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Technoeconomic analysis for industrial projects: What is the cost?
Part 2

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Making a Business Case Virtual Training
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U.S. DEPARTMENT of ENERGY

Goals of this session

- Go over:
  - Discount rates
  - IRR
  - Break even
  - ROI
- The classroom exercise for the Financial Evaluation
- The details of TEA Decision Support component
- The classroom exercise for the Decision Support
- Types of TEA
  - Assessment Process Steps
- Some tips for conducting and reviewing TEA
- Other resources for TEA

Dipti Kamath, Ph.D., CEM

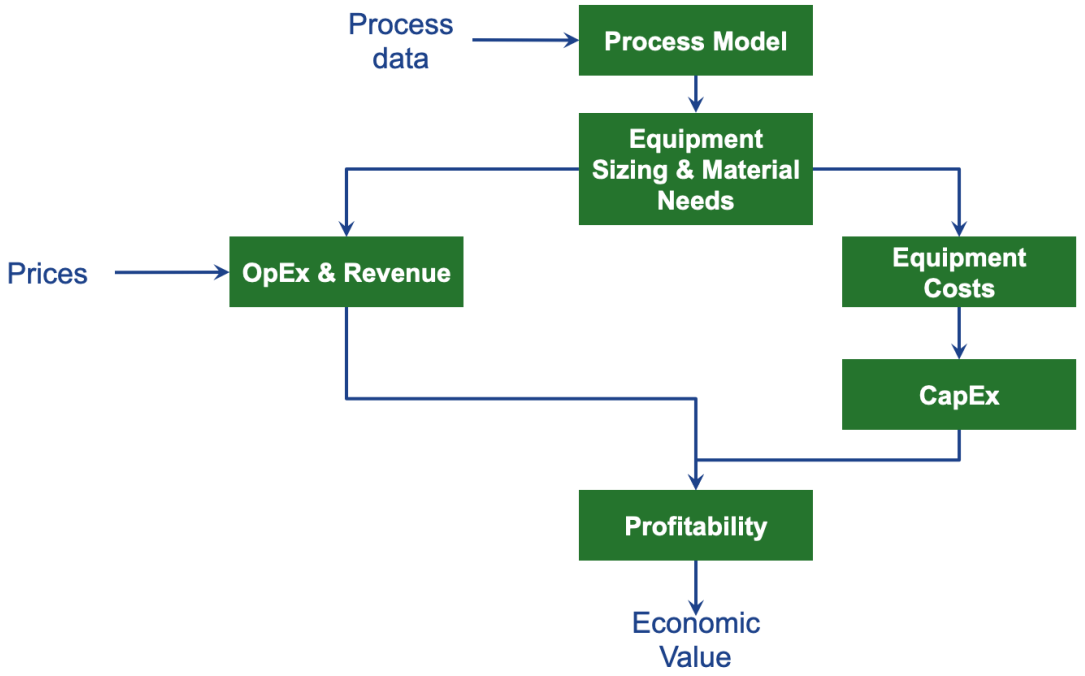


- R&D Associate Staff Member at Oak Ridge National Laboratory
- 5+ years at ORNL

- Technical Expertise/ Research Interests
  - Life cycle assessment
  - Techno-economic analysis
  - System dynamics
  - Industrial workforce development
  - Energy-Intensive Industries: pulp & paper sector

