

CUSTOMER WORTH OF SUPPLY AND APPLICATION TO FUTURE REGULATION OF DISTRIBUTION SYSTEMS

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Content

- Customer perspective—historical development
- Developments in regulation
- Customer perspective
 - Customer outage costs
 - Value of lost load
 - Application

Historical perspective /1

Pre-privatisation (1990)

- industry, on behalf of Government, decided what product to deliver to customers at what price
- no definition of product, just voltage and frequency limits
- no independent oversight or mechanism for customer appeal

Historical perspective /2

Post 1990

- Regulator as purchasing agent on behalf of customer
- introduction of basic product definitions through Overall and Guaranteed Standards
- Improved monitoring of delivery of products

Post 2000

- Information and Incentives Project to
 - improve definition of products purchased
 - improve monitoring of delivery
 - vary price according to performance
 - safeguard the long term

Service Levels

Guaranteed Standards of Service

- attend fuse failure in 3 hours
- restore supply in 18 hours from fault
- provide 7 days notice of planned interruption
- visit voltage complaint within 10 days
- offer 2 hour time banded appointments
- keep appointments as agreed

Overall Standards of Service

- restoration of 95% of supplies within 3 hours
- resolve all voltage complaints in 6 months
- provide new domestic supply in 30 days
- reconnect disconnected customers in 18 hours
- respond to written enquiries in 5 days

Developments in regulation and Information and incentive project

- From asset to performance based regulation
- Value of quality of supply and incentives
- Comparisons between companies
- Implementation issues to be resolved
 - Disaggregation
 - Normalisation
 - Value for money

An alternative to current approach

**Real
Network**



**Reference
Network**

Attributes:

- Inherited characteristics
- Inherent characteristics
 - customer base
 - load growth
 - asset age+ condition
 - replacement cycles
 - embedded generation

Attributes:

- Optimal investment expenditure
- Optimal operation expenditure
- Optimal performance

Real system competes with its optimal model

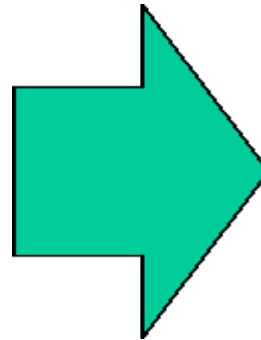
Relationship between input and output

Inputs

- Alternative operation strategies
- Alternative investment strategies
- Alternative maint., replacement and refurbishment strategies
- Embedded generation

***Inherited + Inherent
characteristics of the asset***

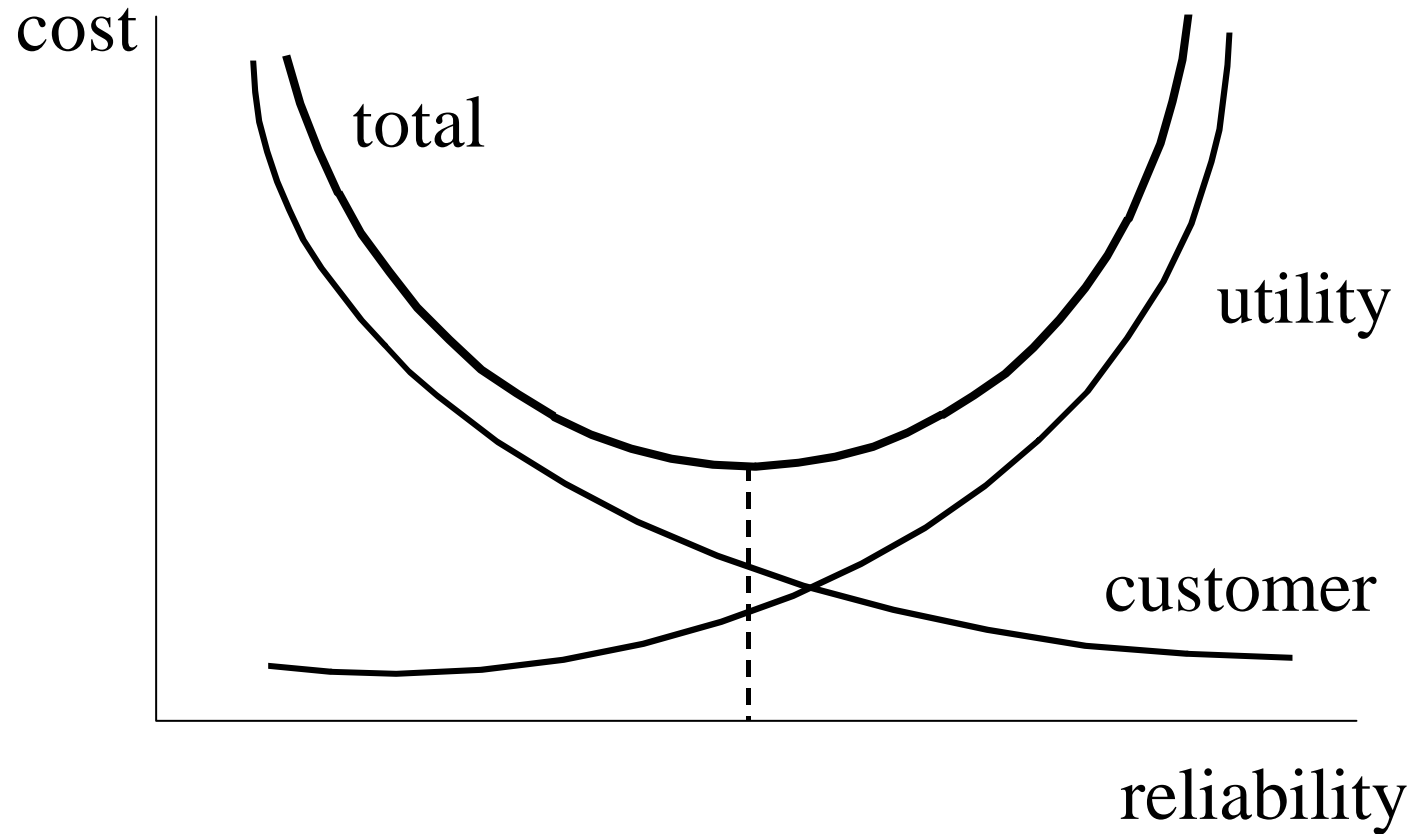
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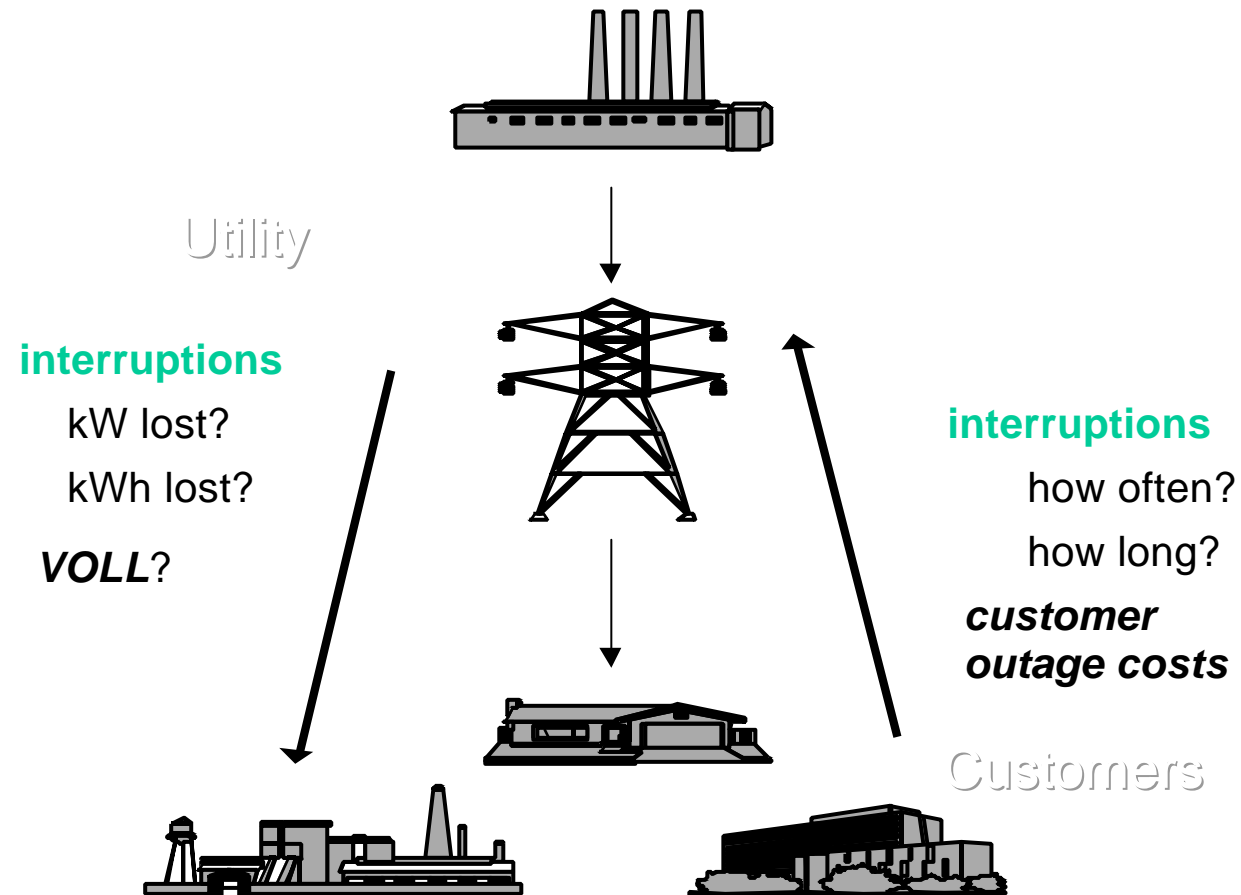
Outputs

