Effect of Losses on Design and Pricing of Distribution Networks

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(presented by Professor Dennis Allan)

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Background

- Environmental concerns
  - EU and UK Governments committed to reducing CO_2 emissions (Kyoto)
  - ***How electricity supply industry should respond to this challenge?***
- Ageing electricity transmission and distribution infrastructure
  - ESI expanded in late 50s and early 60s
  - ***What is the optimal replacement strategy ?***

Response to climate change challenge

- Approach of EU policy makers to reducing CO_2 emissions
  - Targets for renewable generation - 22% of the demand for electrical energy to be supplied by renewables (12% from new generation)
- Opportunities for reducing CO_2 in transport of and utilisation of electricity have not received adequate attention
- Losses in Europeans networks are significant with considerable variation from about 5% to 12%

Business environment and asset replacement strategy

- Deregulation of electricity supply industry brings new pressures and needs to satisfy conflicting objectives
  - reduce operating costs
  - improve utilisation of existing assets
  - satisfy short and long term interests
  - expand the life of existing assets
- Result: change in asset replacement philosophy
  - ***Lowest investment cost approach***

Issues

- Has traditional, minimum life-cycle cost design of distribution networks been abandoned ?
- What are the consequences of the short-term thinking (stuck with a 30 year mistake) ?
- What is the optimal long term replacement strategy?
- What are the impacts are on Manufacturers, Consumers, Environment ?
- How to encourage implementation of loss-inclusive long term network replacement strategies through regulation?