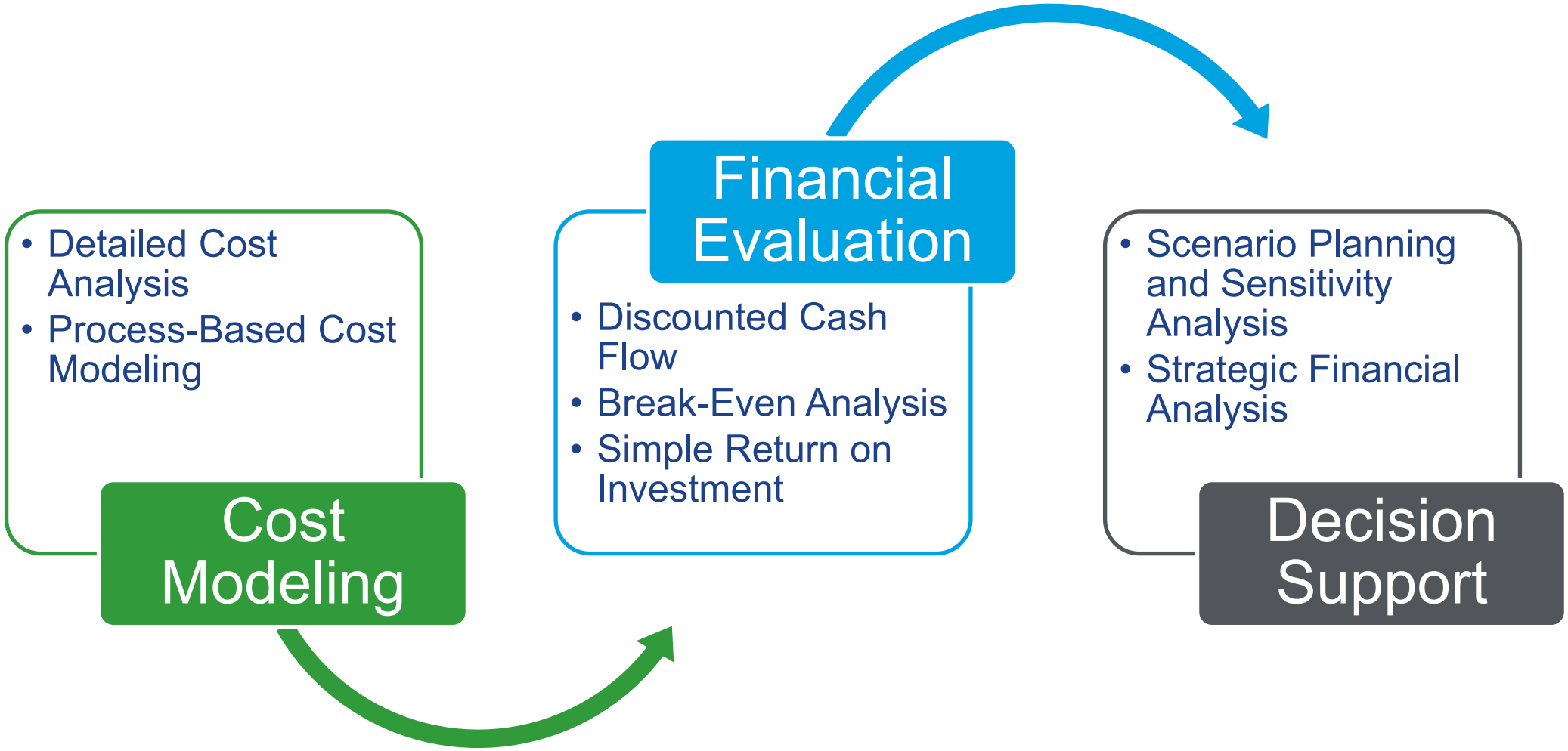
Short Recap:

- Technoeconomic Analysis or TEA: Method for evaluating the economic performance of a technology.
- TEA is more than one number
  - Suggest what drives costs and environmental impacts
  - Compare pathways, scenarios, and scale-up options
  - Show uncertainty and sensitivity to key variables
  - Identify/priorities impactful tasks to optimize cost and environmental impacts and derisk
  - Support go/no-go and investment decisions
- Functional Units



TEA Components

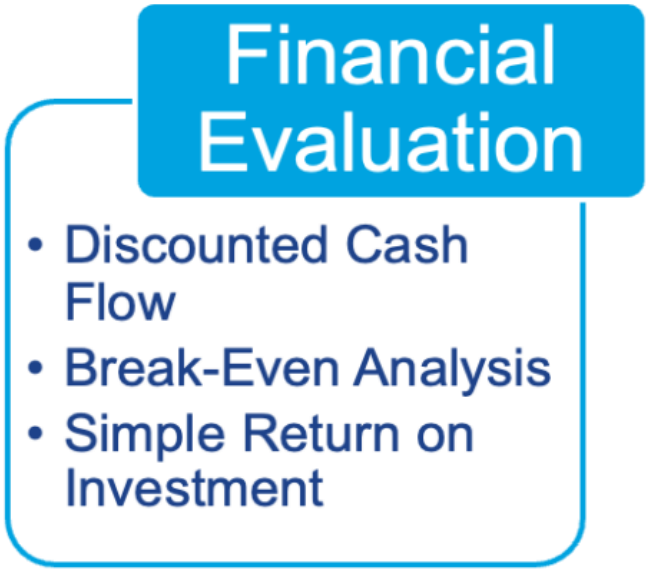
Core methods used to define cost, evaluate financial performance, and test decision robustness



Adapted from: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Financial Evaluation

