Project PARETO: A Systems Approach to Produced Water
From Advanced Infrastructure Buildout, Optimization, and Hydraulic Analysis to Treatment and Beneficial Reuse Across Industries

PARETO — The Produced Water Optimization Initiative

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Project Premise and Goals

Develop a decision-support tool to transport, treat, store, inject and/or reuse produced water from onshore oil & gas operations.

PARETO software helps with: **2021 Focus 2022 Focus 2023 Focus**

a) Infrastructure **buildout**.
b) Produced water **management**.
c) Treatment technologies **selection**.
d) Facilities **placement and sizing**.
e) **Assessing** water reuse options.
f) **Distribution** for reuse.

- Views produced water from a "systems" perspective.
- Is intended to serve as a resource to the community.

PARETO was designed to become a trusted decision-support tool for the produced water community.


Overview

Motivation and Challenges
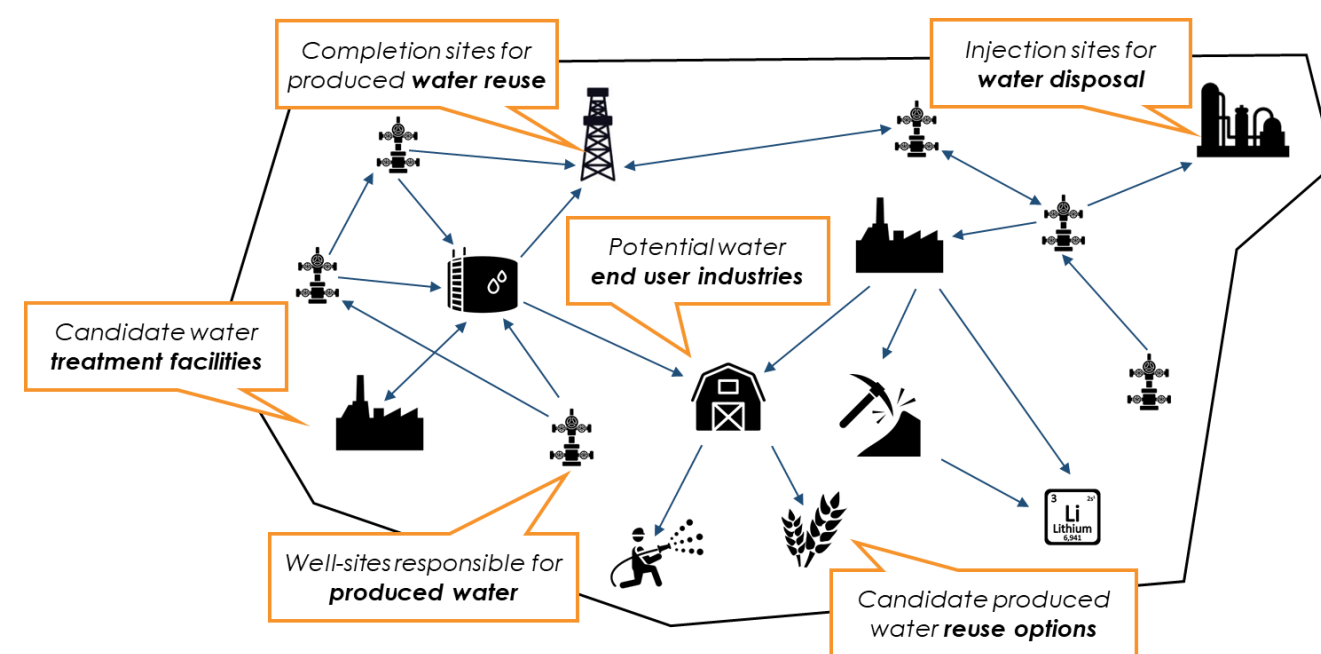
- Produced water **volumes are increasing**.
- Disposal capacity is **rapidly decreasing** (seismicity).
- Produced water is **challenging to treat**:
  - High TDS concentrations (up to 320,000 mg/L TDS).
  - Variety in production quantities and qualities.