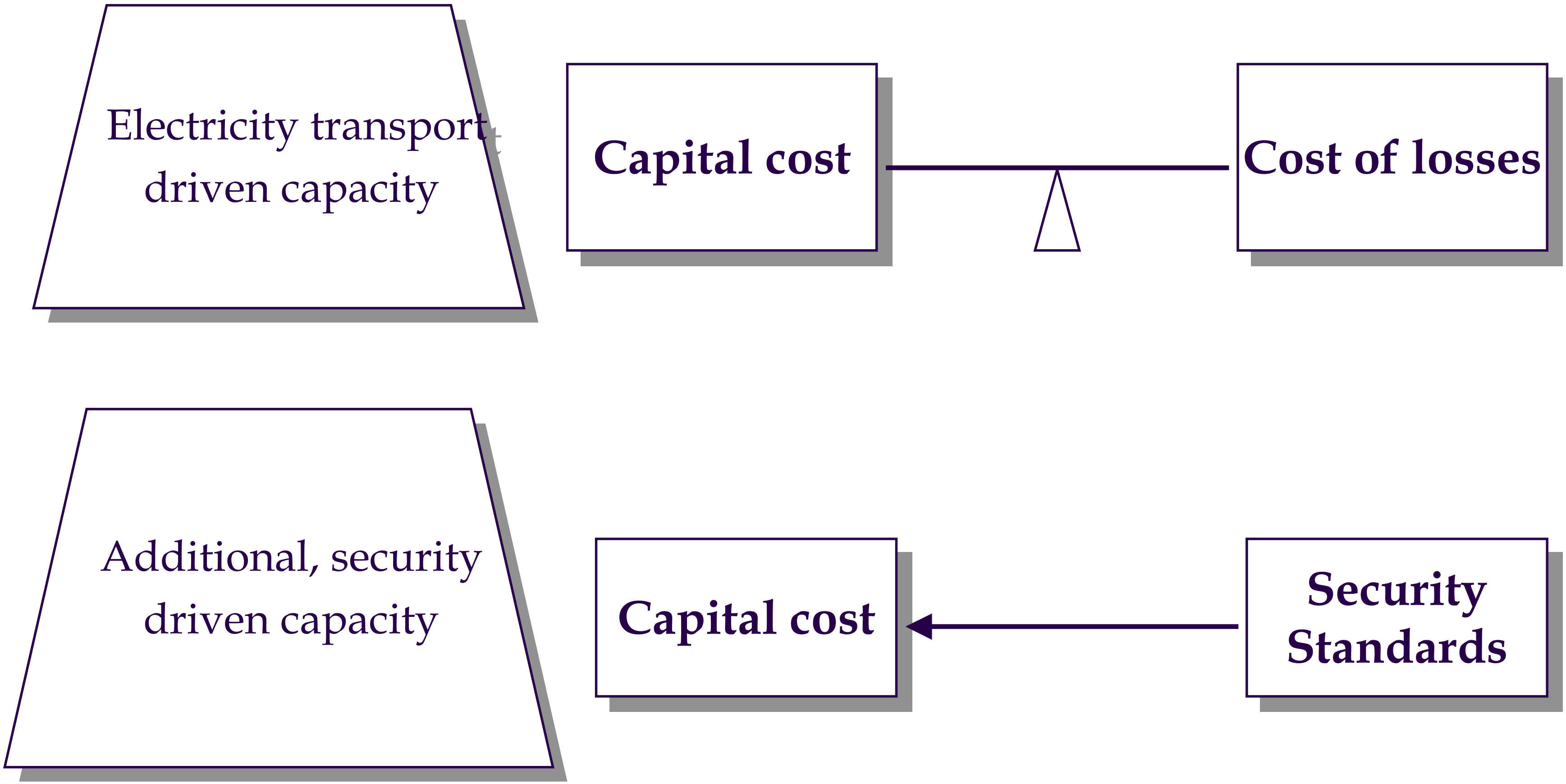
Collaborative research project

- Project Title: Effect of losses on design and pricing of distribution networks
- Project support
  - Engineering and Physical Science Research Council, Alstom Transformers, GPU Power UK, East Midlands Electricity, Pirelli Cables, Association of European Copper Producers
- Two streams of work
  - Technical: Develop long-term loss-inclusive optimal network design and replacement strategies
  - Regulatory/commercial: Develop alternative mechanisms for encouraging minimum life-cycle cost replacement strategies.

Major tasks

- Establish techniques and methods for evaluation of the life-cycle cost of distribution circuits and transformers
- Investigate and develop robust techniques for long-term loss-inclusive optimal network design and replacement strategies of real size distribution networks.
- Investigate and develop alternative mechanisms for encouraging installation of minimum life-cycle cost plant.

❖ Loss inclusive circuit design



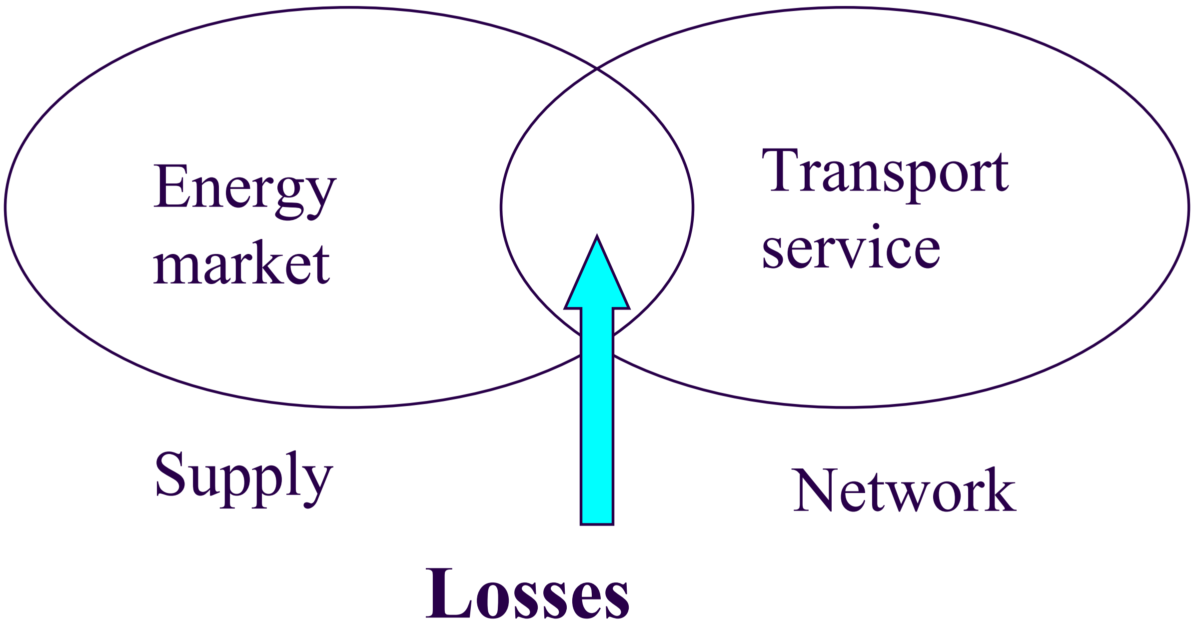
Illustrative results

Optimal utilisation of distribution circuits

	Type of conductor	
Voltage level	Cable	Overhead line
11 kV	0.2 – 0.4	0.13 – 0.20
33 kV	0.3 – 0.5	0.17 – 0.25
132 kV	0.75 – 1.0	0.30 – 0.50