- Discounted Cash Flow (DCF)
  - Calculates the present value of future cash flows to assess project's long term
- Break-Even Analysis
  - Determines the point at which the product costs are covered by revenue
- Simple Return on Investment (ROI) Calculation
  - A basic measure of the potential profitability of the project



Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Process Exhaust Heat Recovery: Financial Evaluation

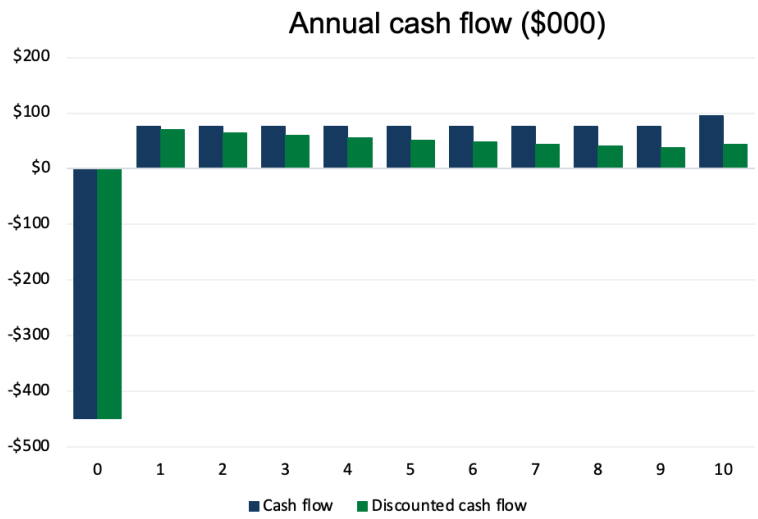
CURRENT ENERGY & PRODUCTION	
Current natural gas (NG) use	80,000 MMBtu/year
Annual production	100,000 units
Gas price	$6/MMBtu
Electricity prices	$80/MWh

ANTICIPATED CHANGES WITH PROJECT	
Expected NG reduction	20%
Additional electricity	100 MWh/year
Additional maintenance	$12,000/year

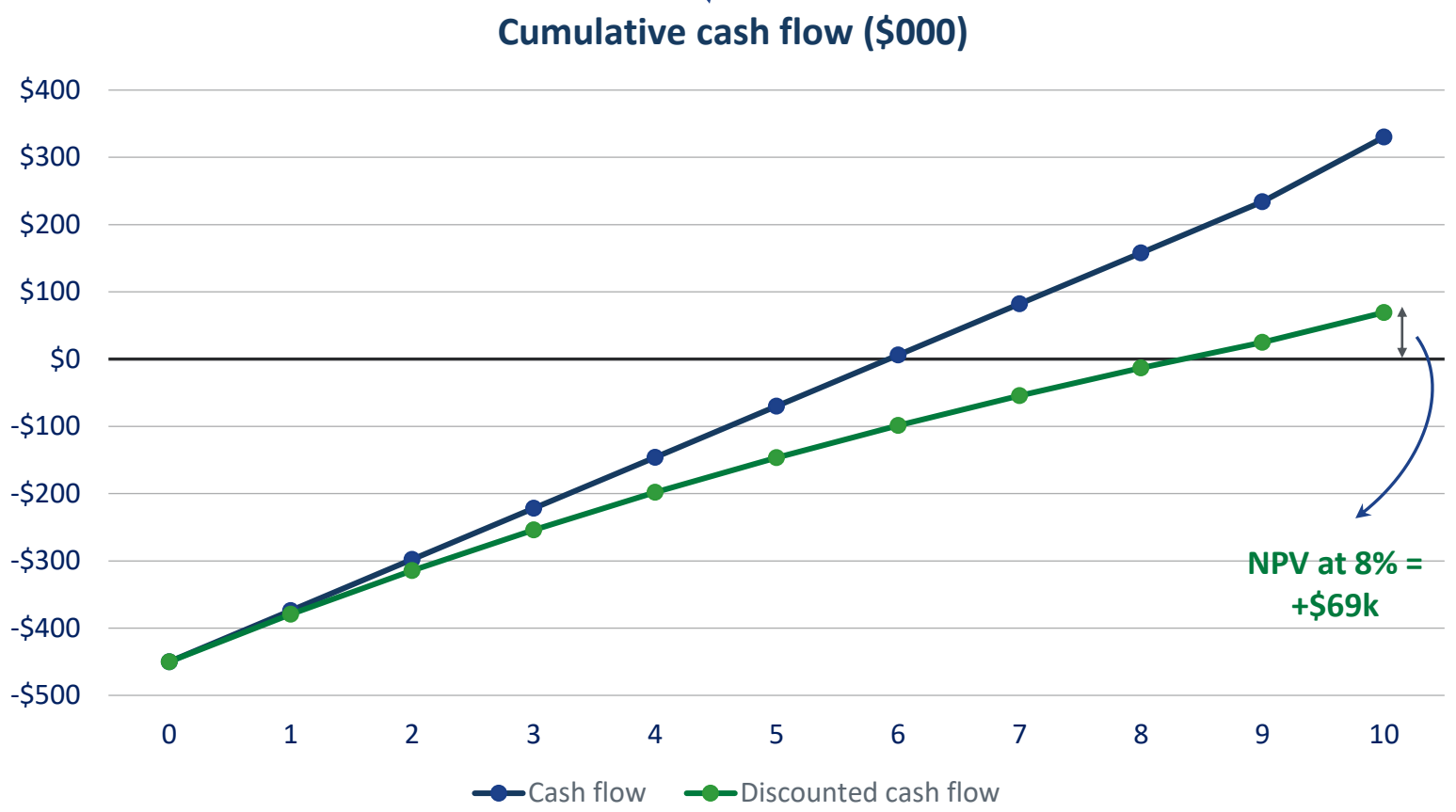
PROJECT FINANCIALS	
Equipment	$280,000
Installation	$140,000
Engineering and commissioning	$40,000
Contingency	$40,000
Utility incentive	$50,000
Project life	10 years
Discount rate	8%
Residual value in year 10	$20,000