Rigorous optimization models will help the industry find new ways of dealing with produced water.
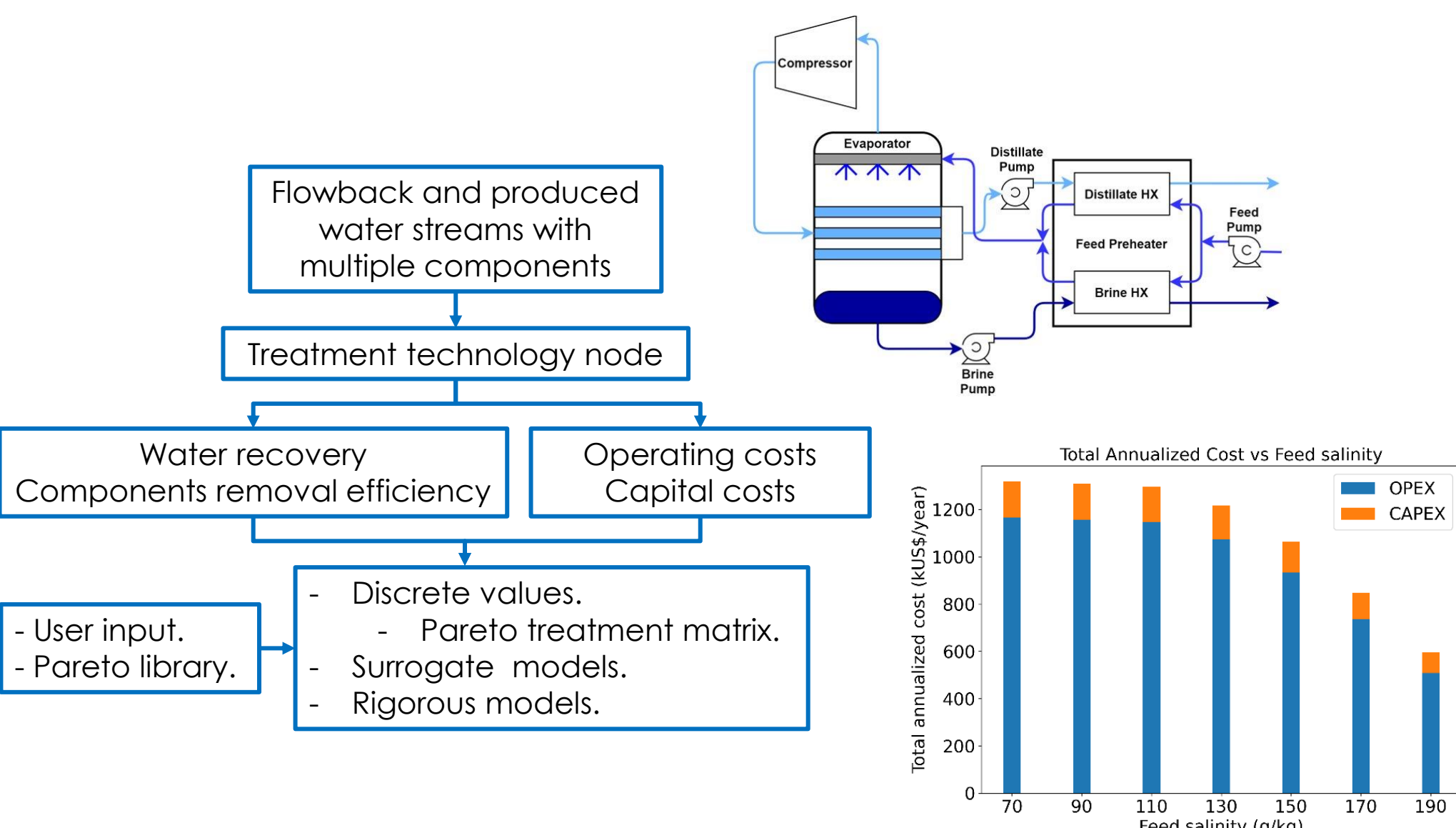

