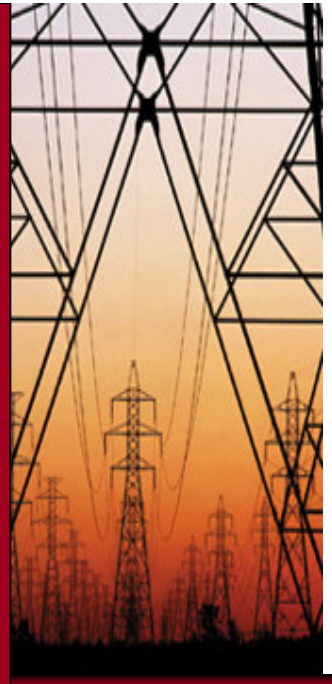

A New Framework for Evaluating Candidate Technologies for Future Energy Systems

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Outline

- Motivation
- Main approach
- Performance matrix as a function of technology choice
- Algorithm
- Illustration of concept
- Conclusion

Motivation

- Systematic comparison of candidate technologies for the changing electrical energy industry
- It is insufficient to invest into given technology without accessing its cumulative operational effects (efficiency, reliability, environmental impact…)

Main approach

- An “optimal” technology (type, capacity, location) is the technology whose cumulative operational benefit over time T equals to its capacity cost [5].

- This captures the inter-temporal dependence between short-term effects (operation) and long-term investments (planning).

Performance matrix …

… as a Function of Technology Choice

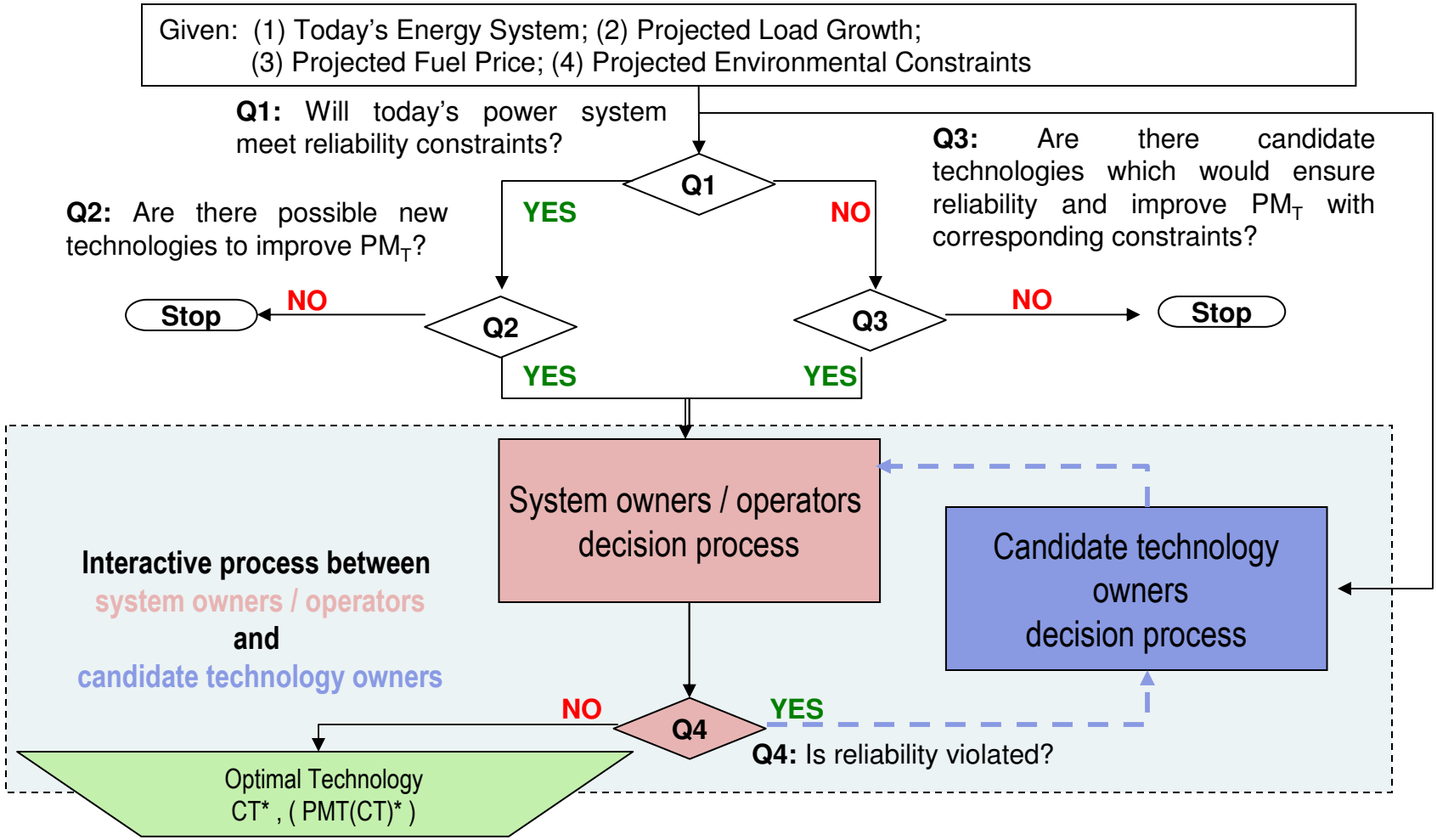
PMT(TC) = Cumulative System Operational Cost
+ Capital Cost
– Cumulative Benefit of Customers