- Calculate annual simple ROI and simple payback.
- Calculate NPV and IRR from the project cash flows.
- Compare with your company's investment criteria.

NPV and Payback from DCF



Illustrative heat-recovery project:
$450,000 net investment,
8% discount rate,
10-year life



Process Exhaust Heat Recovery: Financial Evaluation

- Calculate the following financial metrics
  - Net Present Value = NPV of investment + NPV of year 1-10 savings + NPV of residual value
  - $NPV = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t}$
    - **where:**
    - R_t = net cash inflow - outflows during a single period t
    - i = discount rate or return that could be earned in alternative investments
    - t = number of time periods

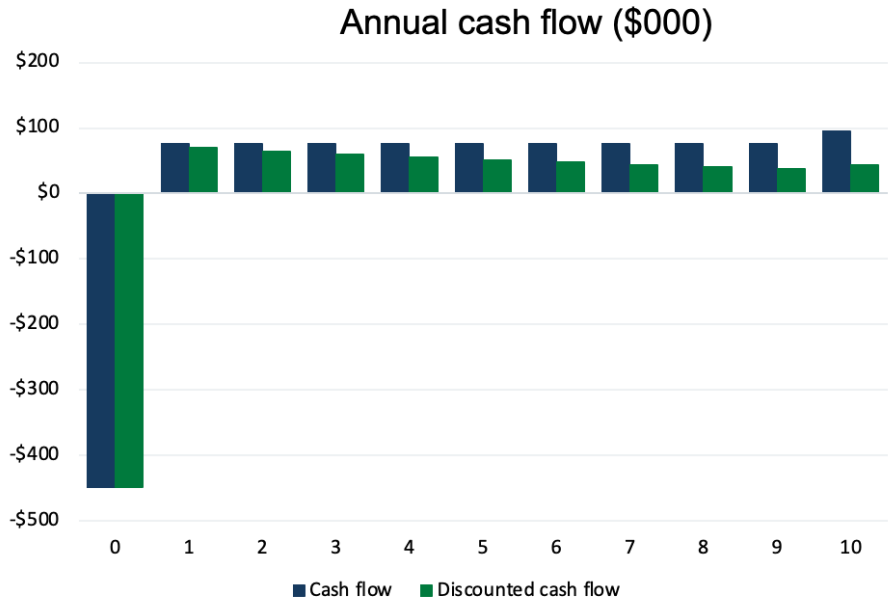
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$$NPV = -450{,}000 + \sum_{t=0}^{10} \frac{76{,}000}{(1+0.08)^t} + 20{,}000 \times \frac{1}{(1+0.08)^{10}}$$