- Optimal utilisation of distribution circuits should be low
- At 11 and 33 kV the bulk of security requirement can be met at no additional capacity (costs)

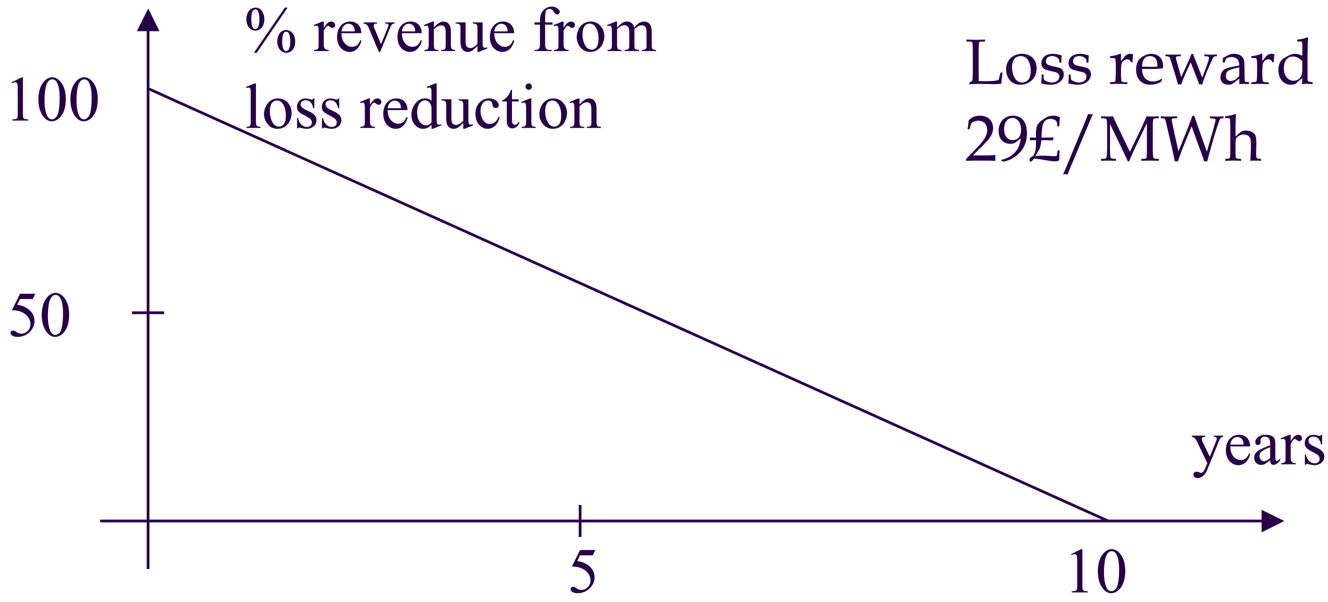
Allocation of benefits from high efficiency plant



Investing in high efficiency of plant is a cost to network owner and a benefit to energy supplier

Incentives for loss reduction

- Loss element in the price control formula (UK)
  - Concept of sharing the benefit of loss reduction between network owners and users over a ten year period.