Subject to: 1) decisions – driven dynamics
2) natural system dynamics and constraints

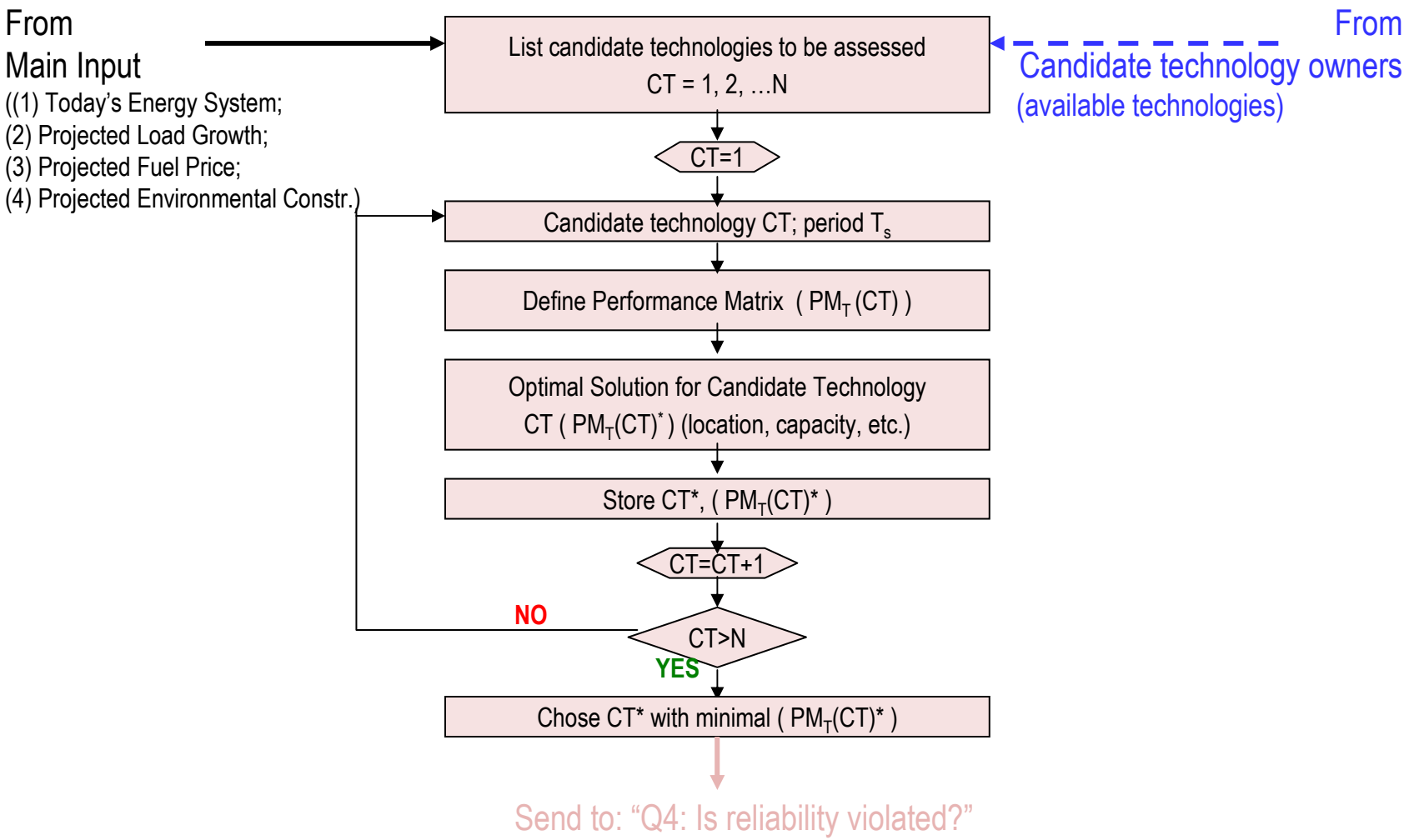
Example of …

- Candidate technologies
  - Load management
  - Software for optimal scheduling
  - Reliability differentiate priority service
  - Advanced generation control
  - Filters for quality of supply
  - Distributed generation
  - Energy storage; V2G
  - FACTS
  - PMU
- Efficiency measures
  - Delivery losses
  - Reserve requirements
  - Environmental effects
  - Harmonics

