Risk Analysis for Flexible Turnaround Planning in Integrated Chemical Sites

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Background

- Turnarounds are huge investments, often in sizable proportion to the annual revenue.
- Tan and Kramer [1997] estimate up to \$30,000/hr in losses for large companies during turnarounds.
- Network interactions in integrated chemical sites offer ample scope for planning turnarounds, as demonstrated by Amaran et al. [2015a,b].
- In this work, we investigate turnaround perturbation risk to further explore flexibility in strategic planning.

Problem Synopsis

Given an integrated chemical sites network with potentially suboptimal turnaround schedules over next 6-9 months,

- What is the benefit of moving a turnaround (Unit 4) from March (for 14 days) to July (for 17 days)?
- What is the risk of moving the turnaround?

Assume plant reliability data and production-operation cost data is available.

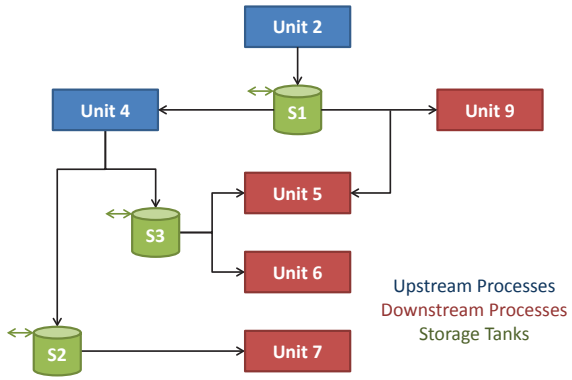


Figure : Illustrative network

Assess the risk in flexibily planning for the following cases:

- Different demand profiles
- Effect of turnaround groupings

Approach

Base vs Alternative plans: Decisions are production capacities and inventory subject to site-wide approximation model.

- Base case: solve LP to maximize profit with current turnaround schedule.
- Alternative case: solve LP to maximize profit for the planning horizon with an alternative turnaround schedule.

Risk profile: To calculate return vs probability of the return – risk profile – adopt the following reactive decision policy (scenarios grow linearly with time periods):

- In case of a minor outage, perform a pit-stop (PS) right-away and then a full turnaround (TA) in July.
- In case of a major outage, perform the full turnaround promptly.