Loss reward price:
29£/MWh

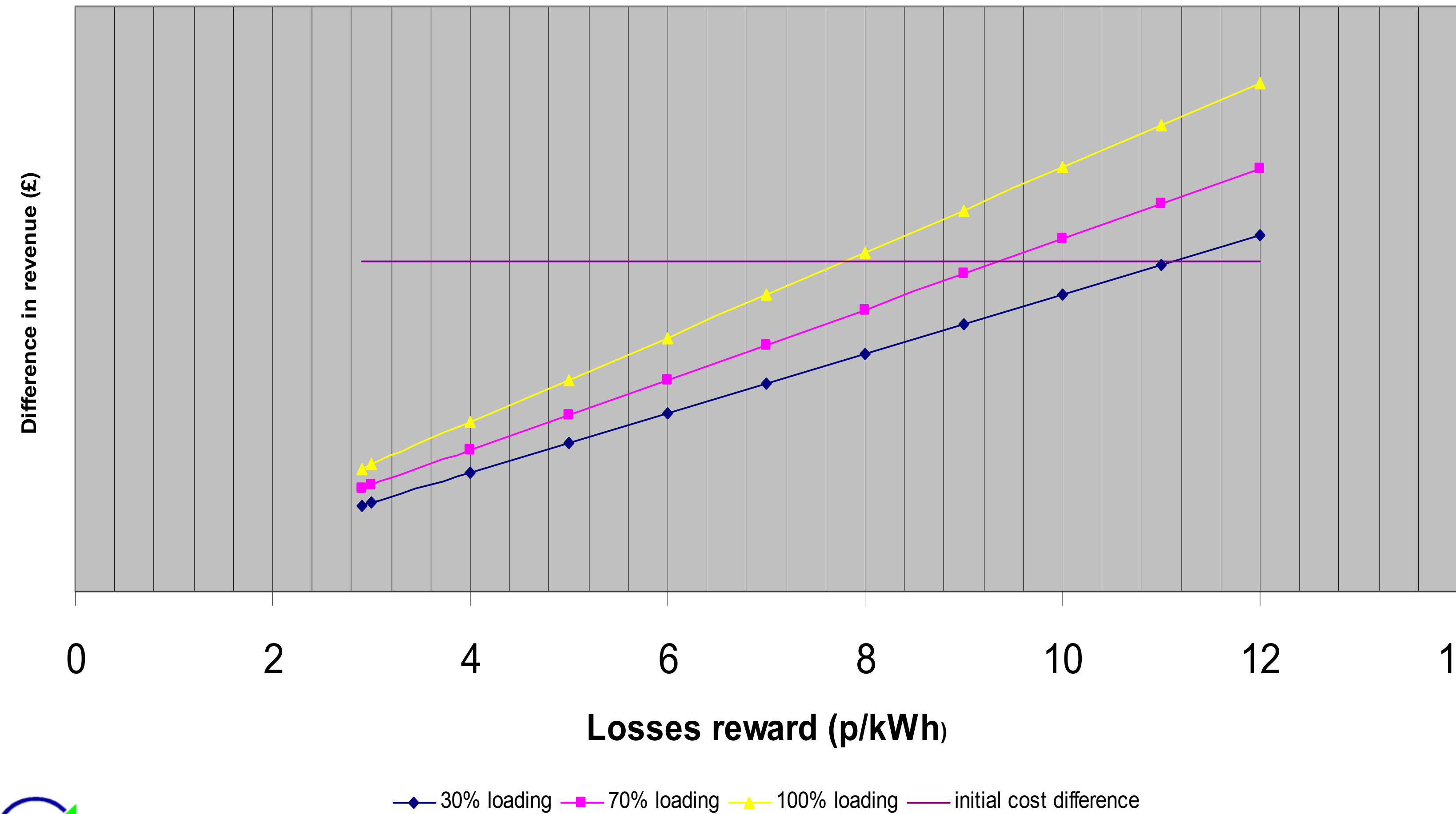
Illustrative example

	Transformer A	Transformer B
Rating (kVA)	315	315
Investment (£)	5,000	6,690
No-load losses (W)	735	380
Load losses (W)	4,800	4,080

Low loss transformer delivers minimum life cycle cost

What a distributor would decide?

Required loss reward price that justifies the purchase of low loss transformer



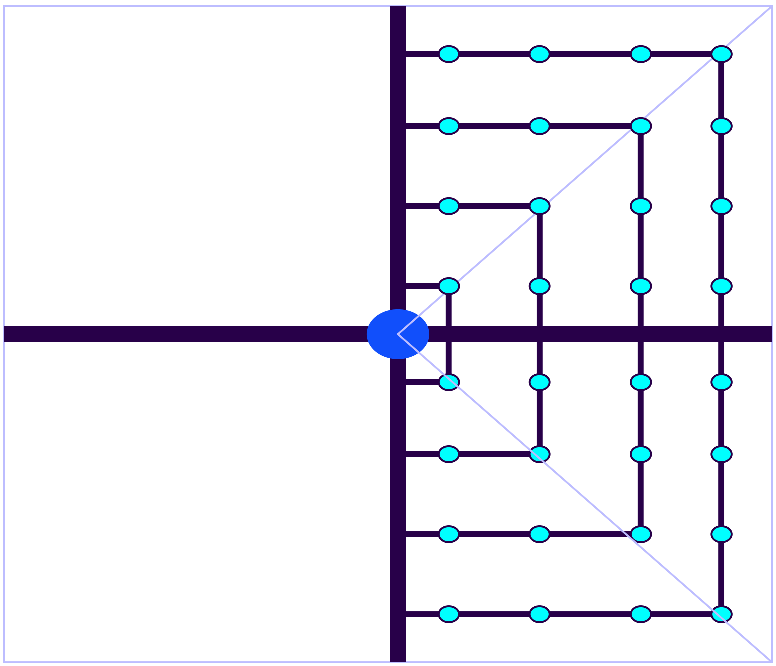
Characteristic of the loss incentive scheme