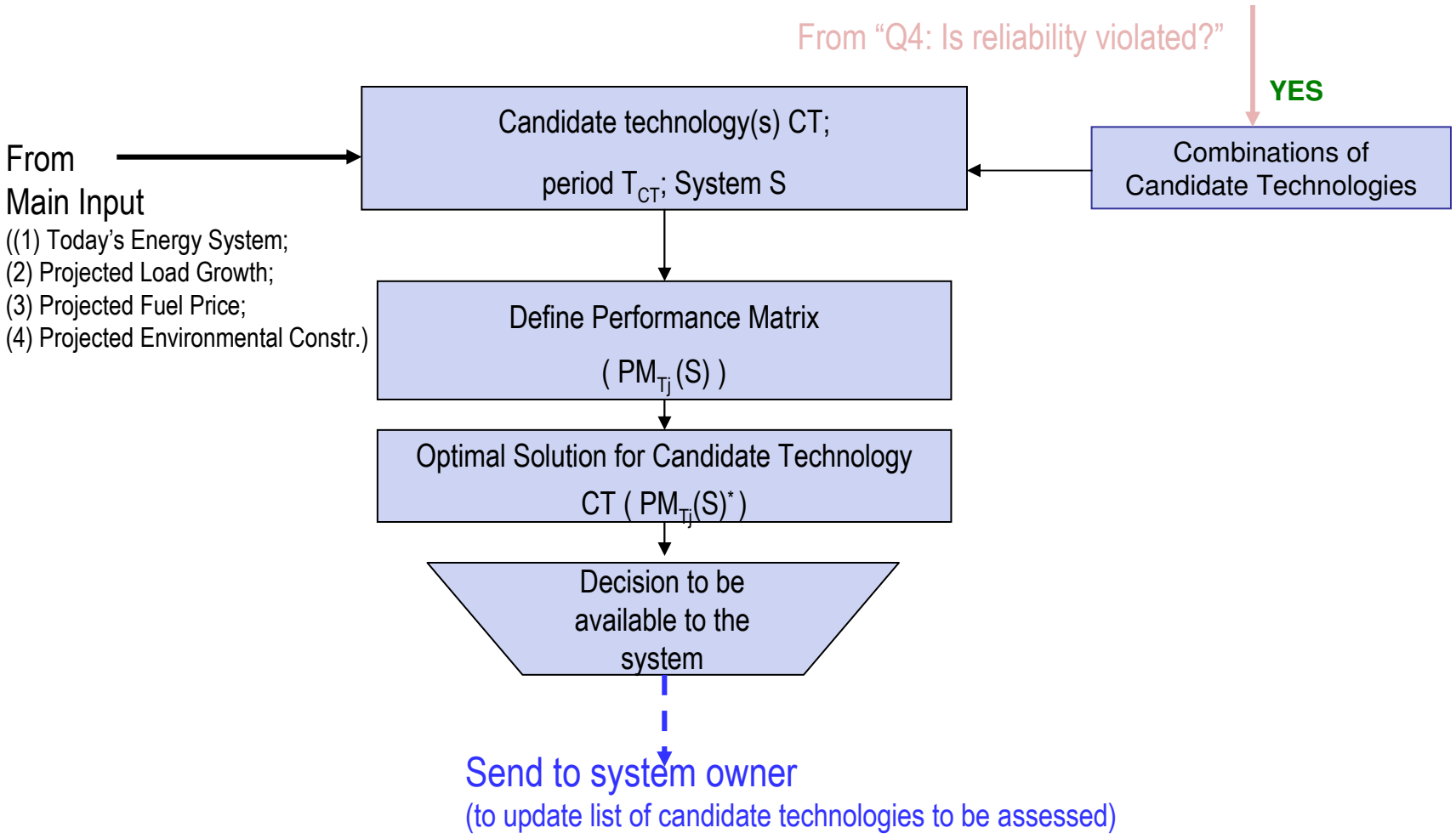
Algorithm


Given: (1) Today's Energy System; (2) Projected Load Growth;
(3) Projected Fuel Price; (4) Projected Environmental Constraints
Q1: Will today's power system meet reliability constraints?
Q1
YES
NO
Q2: Are there possible new technologies to improve PMT?
Q2
NO
Stop
YES
Q3: Are there candidate technologies which would ensure reliability and improve PMT with corresponding constraints?
Q3
NO
Stop
YES
System owners / operators decision process
Candidate technology owners decision process
Interactive process between
system owners / operators
and
candidate technology owners
Q4
NO
YES
Q4: Is reliability violated?
Optimal Technology
CT* , (PMT(CT)*)