- Availability
- Security
- Price
- Customer worth

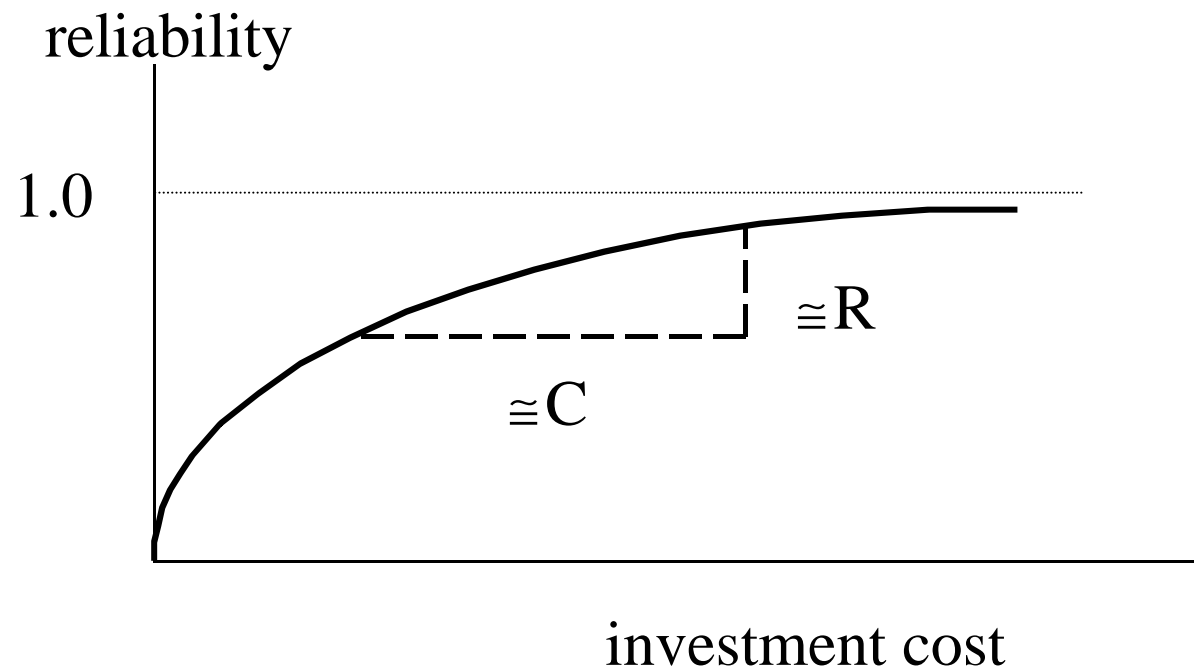
Total Reliability Costs



Customer and Utility Perspectives



Incremental Cost of Reliability



Impact of Outages

- Direct economic
 - lost production
 - idle resources
 - restart costs
 - spoilage
 - equipment damage
 - health & safety costs
 - utility interruption costs
- Direct social
 - loss of transport
- loss of leisure
- lack of heating/cooling
- personal injury
- Indirect losses
 - civil disobedience
 - evacuation for safety
- Short term/long term
 - future mitigation decisions
 - extra protection/standby
 - relocation costs

Factors Affecting Costs

- Customer factors
 - type of
 - nature of
 - size of
 - load and energy needs
 - time dependencies
 - how prepared for outages
- Interruption factors
 - frequency, duration, occasion
 - any advance warning
 - localised or widespread