$$NPV = -450{,}000 + 509{,}966 + 9{,}264 = 69{,}230$$

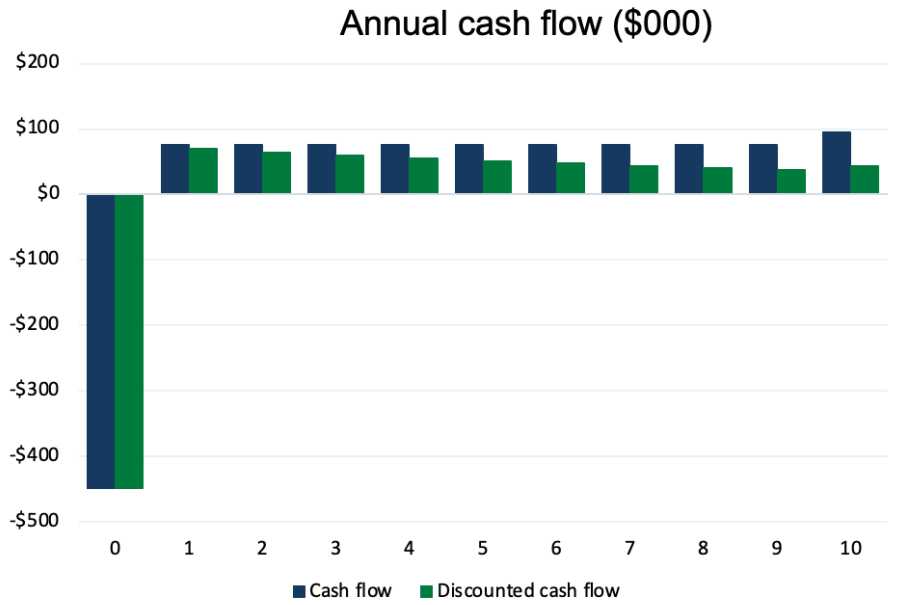
You can also use NPV() in Excel for obtaining NPV, but it does not provide yearly cash flow changes

Internal Rate of Return

IRR is the discount rate that makes the project's NPV equal to zero.

$$NPV = 0 = -450{,}000 + \sum_{t=0}^{10} \frac{76{,}000}{(1+r)^t} + 20{,}000 \times \frac{1}{(1+r)^{10}}$$

$$IRR = r = 11.2\%$$



Use IRR() function in Excel with cashflows in consecutive cells

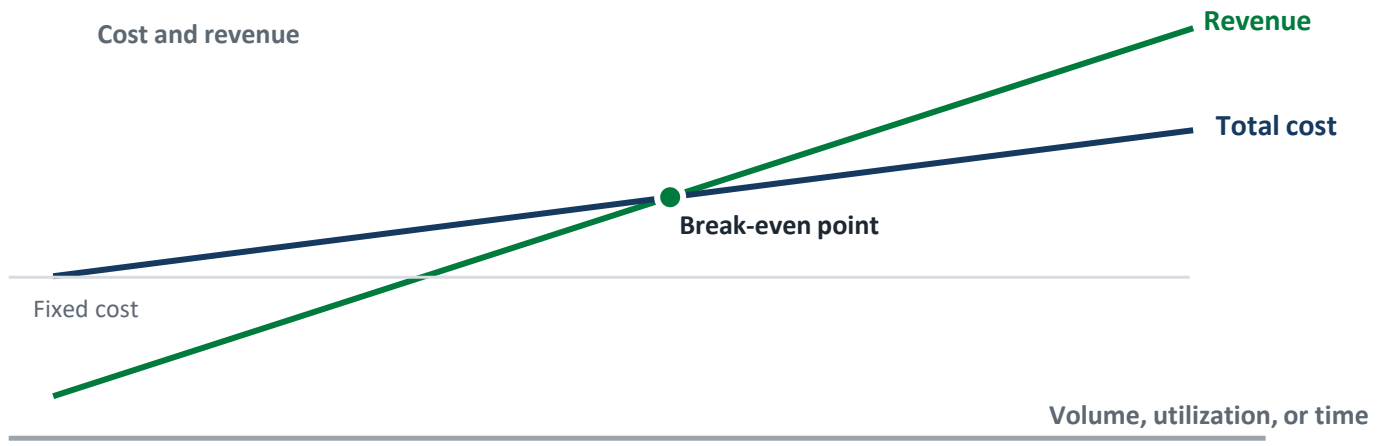
Break-Even Analysis

- Finds the point where cumulative or annual revenue equals total cost. The method can use volume, sales, utilization, or time.

Questions Answered	
	How much output must the project sell to cover cost?
	What utilization or price reaches break-even?
	How far is the expected case from the threshold?

Best Fit:
Early screening and expanded TEA, especially when price and variable cost can be estimated.