System owners decision process



Candidate technology owners decision



Algorithm

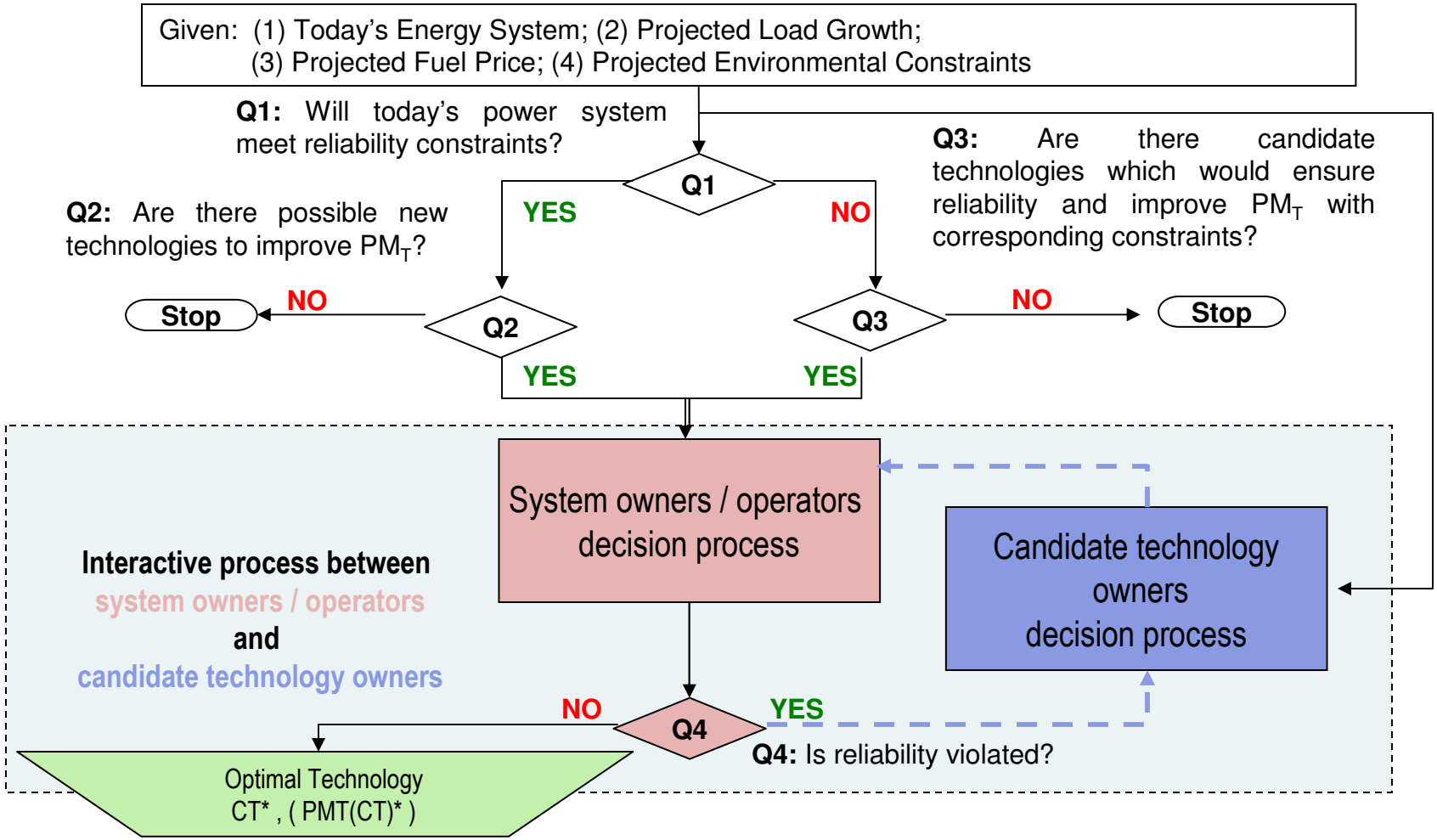

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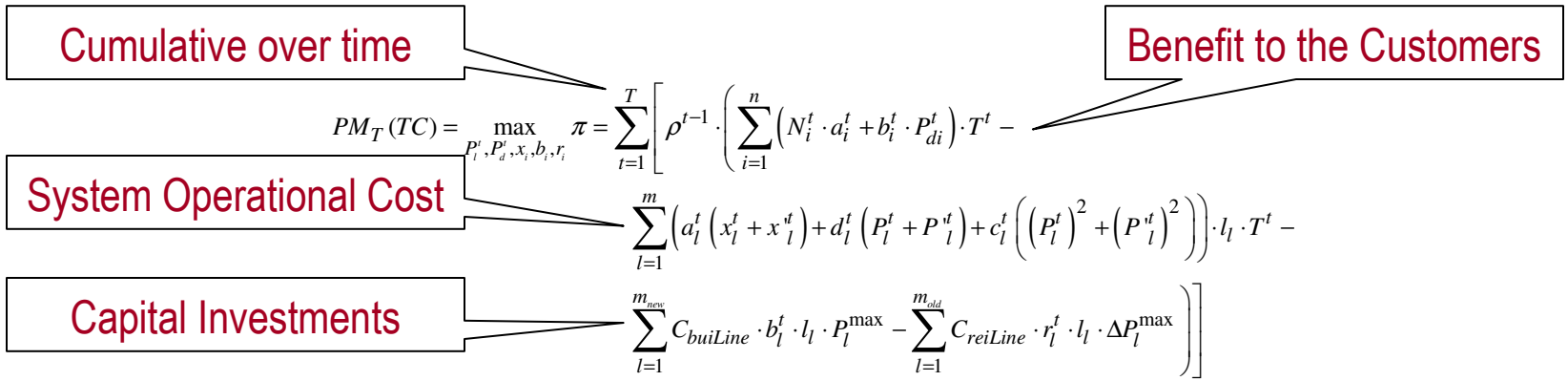
Illustration of concept

- Distribution system planning
- Motivation: New technologies and customer demand types
- The main idea: Capture the inter-temporal dependence between short-term effect and long-term investments
- Approach: Find the "optimal" technology



Subject to: 1) decisions – driven dynamics

2) natural system dynamics and constraints

Illustration of concept (cont.)

- Different technologies and different scenarios