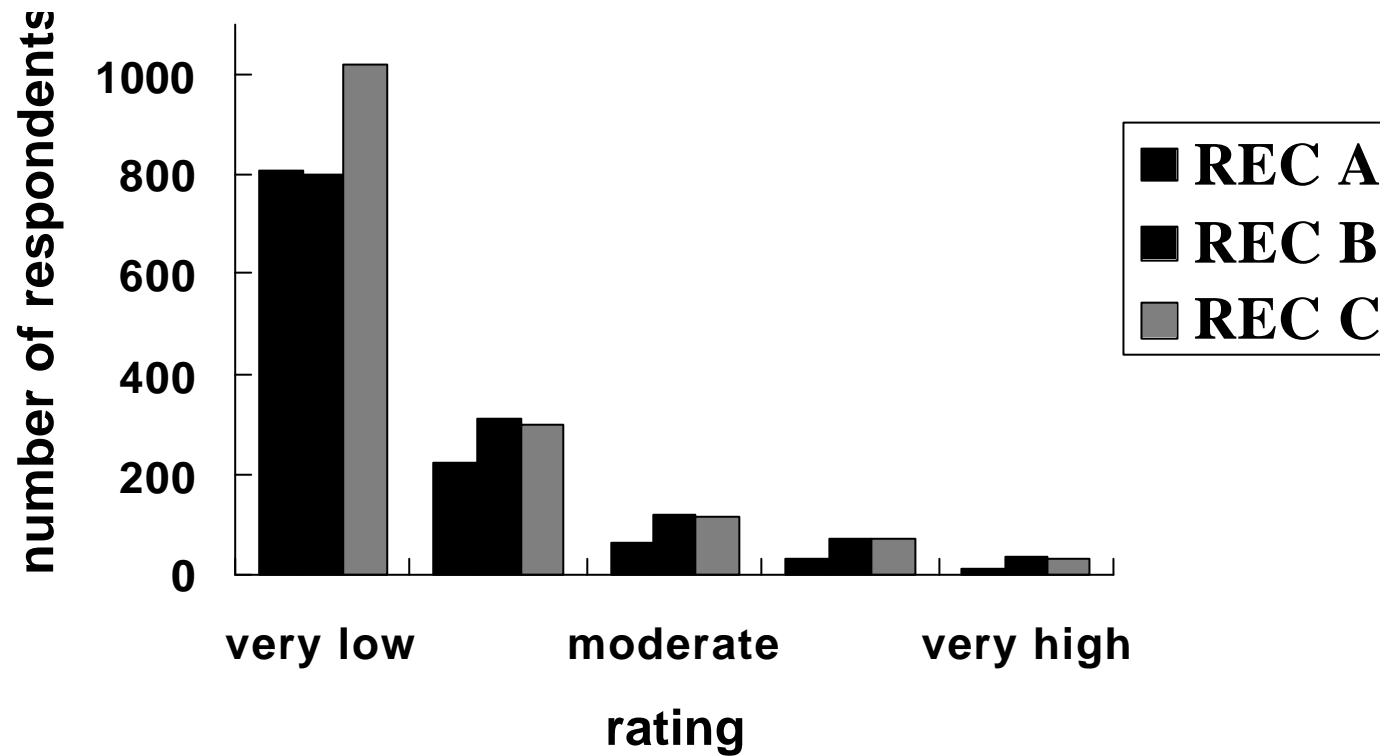
Basis of Customer Surveying

- Non-residential (industry, commercial)
 - losses are tangible, identifiable, e.g. lost sales, damage to materials, restart costs, etc
 - estimation of actual interruption costs
- Residential
 - subjective, e.g. inconvenience, fear, etc
 - choice from list of preparatory actions and costs

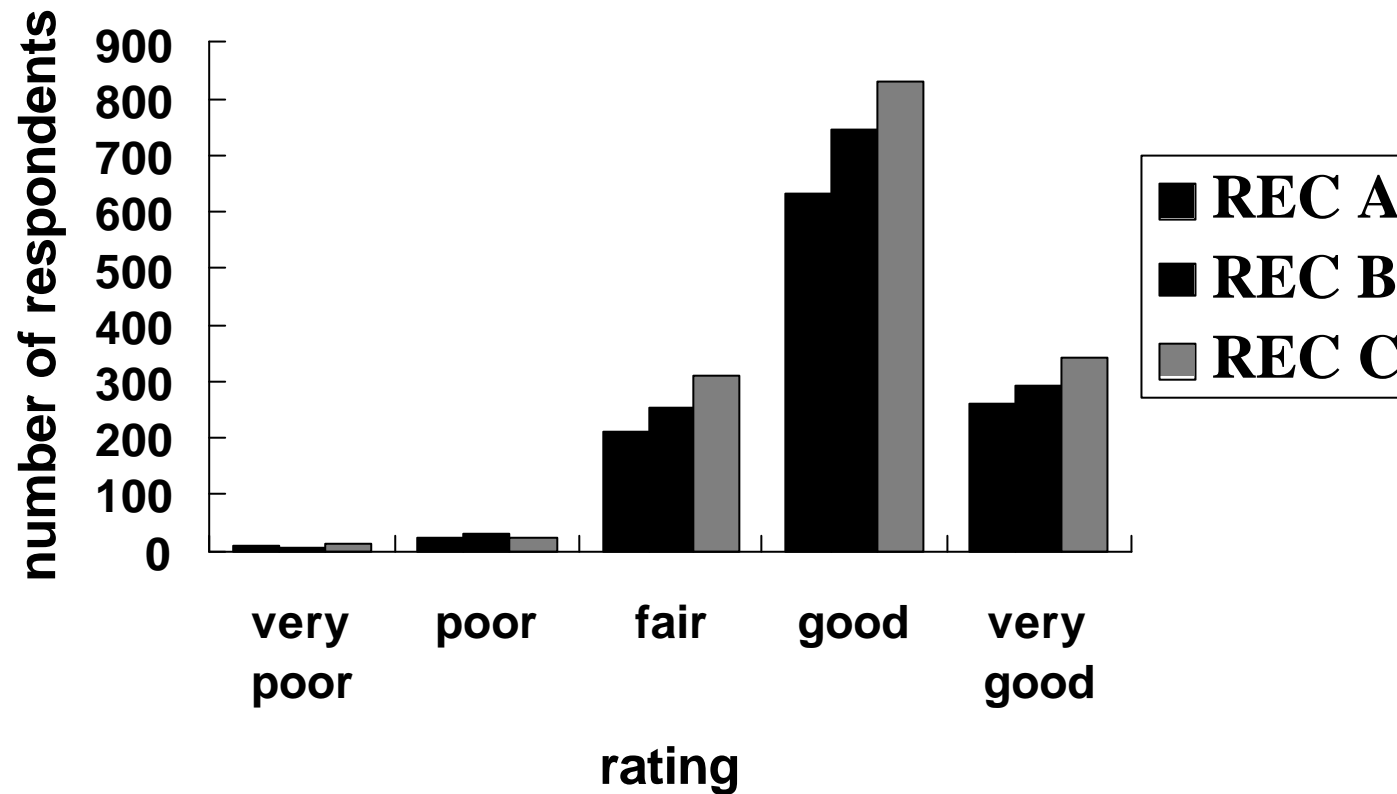
UMIST Survey

- Scope
 - 21000 residential, 5000 commercial, 2000 industrial, all users > 8MW
- Questionnaires - hypothetical scenarios
 - residential base - 4h monthly outage after 4pm on winter weekdays
 - non-residential base - 10am Wednesday near end of January
 - variations with frequency, duration, occasion