Project Development
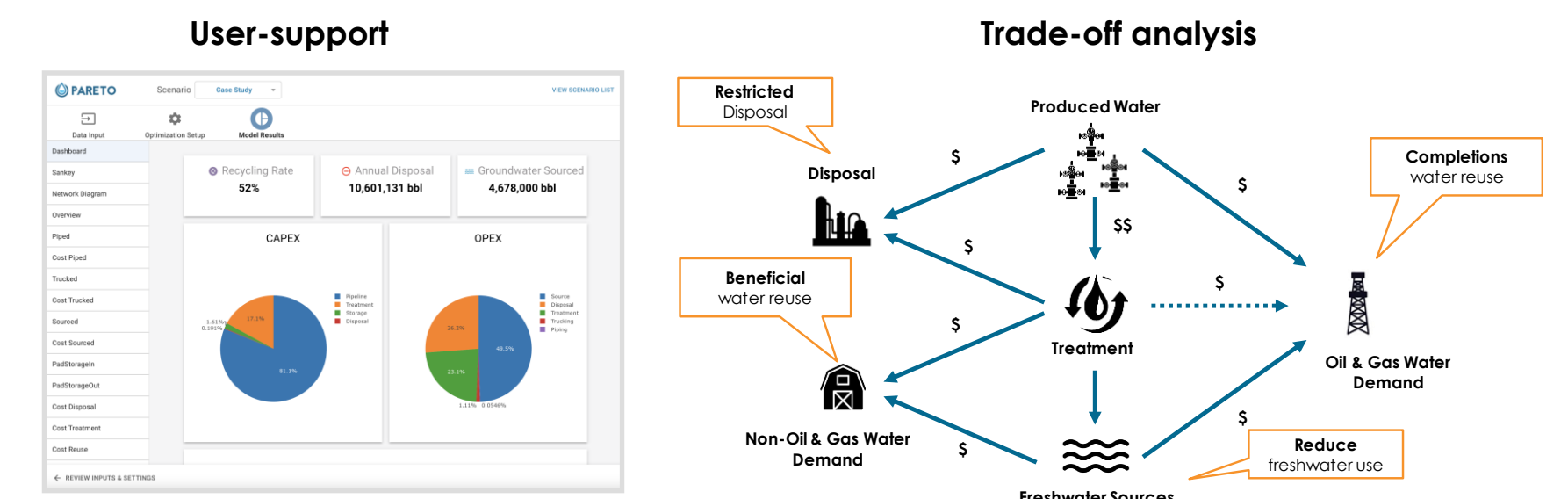
- Open-source framework and user-interface development.
  - https://www.project-pareto.org/
  - https://github.com/project-pareto/project-pareto
- Capabilities to solve existing real-world challenges.
  - Water treatment placement, **beneficial reuse**, seismic restrictions, **hydraulics**, etc.
- **Industrial collaborations** and applications.
  - Evaluating through the lens of potential users.

Team PARETO actively engages with its stakeholders to identify important challenges and develop solutions.

Treatment and Beneficial Reuse

Treatment for Recycling and Beneficial reuse

PARETO models treatment centers with different detail levels to align with user needs and ensure water quality requirements.

Beneficial Reuse Network Highlights

Beneficial reuse network:
- Adapts to diverse streams per site
- Addresses seasonal needs
- customizes post-desalinated water to site quality standards.
- Relies on meeting concentration targets and securing volume for resource recovery
- Dictates unique cost profiles for each material

Beneficial reuse example	Agricultural Application	Hydrogen Demonstration	Solution Mining	Fertilizer Production Facility	Critical Mineral Recovery
Material and Quality Requirement	Desalinated and re-mineralized water	Ultra-pure water	Clean brine	Pure Ammonia	Clean brine or concentrated brine
Demand Seasonal Variability	High	Moderate	Low	Low	None
Model economic inputs	Cost of treatment/post-treatment/process, storage, and transportation · Beneficial reuse credit				

PARETO addresses beneficial reuse challenges with tailored inputs, constraints, outputs, and objectives.