Approach

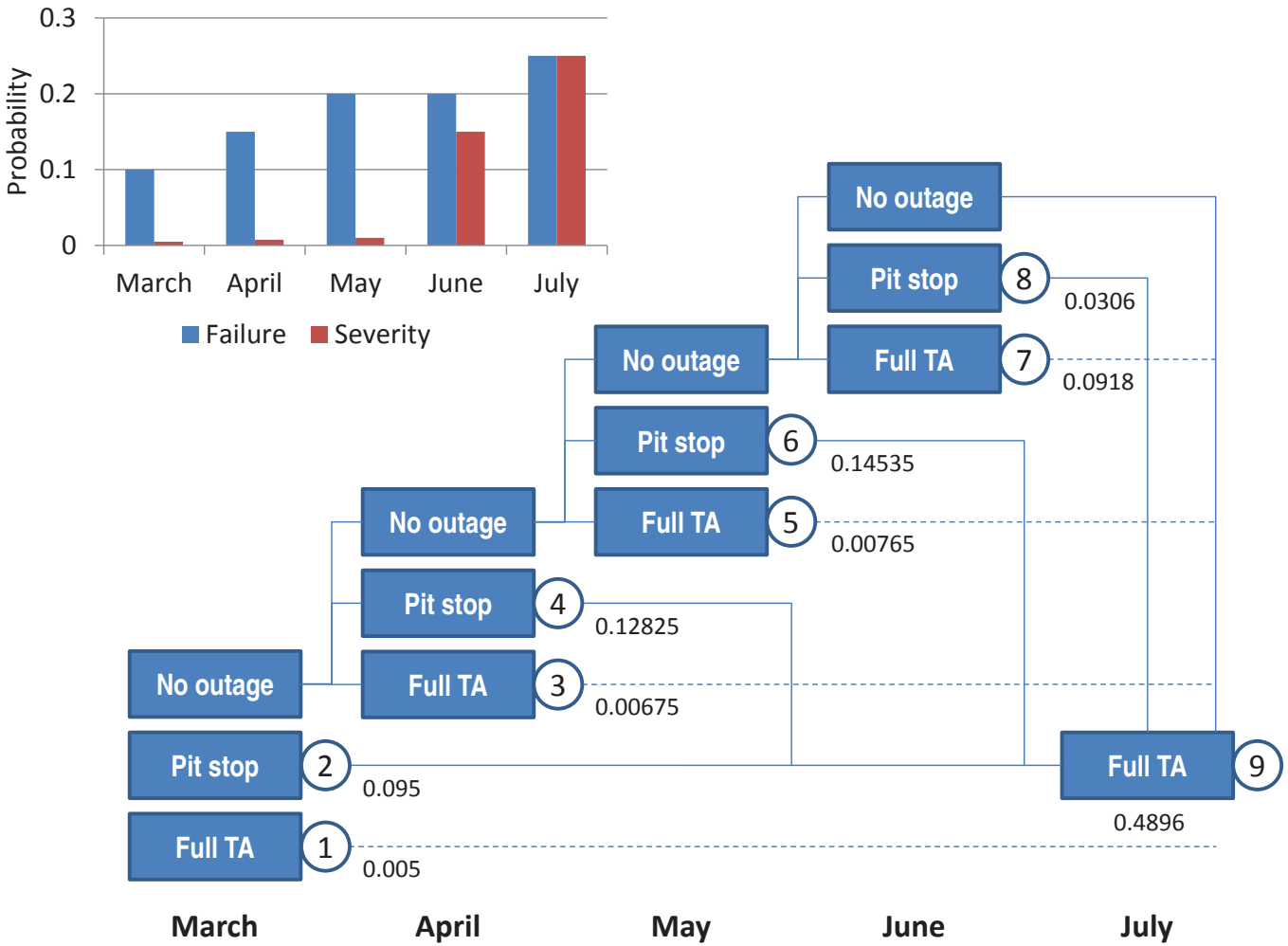


Figure : Unit 4 reliability data and likely outage scenarios

Approach

Unhedged vs Hedged planning: Recourse decisions are production capacities and inventory to maximize profit accrued for time periods since reactive maintenance procedure.

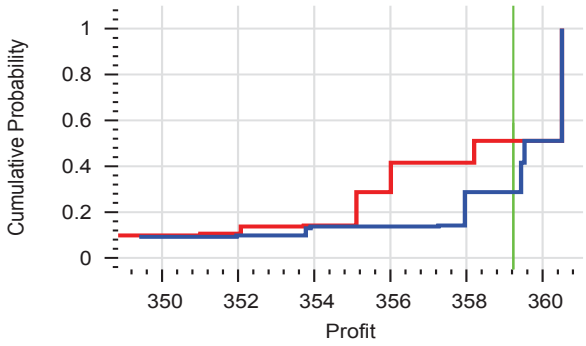
- Unhedged case: maximize profit for future time periods from current state (sequence of LPs).
- Hedged case: maximize expected profit for future time periods conditional to past decisions and uncertainty realizations (multistage stochastic linear program).

Without TA grouping effect

Only one turnaround (Unit 4) studied in isolation.

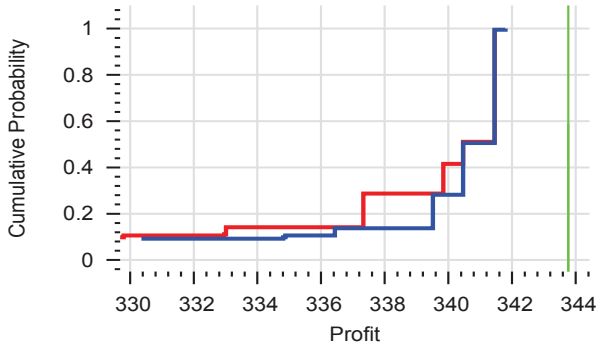
Demand: 90% max capacity

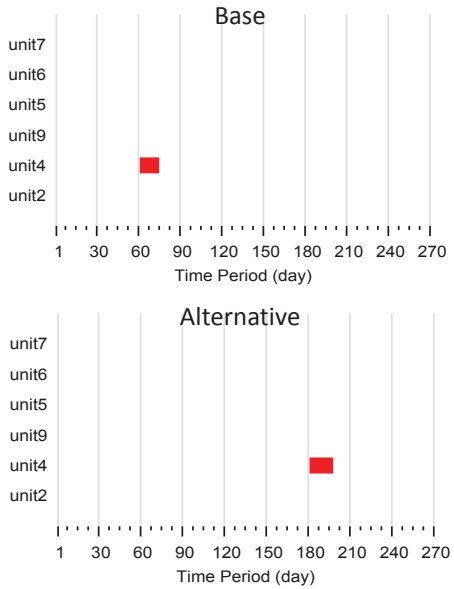
Base: 359.23 Unhedged: 357.30
Alternative: 360.51 Hedged: 358.56