- No direct link with minimum ownership cost.
- Excessive losses are not effectively discouraged.
- Investments in high efficiency plant on the basis of the price control formula cannot be justified.
- New plant that replaces old plant often with higher losses

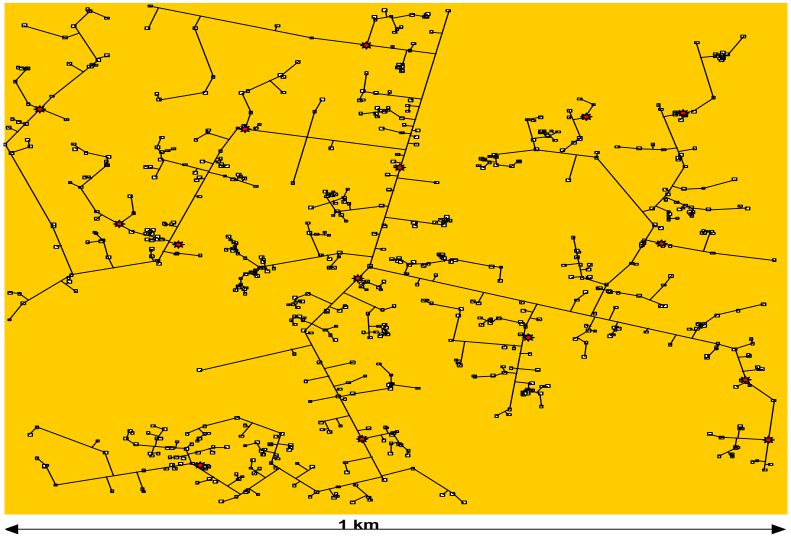
Approach to design of loss inclusive network replacement strategy

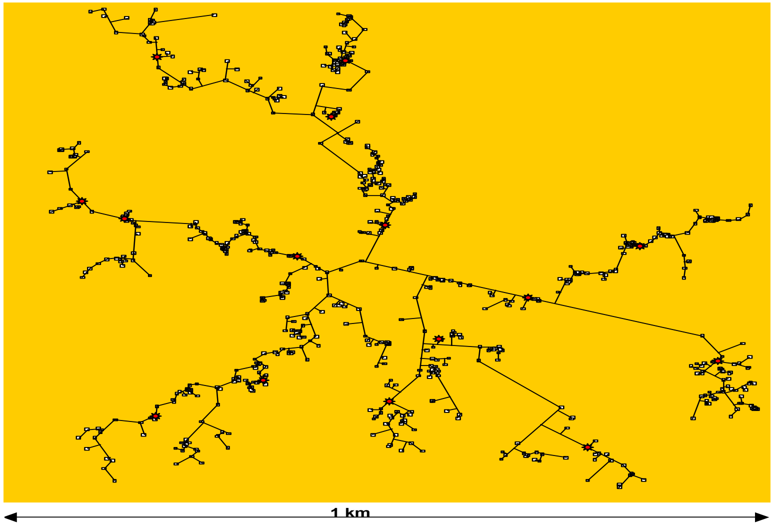
- The project investigates alternative methods for determining optimal design strategy for the system as whole
- Main inputs:
  - Customer load characteristics (density and profile)
  - Technical and cost characteristics of transformers and circuits
  - Cost of electricity
- Main outputs:
  - Optimal number of transformers (per km2)
  - Optimal circuit design
- Constraints:
  - Voltage drop
  - Thermal capability

Geometric model



Statistical model





Two approaches

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Conclusions

- Re-establish minimum life-cycle cost philosophy
- Develop optimal system design and replacement strategies
- Develop alternative regulatory approaches to encourage installation of efficient plant
- **Beneficiaries**:
  - ***Network developers***: design optimal long-term network replacement strategy
  - ***Manufacturers***: increase competitiveness
  - ***Regulator***: control of financial performance
  - ***Consumers:*** - low long-term electricity cost
  - ***Society:*** – reduced CO_2 emissions