ILLUSTRATIVE RELATIONSHIP



CORE CALCULATION

Break-even volume = fixed cost / (price per unit - variable cost per unit)

TYPICAL OUTPUTS

Break-even volume	Required sales	Required utilization	Time to break-even

Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Simple Return on Investment (ROI)

- Measures the expected profitability of a project as a percentage of the investment. Simple ROI does not discount future cash flows.

Questions Answered	
	How large is the benefit relative to the investment?
	How does the project compare with other simple options?
	Does the return clear an internal screening threshold?

Best Fit:
Quick project screening when benefits and costs occur over a comparable period.

CORE CALCULATION

$$\text{ROI (\%)} = \frac{\text{Total benefits - Total costs}}{\text{Initial investment}} \times 100$$

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ILLUSTRATIVE EXAMPLE

Investment	Annual net benefit	Simple ROI	Simple payback
$2.0M	**$0.5M**	**25% per year**	**4.0 years**

CORE CALCULATION

$$\text{ROI (\%)} = \frac{\text{Total benefits - Total costs}}{\text{Initial investment}} \times 100$$

For multi-year projects, use DCF to account for timing and the discount rate.

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CORE CALCULATION

$$\text{ROI (\%)} = \frac{0.5}{2} \times 100 = \frac{50}{2} = 25\%$$

For multi-year projects, use DCF to account for timing and the discount rate.

Any Questions as of now?

Did you use any of the previous class learnings for your site projects?

Decision Support

- Scenario Planning and Sensitivity Analysis
  - Develops multiple scenarios (e.g. optimistic, pessimistic, most likely) to assess project's potential outcomes under different conditions
  - Examines the impact of changes in multiple key assumptions simultaneously
- Strategic Financial Analysis
  - Integrates financial analysis with broader strategic objectives, assessing the project's impact on the company's overall performance



Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Scenario Planning and Sensitivity Analysis

- Tests the stability of results when technical, market, and financial assumptions change individually or together.

Questions Answered

- Which assumptions have the strongest effect on the result?
- What values cause the project to miss a target?
- Does the decision hold under plausible downside conditions?

Best Fit:
Every TEA stage. The level of detail should increase as data and investment stakes improve.

ANALYSIS OPTIONS

Method	How it works	What it shows
One-way sensitivity	Change one input at a time	Ranks the strongest drivers
Scenario analysis	Change linked assumptions together	Compares base, upside, and downside cases
Probabilistic analysis	Assign distributions and simulate	Estimates ranges and probabilities

COMMON INPUTS

Price, yield, utilization, capital cost, operating cost, discount rate

TYPICAL OUTPUTS

Key drivers | **Threshold values** | **Outcome ranges** | **Probability of meeting target**

Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Strategic Financial Analysis

- Extends project finance beyond a single metric by testing whether an investment supports broader company objectives and constraints.

Questions Answered
Does the project support the company's strategic direction?
Can the organization execute and absorb the investment?
What portfolio trade-offs or risks affect the decision?

Best Fit:
Detailed TEA and investment decisions that require more than NPV, IRR, or payback alone.

EVALUATION FRAMEWORK

Criterion	Evidence considered	Decision question
Financial return	NPV, IRR, margin	Is the return adequate?
Market position	Revenue, price, adoption	Is demand credible?
Operating fit	Capacity, skills, supply chain	Can the company execute?
Risk exposure	Technical, market, regulatory	What could change the result?
Portfolio impact	Capital use, timing, opportunity cost	Is this the best use of resources?

OPTIONAL SCORING

Weighted score = sum of (criterion weight × rating)

TYPICAL OUTPUTS

Ranked options | **Conditions for approval** | **Portfolio trade-offs** | **Investment rationale**

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Process Exhaust Heat Recovery: Uncertainty and break-even

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- Find the gas price required for a five-year simple payback.
- Identify the assumptions that require measurement or validation.
- Evaluate the downside, base, and upside cases.