  - "Classical" approach – addition of new lines,
  - "With CDG" approach – addition of new lines and controllable distributed generators,
  - "With DLC" approach – addition of new lines and direct load control,
  - "With DLC and CDG" approach – addition of new lines, direct load control and controllable distributed generators,
  - "With DLC and DG" approach – addition of new lines, direct load control and uncontrollable distributed generators that will always produce Pmax.

Illustration of concept (cont.)

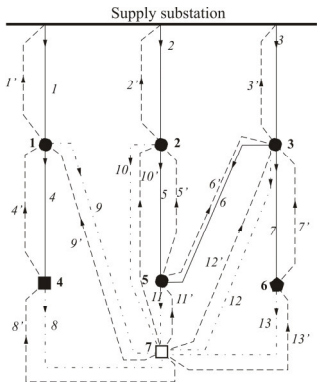


Fig 1 - Test network

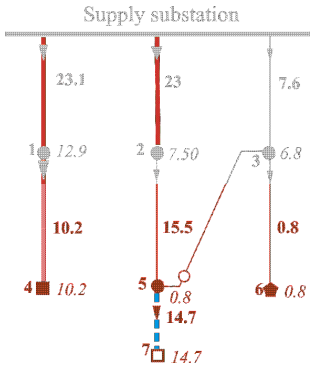


Fig 2 – "Classical Approach"