Beneficial Reuse Outcomes

PARETO:
- Offers insightful recommendations for beneficial reuse selection and resource allocation.
- Empowers dynamic 'what-if' scenarios and sensitivity analysis.
- Illustrates seamless integration of beneficial reuse with other water management strategies.
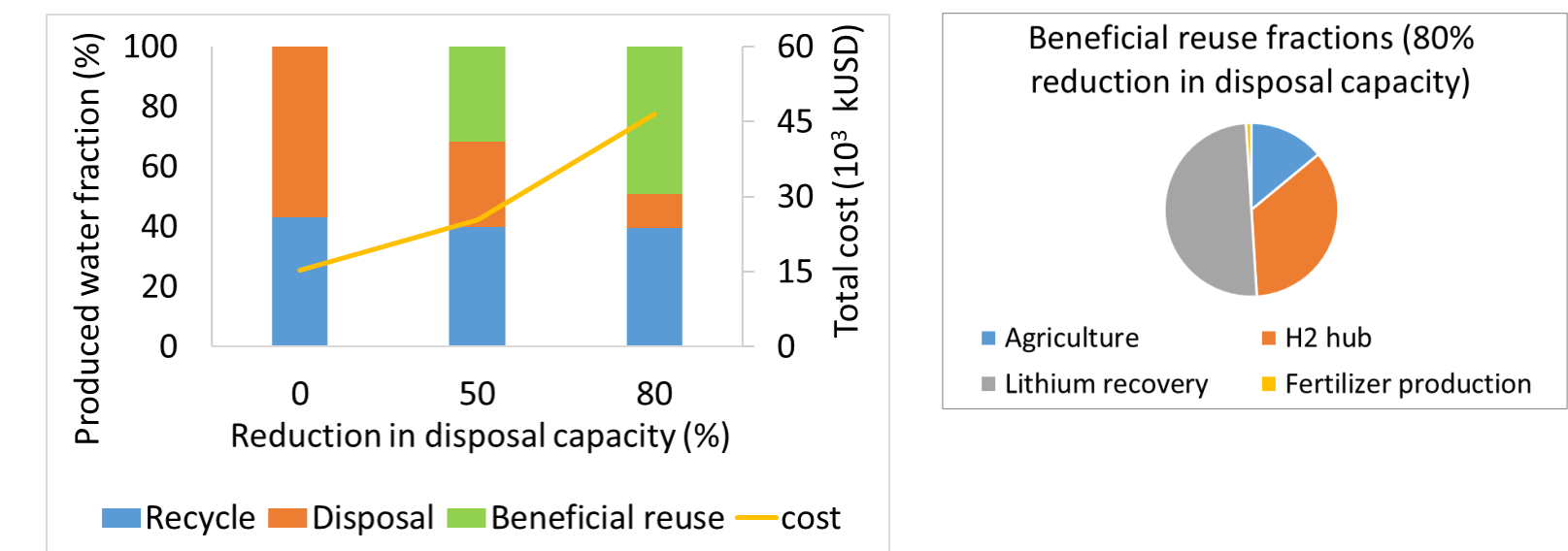
Beneficial reuse realization is enhanced by PARETO providing dynamic analysis, and integrated strategies.

Industrial Collaborations

Ongoing Industrial Collaborations

The team continues to **collaborate** with several industrial partners:

	OLYMPUS ENERGY	ConocoPhillips	ARIS WATER
Basin Segment	Appalachian Upstream	Permian Upstream	Permian Midstream
Case Study Focus	Truck routing, storage placement/sizing, treatment/disposal cost sensitivities	Capacity expansion (injection, pipelines, storage), third party constraints	Water management, desalination integration, beneficial reuse
PARETO Model	PARETO[Ops]	PARETO[Strategy]	PARETO[Strategy]

Industrial case studies are critical to demonstrate PARETO's usefulness, relevance, and importance to practitioners.

Mid-stream Case Study Example: ARIS Water

Given:
- Network configuration
- Forecasts (production, flowback)
- Capacities and costs
- Planning horizon (18 months)

Determine:
- Infrastructure (capital decisions)
- Optimal flows and directions
- Capacity utilization
- Optimal job (flowback) selection