Demand: 85% max capacity

Base: 343.77 Unhedged: 338.73
Alternative: 341.45 Hedged: 339.68



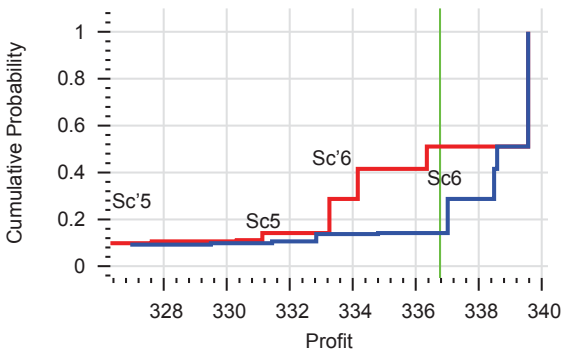


Case Studies

With TA grouping effect

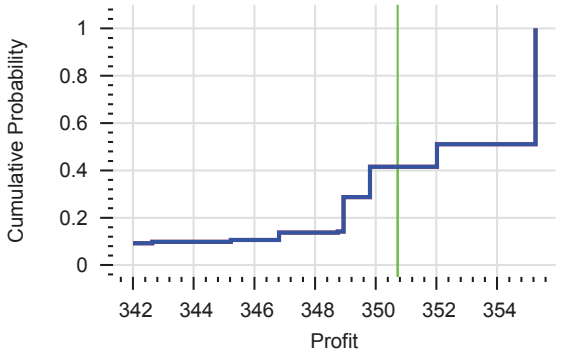
Demand: 90% max capacity

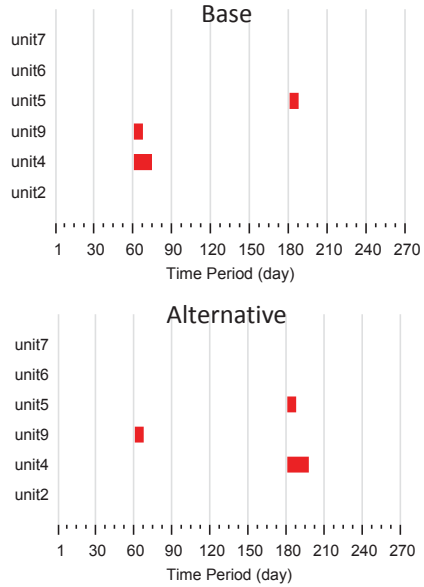
Base: 336.77 Unhedged: 335.84
Alternative: 339.57 Hedged: 337.44



Demand: 100-90-100% max capacity

Base: 350.72 Unhedged: 351.67
Alternative: 355.27 Hedged: 351.67





(In all case studies, relative profit margins of final products are constant with time (contractual); production rate degrades 2-6%; alternative TA duration is 20% longer* and inflation adjusted; reactive TA duration is 50-75% longer and 20% more expensive*; PS duration is 15-40% long and 10-20% expensive*; time value of money is 10%; storage capacities stock-out in 10 days. *compared to base case)

Conclusions

- Moving a turnaround could be profitable depending on demands and integration effects from grouping turnarounds.
- Simple case studies show as much as 1.5% (equivalent to about 12 days-worth production at maximum capacity) increase in profits.
- Production planning without hedging against future uncertain outages could lead to losses.
- Need to investigate risk-averse planning and with demand uncertainties.

References

S. Amaran, N. V. Sahinidis, B. Sharda, M. Morrison, S. J. Bury, S. Miller, and J. M. Wassick. Long-term turnaround planning for integrated chemical sites. *Comput. Chem. Eng.*, 72:145–158, 2015a.

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