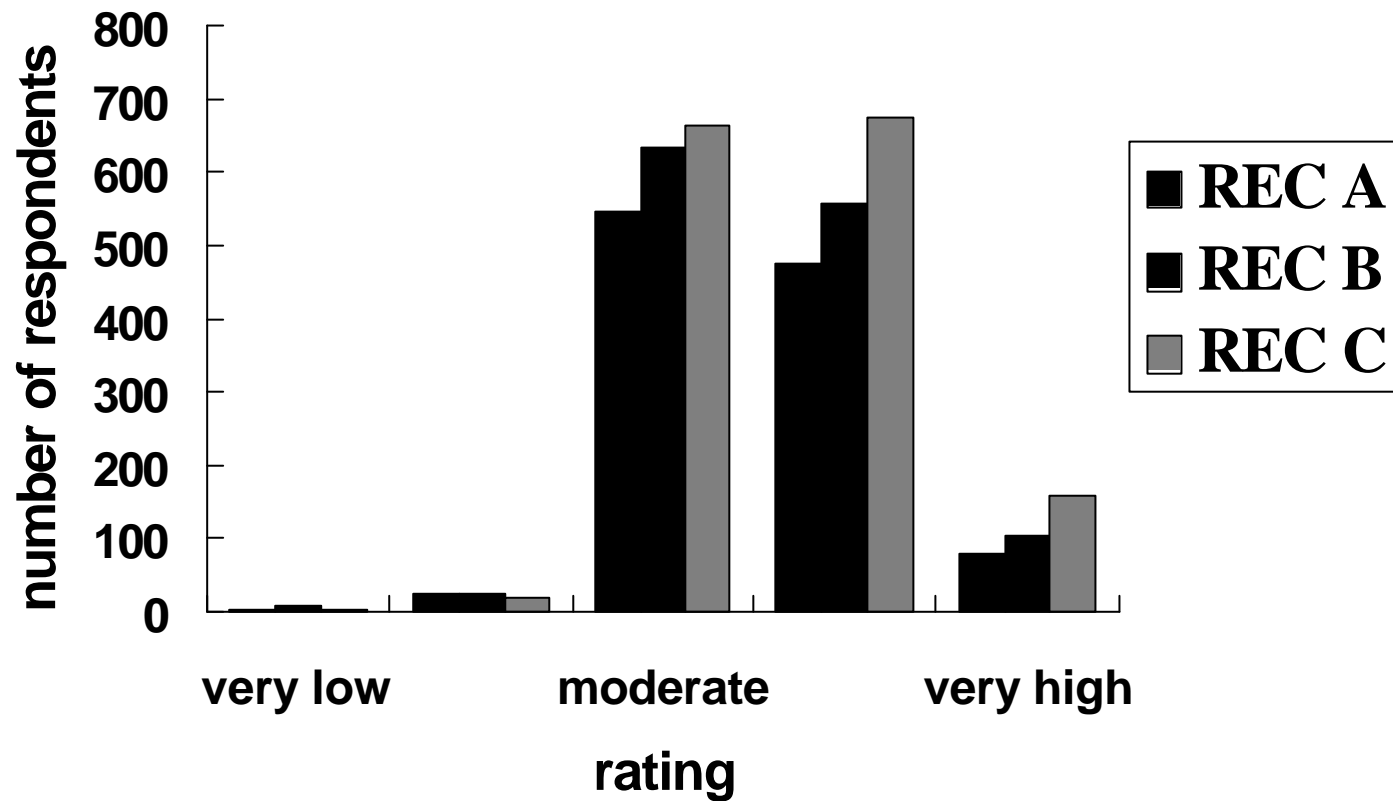
Rating of Number of Failures



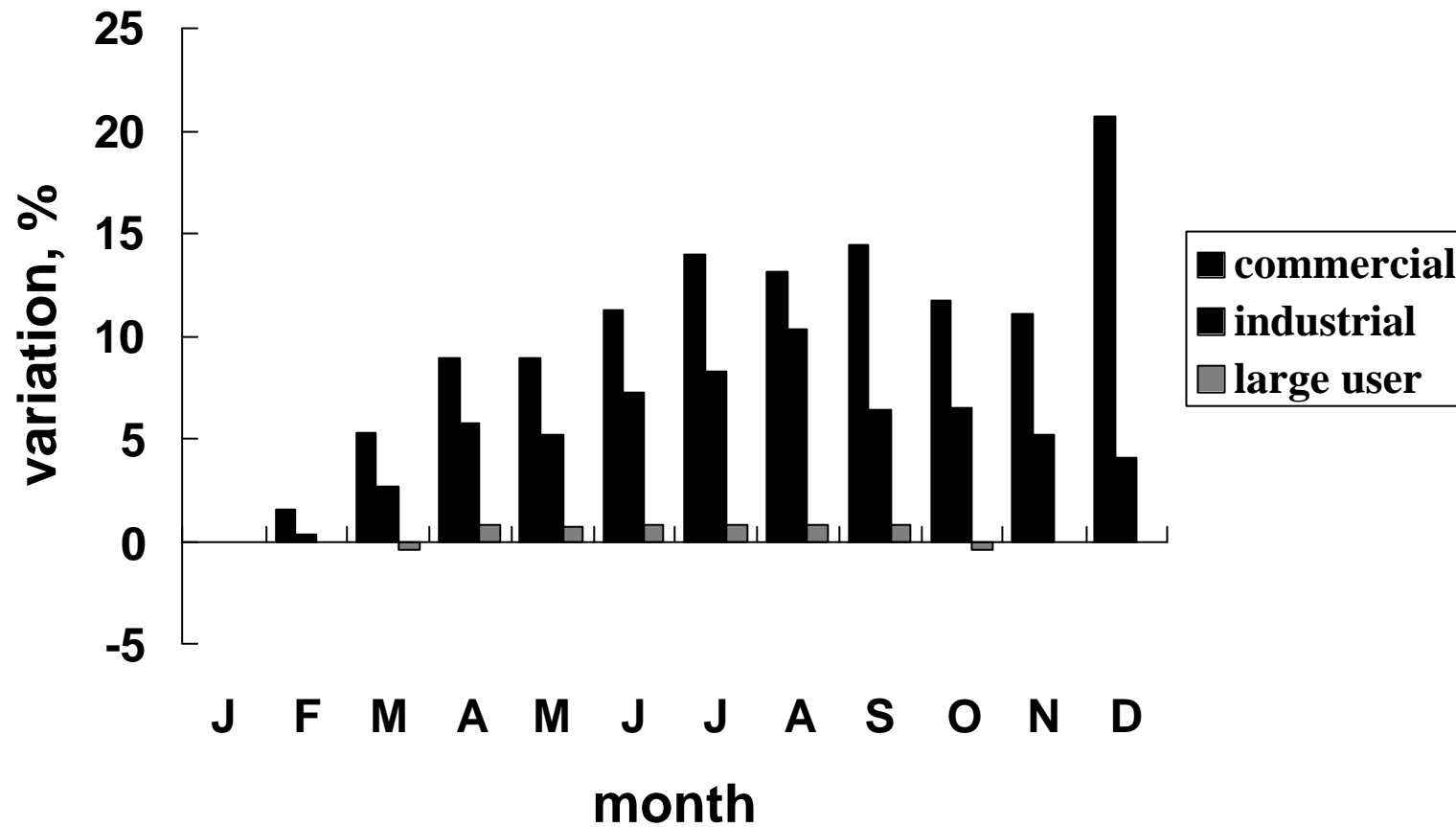
Rating of Quality of Service



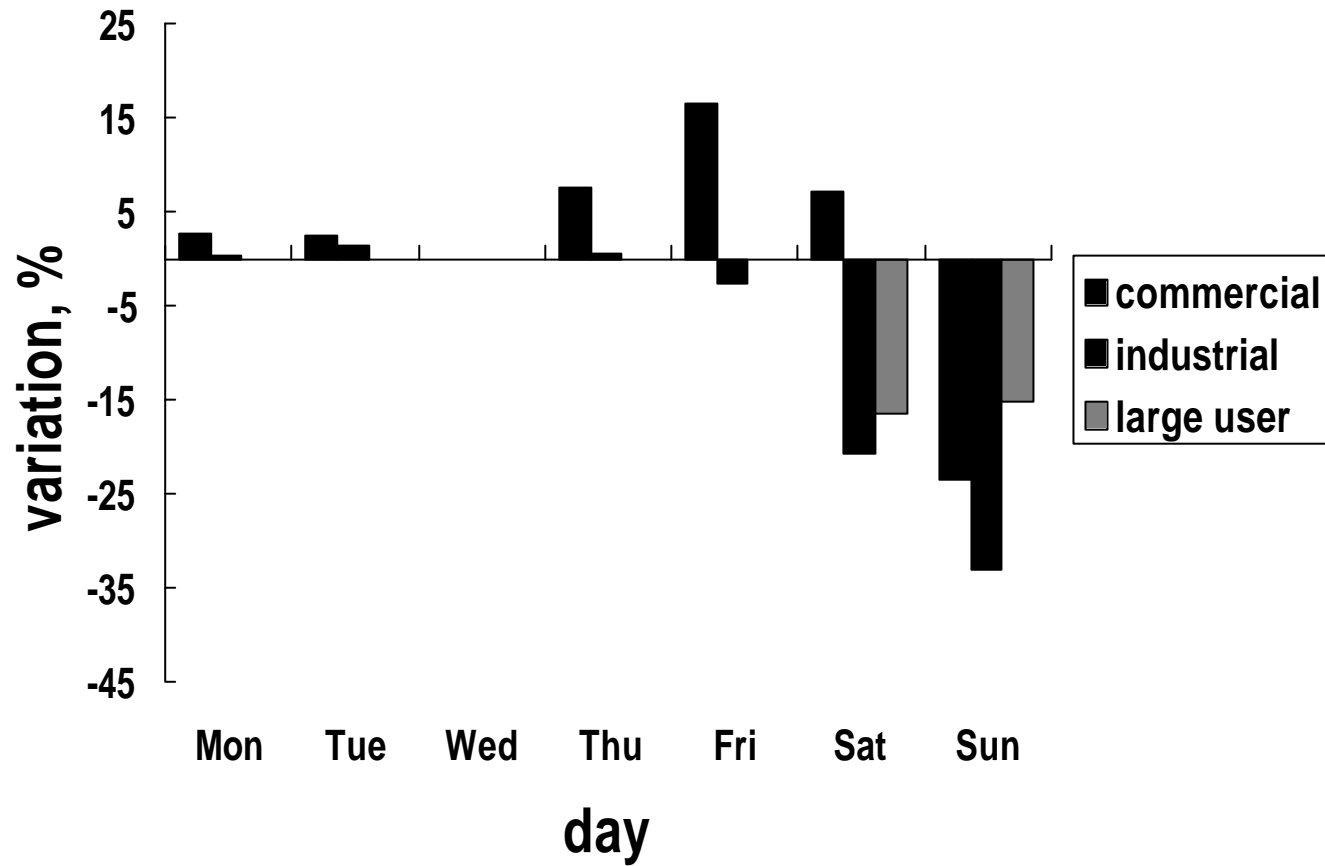
Rating of Price of Electricity



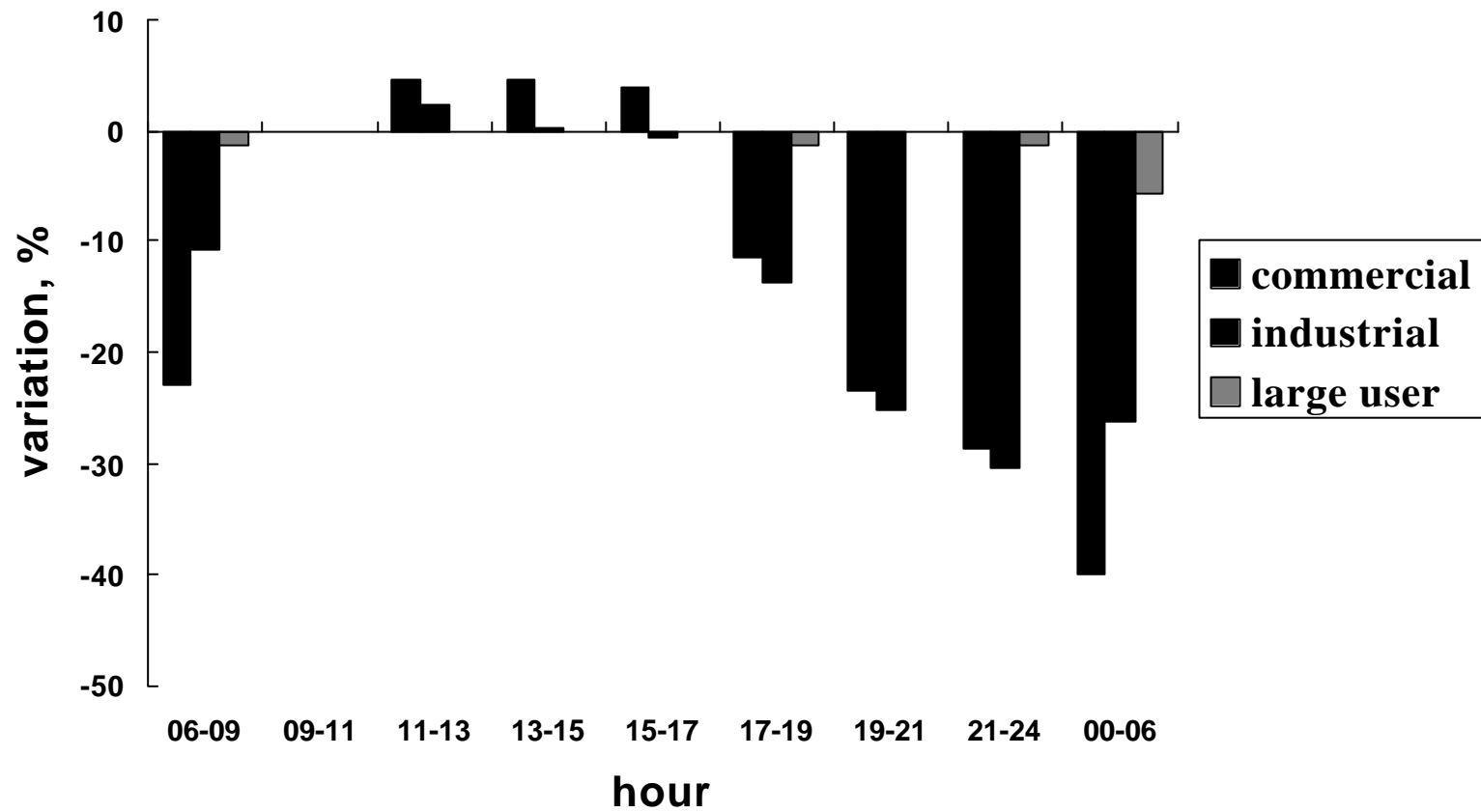
Variation with Month



Variation with Day



Variation with Hour



Customer Damage Functions

- Sector Customer Damage Function - SCDF
 - the cost function of each customer sector
 - system independent
- Composite Customer Damage Function - CCDF
 - aggregated SCDFs at specific load point(s)
 - weighted proportionally to energy or demand
 - system dependent

Reliability Cost and Worth

CDFs can be used in one of two ways:

1. to give customer outage costs for relevant load points, subsystem, or system
- useful for comparing reinforcement schemes in distribution systems
2. Converted to a global index such as VoLL
- useful for comparing alternatives at HLI and HLII