No. of Variables: **136,869**   Binary Variables: **64,961**   Constraints: **55,466**   Solver: **Gurobi**
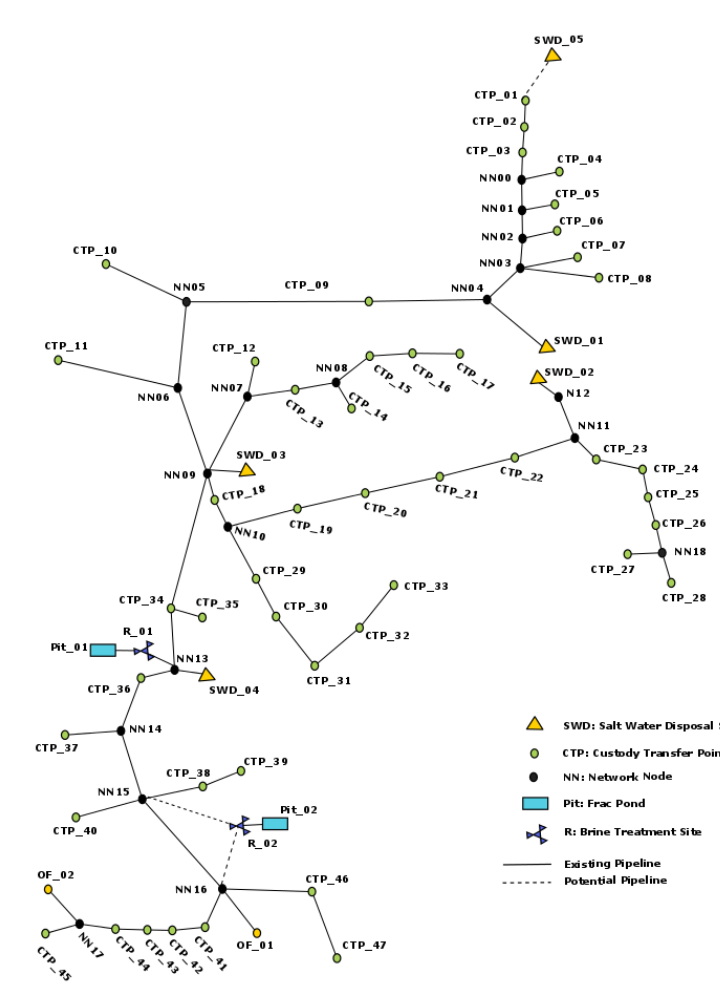
PARETO takes < 30 seconds to solve the problem, allowing the operators to perform several "what-if" scenario analyses.
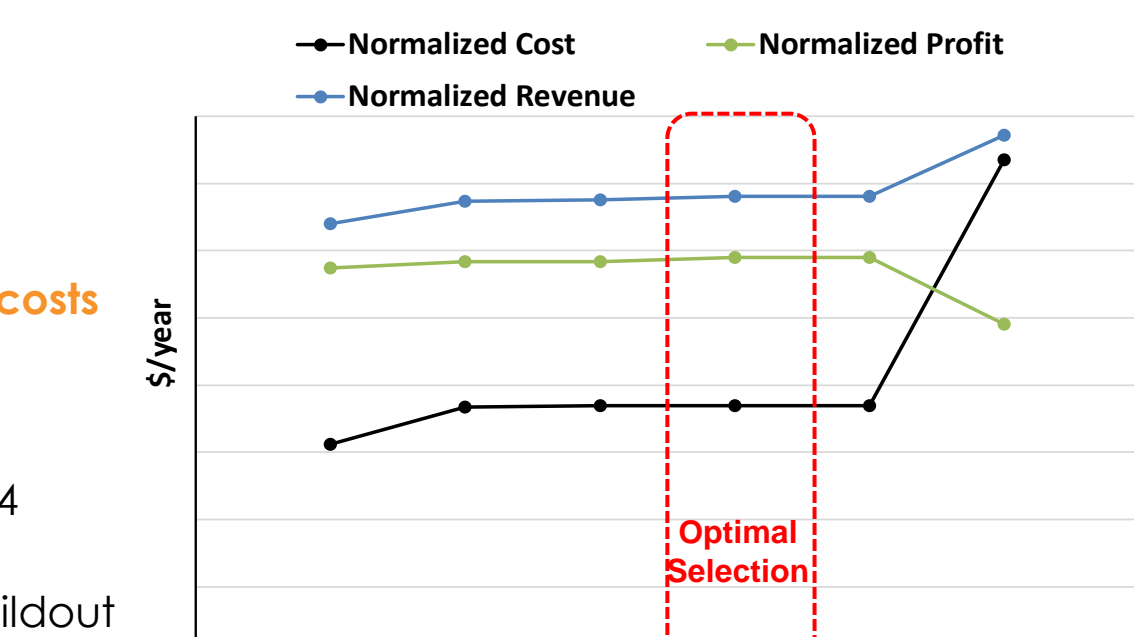
In-depth Analysis and Insightful Results