Process Exhaust Heat Recovery: Uncertainty and break-even

Scenario	Gas price	Gas reduction	Net investment	Annual savings	NPV
Downside	$4/MMBtu	15%	$550,000		
Base	$6/MMBtu	20%	$450,000		
Upside	$8/MMBtu	20%	$450,000		
Downside (alternative)					
Baseline (alternative)					
Upside (alternative)					

Process Exhaust Heat Recovery: EHS and decision

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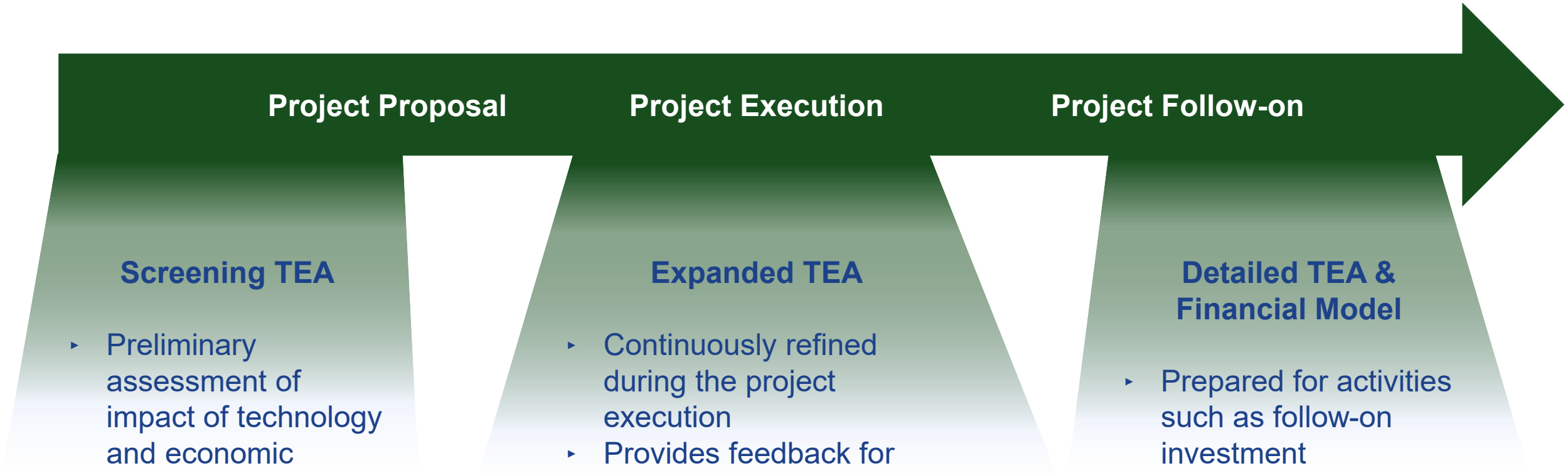
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- Identify safety, maintenance, and production risks.
- Apply the strategic scoring criteria.
- Prepare an approval, rejection, or conditional recommendation.

Types of TEA

TEA evolves through the life of a project



Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Screening TEA => Basic Financial Analysis

- **A preliminary estimate of the cost of production of a system at scale which will be used to calculate LCOx (Levelized Cost Of X; e.g. Energy, Storage, etc.).**

- Questions to answer:
  - Does the technology provide more value/product than existing alternative?
  - What are the main costs used as inputs for analysis?
  - What is minimum performance levels to have technology economically feasible?
  - What processes/components are most influential and should be prioritized in further R&D?

Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Expanded TEA => Intermediate Financial Analysis

- **A more accurate estimate of the cost of production of a system and builds up on more accurate input values than those used in screening TEA.**

- Questions to answer:
  - Should continue development given the knowledge acquired from lab/pilot scale experiments?
  - What processes/components are most influential and should be prioritized in further R&D?
  - What minimum performance levels at scale will be necessary to have an economically feasible design/process?
  - What is the estimated long-term profitability of project?
  - Is the technology investable? Sustainable?

Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Detailed TEA & Financial Model => Advanced Financial Analysis

- **A detailed estimate of the cost of production and projected revenue that allows detailed information for analysis to support decision-making on substantial investments.**

- Questions to answer:
  - What processes/components are most influential and should be prioritized in further R&D?
  - Were the engineering and manufacturing risks removed?
  - What are the effects of efficiency, yield and costs?
  - Are the market risks removed (revenue projections)?
  - Should investment to build commercial system be pursued?