Processing of Outage Costs

1 Raw costs

- provide customer interruption costs

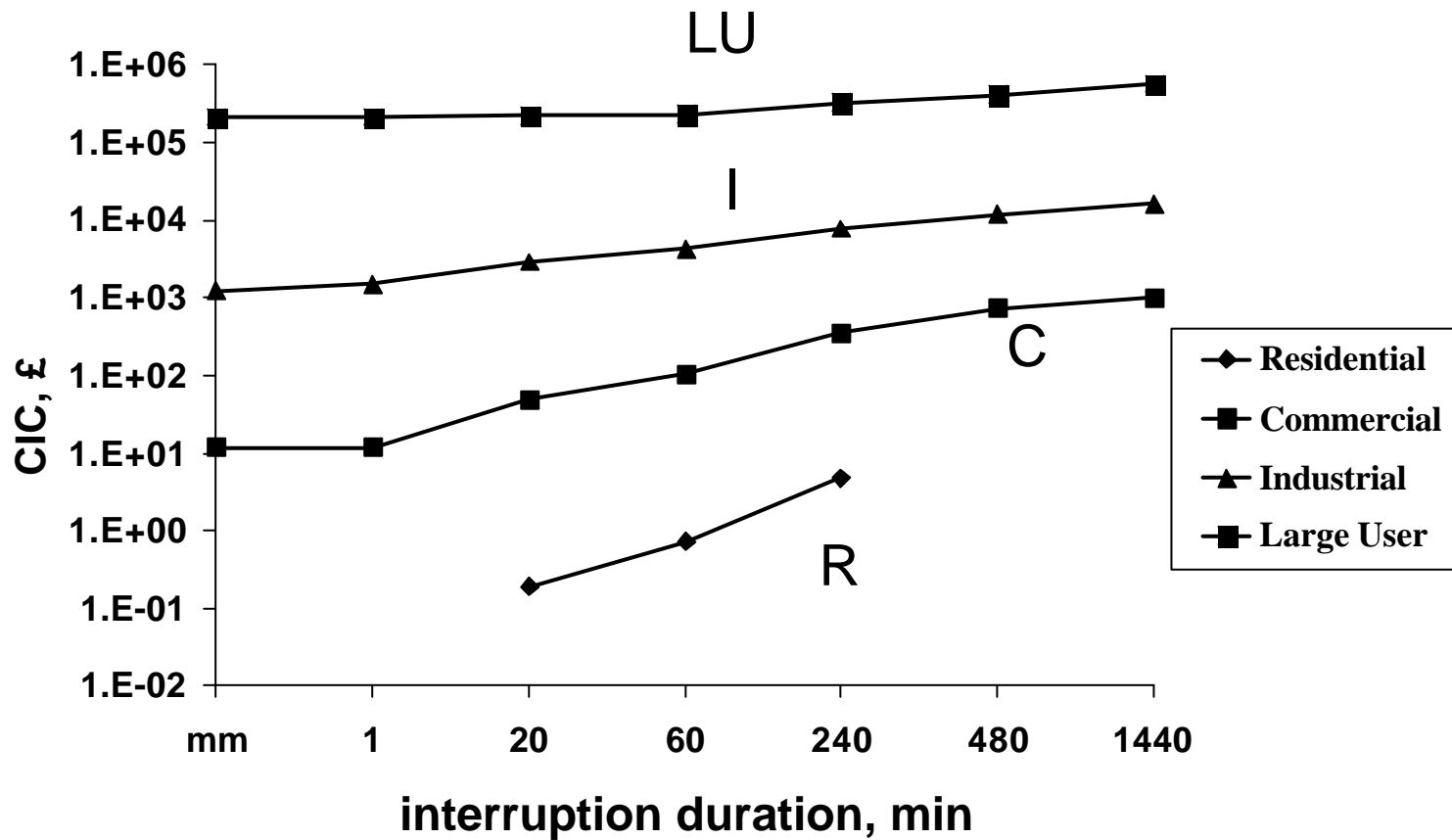
2 Sector Customer Damage Function, SCDF

- raw costs normalised by
 - annual peak demand, kW
 - annual energy consumed, kWh

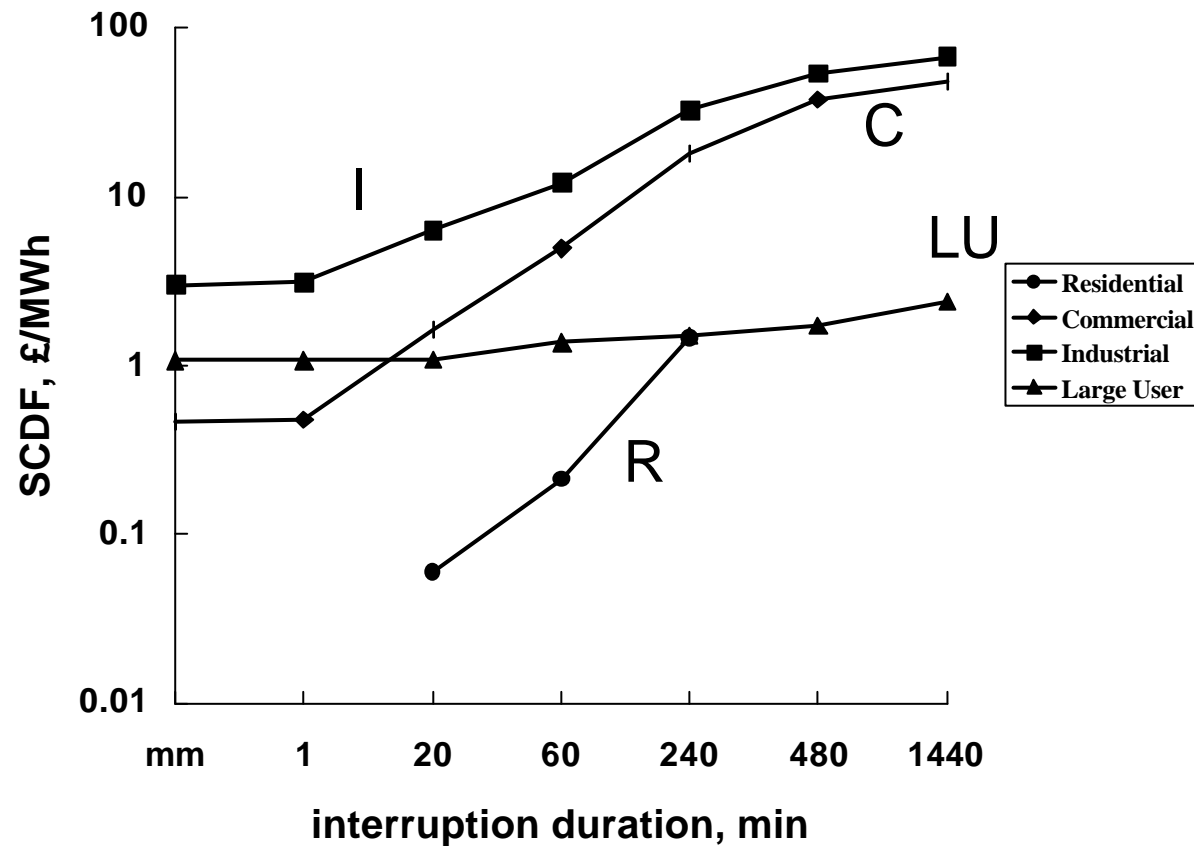
3 Composite Customer Damage Function, CCDF

- SCDFs weighted in proportion to sector peak demands or energy to provide CCDFs for load points, areas, etc

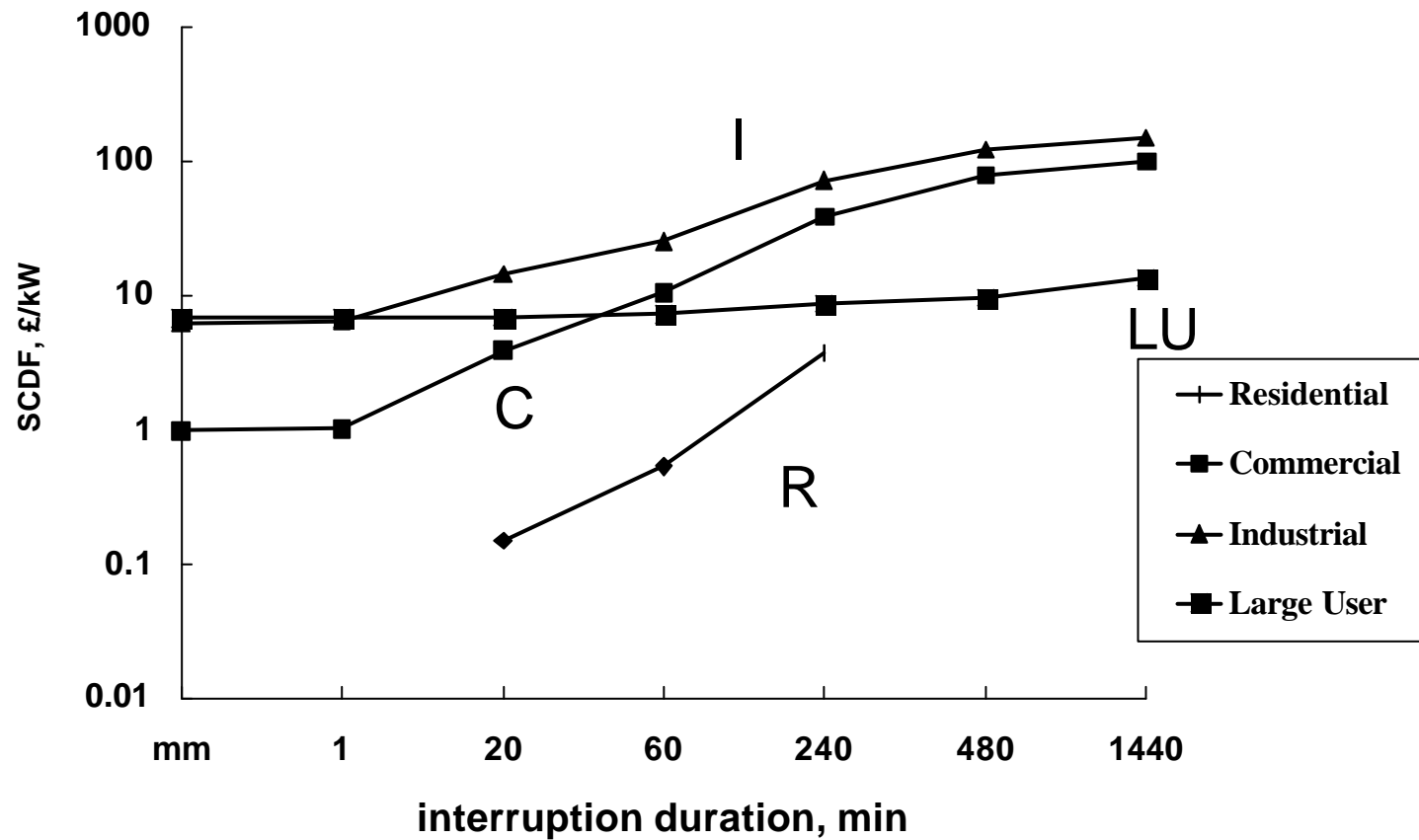
Customer Interruption Costs - CIC (£)