Optimization Setup
- Seven jobs to choose from
  - CP01, ..., CP07
- PARETO chooses "optimal" jobs
  - Considering **revenues** and **costs**
  - Maximizing profits

Qualitative Results
- PARETO chooses CP01 and CP04
- CP03 is a similar solution
  - Requires further pipeline buildout

Scenario-Based Infrastructure Buildout and System Analysis

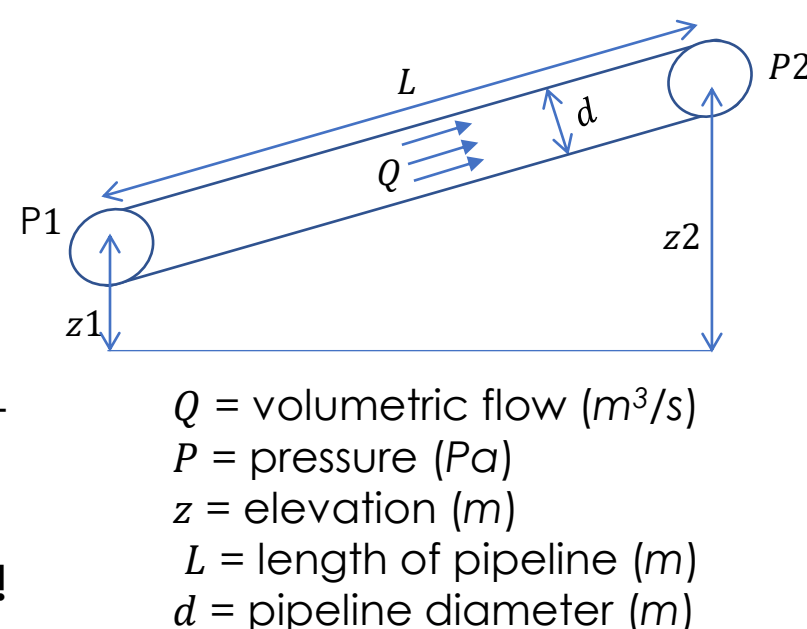|	Reduced Flowback (-30%)	Nominal Flowback	Increased Flowback (+30%)
Reduced Completions (-30%)		Disposal: - Storage: -	Disposal: - Storage: -
Nominal Completions	Disposal: -23% Storage: -	Nominal Scenario	Disposal: - Storage: + 60%
Increased Completions (+30%)	Disposal: - 23% Storage: + 100%	Disposal: - Storage: + 100%	

Hydraulics

Motivation

Motivation: Feedback from PARETO Stakeholder Board!