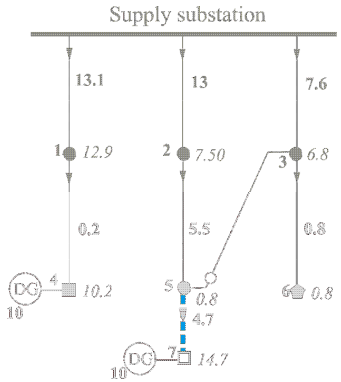


Fig 3 – With Controllable Distributed Generation

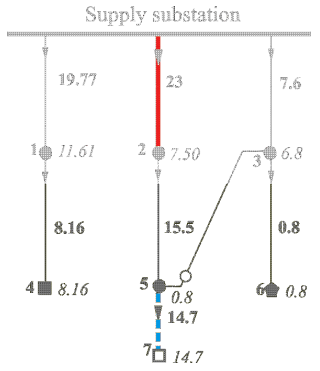
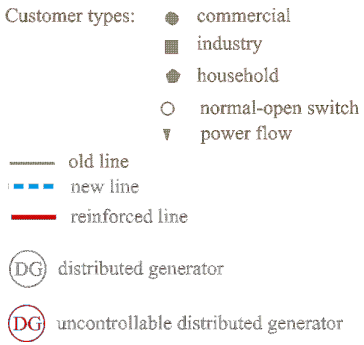


Fig 4 – With Direct Load Control



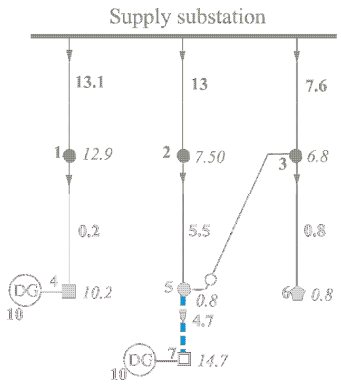


Fig 5 – With Direct Load Control and Controllable Distributed Generation

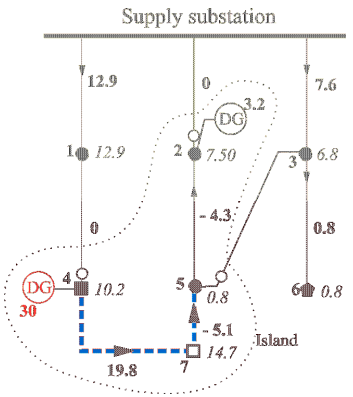


Fig 6 – With Direct Load Control and Uncontrollable Distributed Generation

Illustration of concept (cont.)

	"Classical"	With CDG	With DLC	With DLC and CDG	With DLC and UDG
Build new line	**Yes** Line:11 Year:5	**Yes** Line:11 Year:5	**Yes** Line:11 Year:5	**Yes** Line:11 Year:5	**Yes** Line:11 Year: 1 Line: 8 Year: 1
Replacement	**Yes** Line:2 Year:6 Line:1 Year:9 Lline:4 Year:10	No	**Yes** Line:2 Year:8	No	No
Load reduction	No	No	**Yes**	No	No
Bi-directional power flow	No	**Yes**	No	**Yes**	**Yes**
Performance Matrix	Minimal Costs $ 4,064,024	Minimal Cost $ 875,605	Maximal Social Welfare $ 19,865,187	Maximal Social Welfare $ 21,857,525	Maximal Social Welfare $ 18,490,074

Conclusions

- New technologies require new paradigms of planning and operations
- Systematic comparison and evaluation of both old technologies and new candidate technologies is needed
- It is insufficient to invest into technology without accessing its cumulative operational effects

References:

1) M. Prica, and M.Ilić, “A New Framework for Evaluating Candidate Technologies for Future Energy Systems,” working paper
2) M. Prica and M. Ilić, “Optimal Distribution Service Pricing for Investment Planning,” *Proceedings of the IEEE General Power Meeting*, Tampa, FL, 2007
3) M. Prica and M. Ilić,“Peak-Load Pricing Based Planning for Distribution Networks Under Change,” *Proceedings of the IEEE General Power Meeting*, Montreal CA, June 2006
4) J.P. Leotard “Transmission Pricing and Incentives for Investments under Uncertainty in the Deregulated Power Industry”, Ms thesis, MIT, February 1999.

Thank you!

Questions?