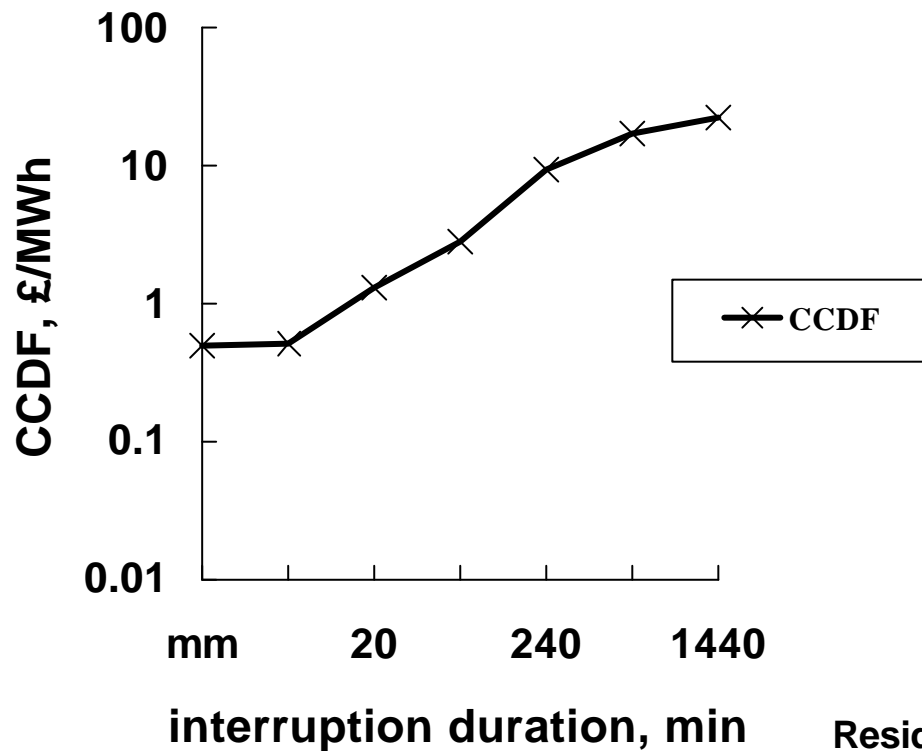
Sector Customer Damage Functions - SCDFs (£/MWh demanded)



Sector Customer Damage Functions - SCDFs (£/kW peak load)



Composite Customer Damage Function - CCDF (£/MWh demanded)



Residential, E=8700 MWh, L=2.43 MW
Commercial, E=14600 MWh, L=3.97 MW
Industrial, E=9800 MWh L=2.00 MW

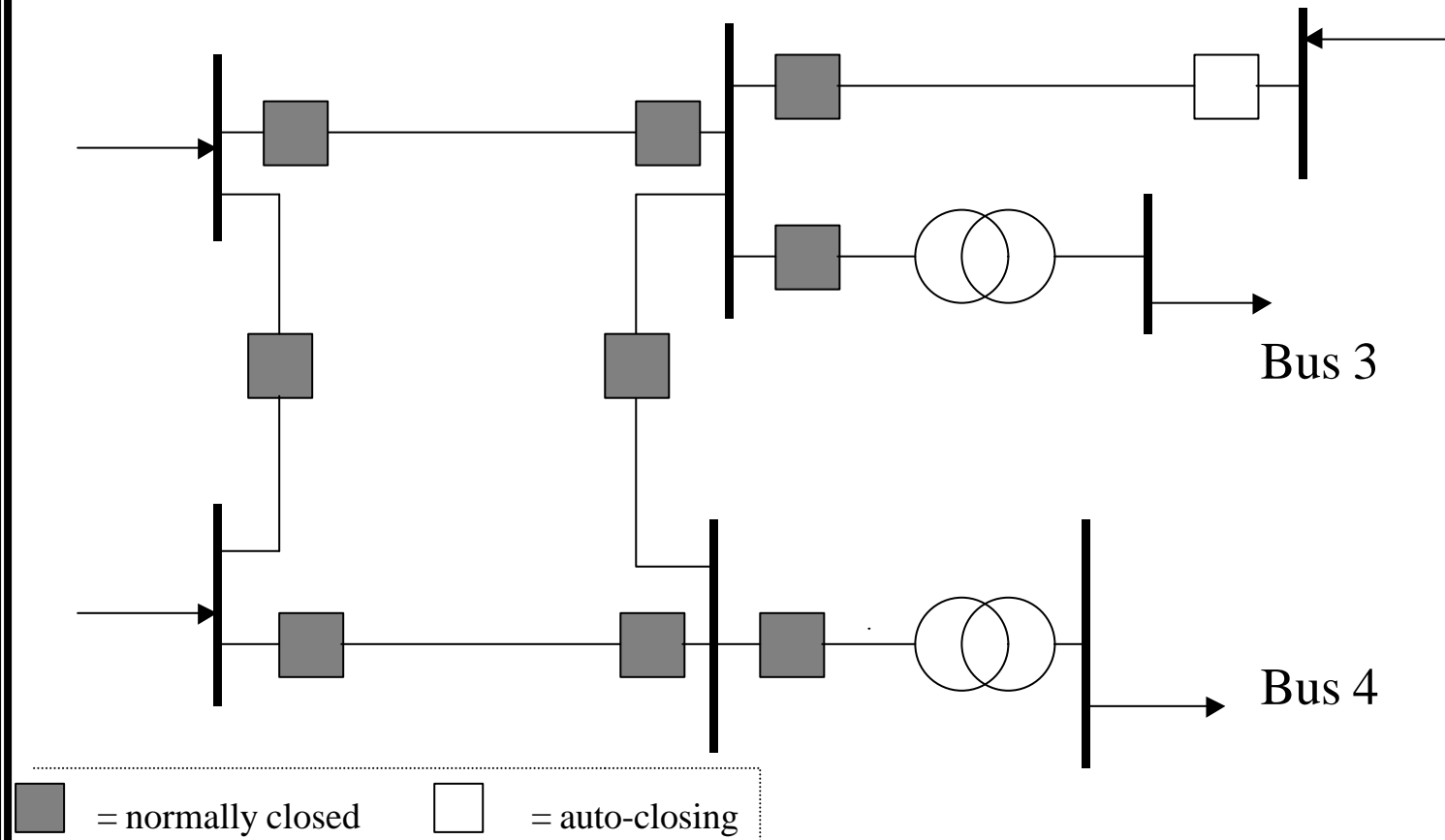
Evaluating Customer Outage Costs

- COCs are a function of
 - frequency and duration of outage
 - customer interruption costs, number and mix of customers
- frequency and duration found from reliability assessment
- customer costs found from CDFs