Source: https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf

Assessment Process Steps

Level	TEA type	Assessment Components	Process Steps
1	Screening TEA	1. Cost Analysis • (Focus on understanding the direct and indirect costs associated with developing and launching the product/technology) 2. Comparison with competing technology	1. Identify baseline for comparison 2. Conceptual product/process design 3. Estimate CAPEX and OPEX for each process in scope 4. Simplified (High-Level) Cost Analysis
2	Expanded TEA	1. Detailed Cost Analysis (DCA) 2. Revenue Projections: Establishes a basic understanding of potential sales and revenue streams 3. Discount Cash Flow (DCF) Analysis 4. Break-Even Analysis 5. Simple Return on Investment (ROI) Calculation	1. Develop process block diagram 2. Develop product design and manufacturing process block diagram 3. Refine Cost Analysis with new-insights from technology development 4. Estimate projected revenue 5. Estimate break-even point, ROI, other financial metrics 6. Incorporate new-insights from technology development and process data collection
3	Detailed TEA/ Financial Modeling	1. Scenario Planning 2. Process Based Cost Modeling 3. Strategic Financial Analysis 4. Sensitivity analysis of Multiple Variables	1. Update data from previous stages 2. Detail process model / product design 3. Refine costs & revenue estimation / consider scaling factors 4. Integrates financial analysis with broader strategic objectives, assessing the project's impact on company's performance

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Some tips for conducting and reviewing TEA

- **Pay attention to the assumptions!**
  - Assumptions are the key to the results!

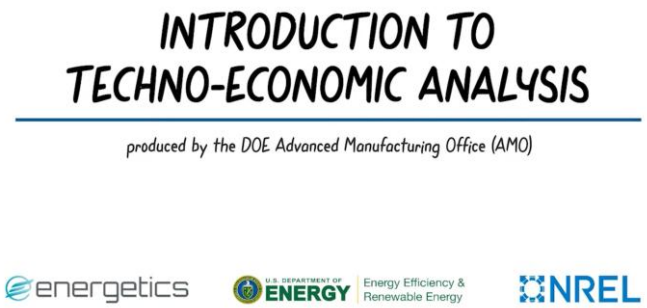
- Attempt to estimate upper and lower bounds for input values that are uncertain.
  - **Use these bounds to understand the magnitude of uncertainty of a particular data point and how much this uncertainty impacts the total production cost.**

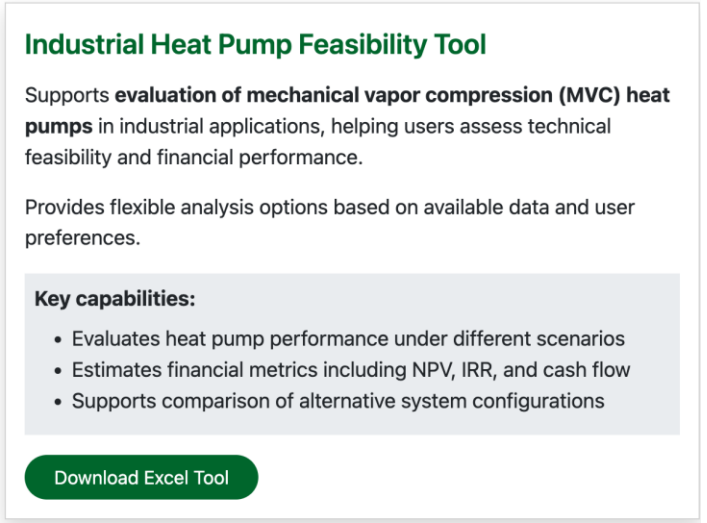
- **Uncertain data points can always be revisited if they are major drivers of TEA results.**
  - If they aren't major drivers, you can avoid spending too much time trying to get an accurate estimate.

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Other Resources for TEA

- TEA at ARPA-E
  - https://arpa-e.energy.gov/sites/default/files/2025-06/Techno-Economics%20for%20ARPA-E%20Performers.pdf
- DOE's Life Cycle Assessment and Techno-Economic Analysis Training
  - https://www.energy.gov/cmei/ito/life-cycle-assessment-and-techno-economic-analysis-training
- DOE's Techno-EconomiC Heuristic Tool for Early-Stage Technologies (TECHTEST) Tool
  - https://www.energy.gov/cmei/ito/techno-economic-heuristic-tool-early-stage-technologies-techtest-tool
- ORNL Industrial Resources Software Tool Suite
  - https://industrialresources.ornl.gov/additional-resources





Other General Resources

- Choose Your Own Solution
  - https://cyos.ornl.gov/
- Database of State Incentives for Renewables & Efficiency®
  - https://dsireusa.org/
- DOE's Better Buildings Better Plants Financing Navigator
  - https://betterbuildingssolutioncenter.energy.gov/financing-navigator
- DOE's Funding Opportunities
  - https://www.energy.gov/funding-opportunities
- DOE's Industrial Validation Program
  - https://betterbuildingssolutioncenter.energy.gov/industrial-technology-validation-program

THANK YOU!

For More Information:

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https://bptraining.ornl.gov/