- Elevation changes across PW pipeline systems
- Fluctuations in pressures and flows (e.g., due to new wells)
- Flow capacity restrictions & MAOP near-violations
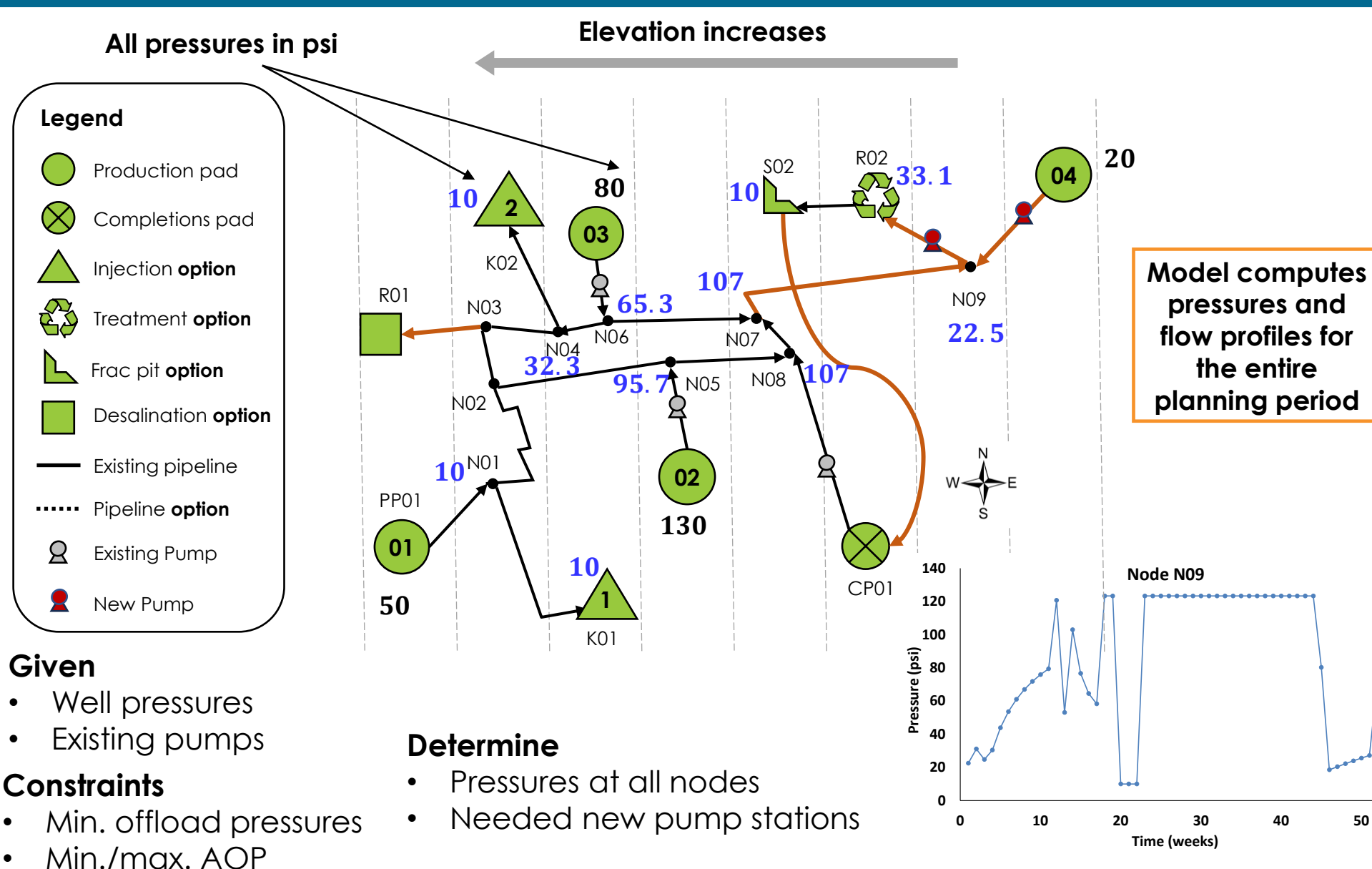
Action: Incorporate hydraulics into PARETO!

- Consider elevation changes explicitly [$z2 - z1$]
- Factor pressure into pipeline network design
- Identify pumping needs

PARETO's hydraulics module computes pressures at each node and determines pumping/throttling needs.

Q = volumetric flow (m^3/s)
P = pressure (Pa)
z = elevation (m)
L = length of pipeline (m)
d = pipeline diameter (m)

Given
- Well pressures
- Existing pumps

Constraints
- Min. offload pressures
- Min./max. AOP

Determine
- Pressures at all nodes
- Needed new pump stations

Model computes pressures and flow profiles for the entire planning period

Framework

- Fast computation
- Scalable and requires fewer inputs
- Less comprehensive (cannot change existing infrastructure or flows)

PARETO Options	Features
No Hydraulics	· Doesn't run hydraulics module
Post Process	· Compute pressures post optimization · Detect potential pressure violations · Determine pumping needs
Co-optimize	· Network design considering hydraulics · Pipeline sizing considering pressures · Pumping stations and sizing

- Comprehensive (network design with hydraulics)
- Computationally intensive

The hydraulics module can assess network operations (post-process) or design new infrastructure (co-optimize).

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