Cost Impact

- Unconstrained Funding
- Stable Program
- 2010 IPR Recommended Plan Funding Level
- Reduce Funding 10 Percent
- Reduce Funding 20 Percent

Investment Cost Savings: $386m
Increase in Risk: $547m
SAVINGS
RISK

INVESTMENT

ASSET

RISK
CONCLUSIONS

• All previous speakers were right!
• Engineers tend to think bottom-up
• Management tends to think top-down
• Decisions need to consider all objectives and constraints
• Everything changes with time
• Prioritization generally leaves money on the table
• Enter Multi-Criteria Decision Analysis
• Best practices
  • Consider alternatives
  • Make everything time-dependent
  • Develop a common value scale (and monetize)
  • Use proper optimization
  • Explore “what-if” scenarios
  • Close the loop: with long term plans and with project execution
• It’s a journey…
Thank You

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WHERE TO START?
PER ASSET CLASS

- Tx Division
  - Tx North
    - Transformers
    - Breakers
    - Lines
  - Tx South
    - Substations
    - Lines
PER ASSET CLASS

- Tx Division
  - Tx North
    - Transformers
    - Breakers
    - Lines
  - Tx South
    - Substations
    - Lines
COMPETING ASSET CLASSES

- Tx Division
  - Tx North
    - Transformers
    - Breakers
    - Lines
  - Tx South
    - Substations
    - Lines
MORE ASSET CLASSES

- Tx Division
  - Tx North
    - Transformers
    - Breakers
    - Lines
  - Tx South
    - Substations
    - Lines
PER DIVISION

- Tx Division
  - Tx North
    - Transformers
    - Breakers
    - Lines
  - Tx South
    - Substations
    - Lines
GRADUALLY ESCALATE
TOP-DOWN