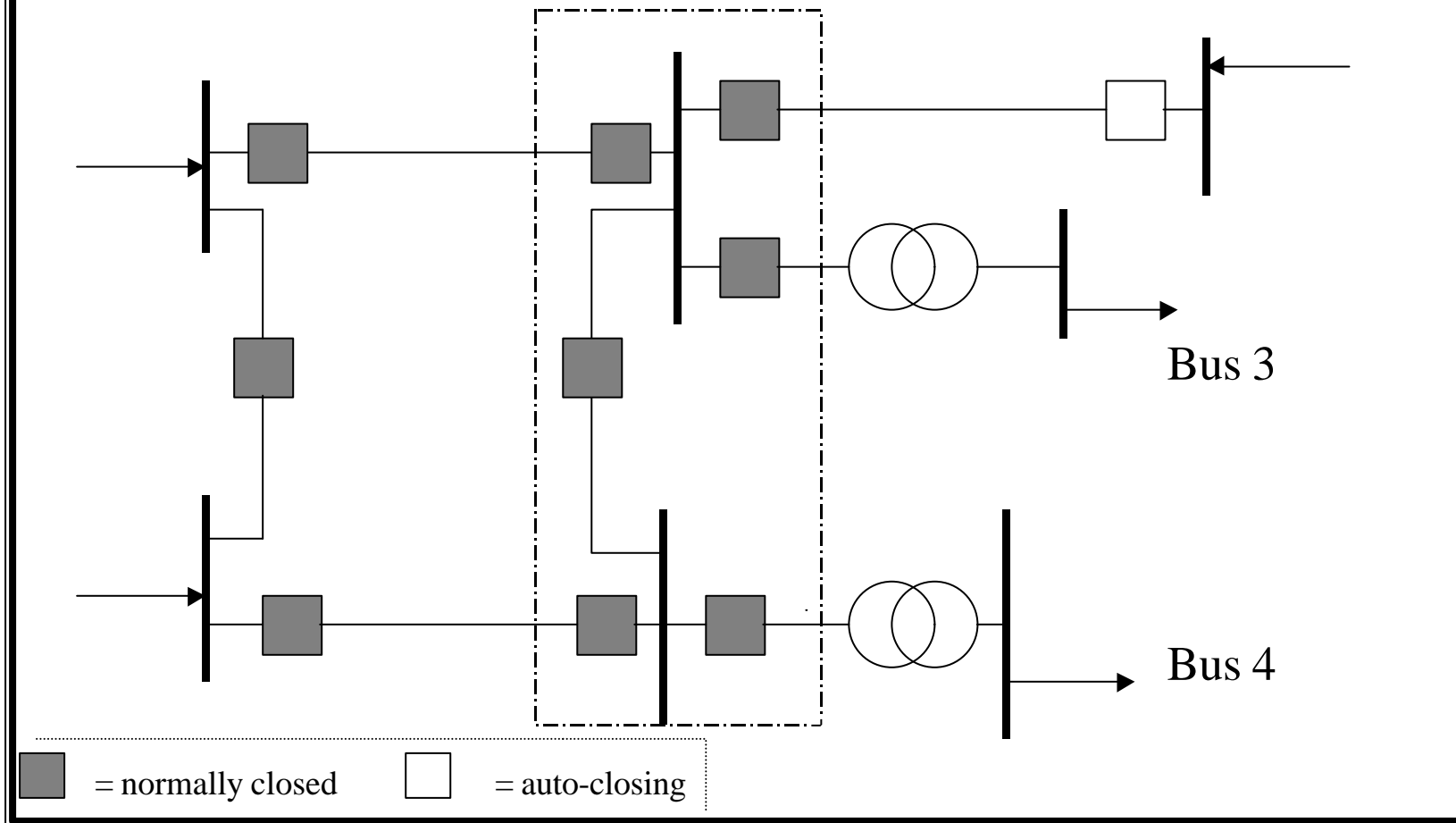
Asset Replacement

- most system plant dates from 50s and 60s
- need for major replacement programmes
- possibilities include:
 - like-for-like
 - with modern equivalent
 - only that providing required quality of service
- constraints are:
 - technical (e.g reliability)
 - economic (e.g. cost-benefit)

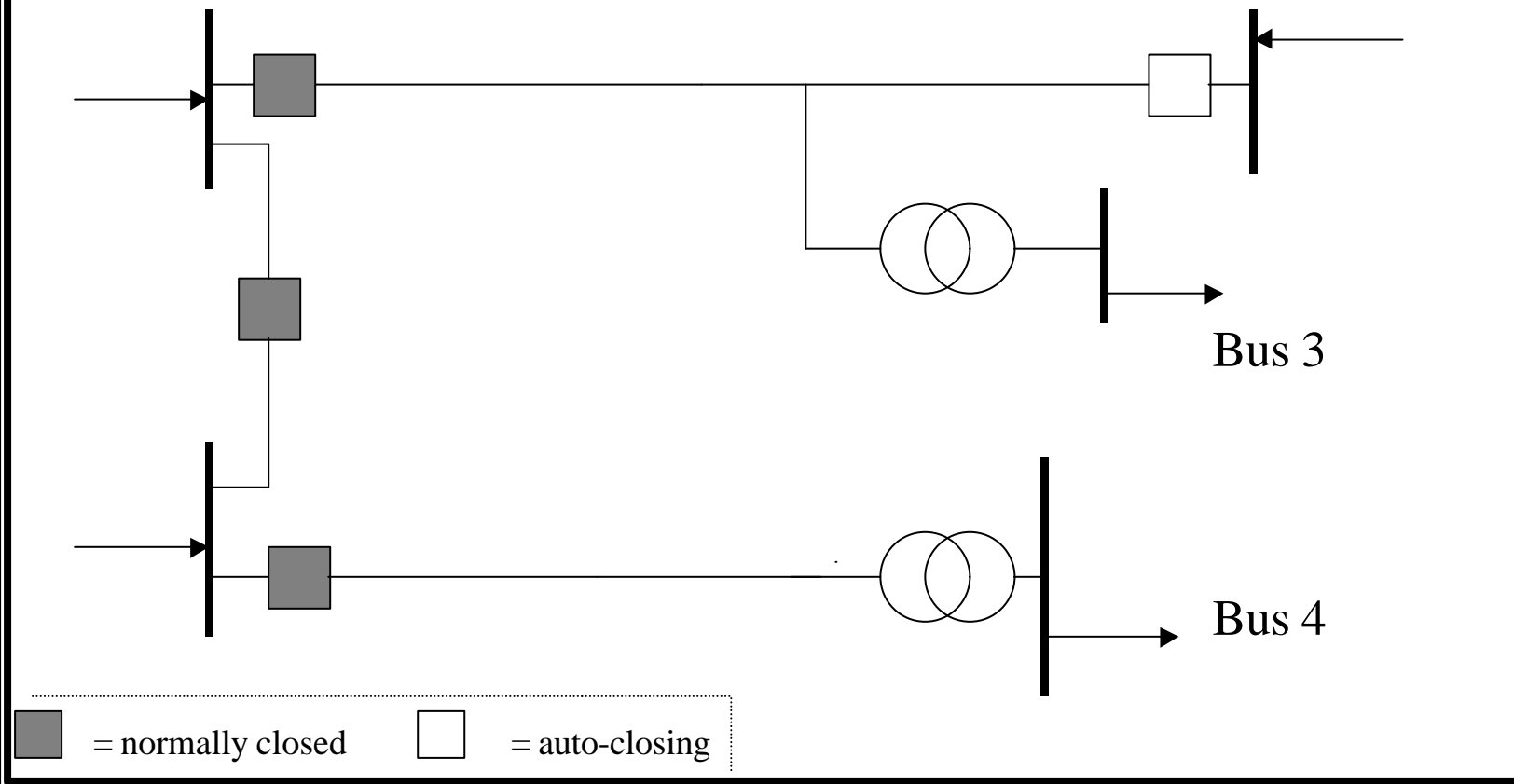
System Before Modification



System To Be Modified



System After Modification



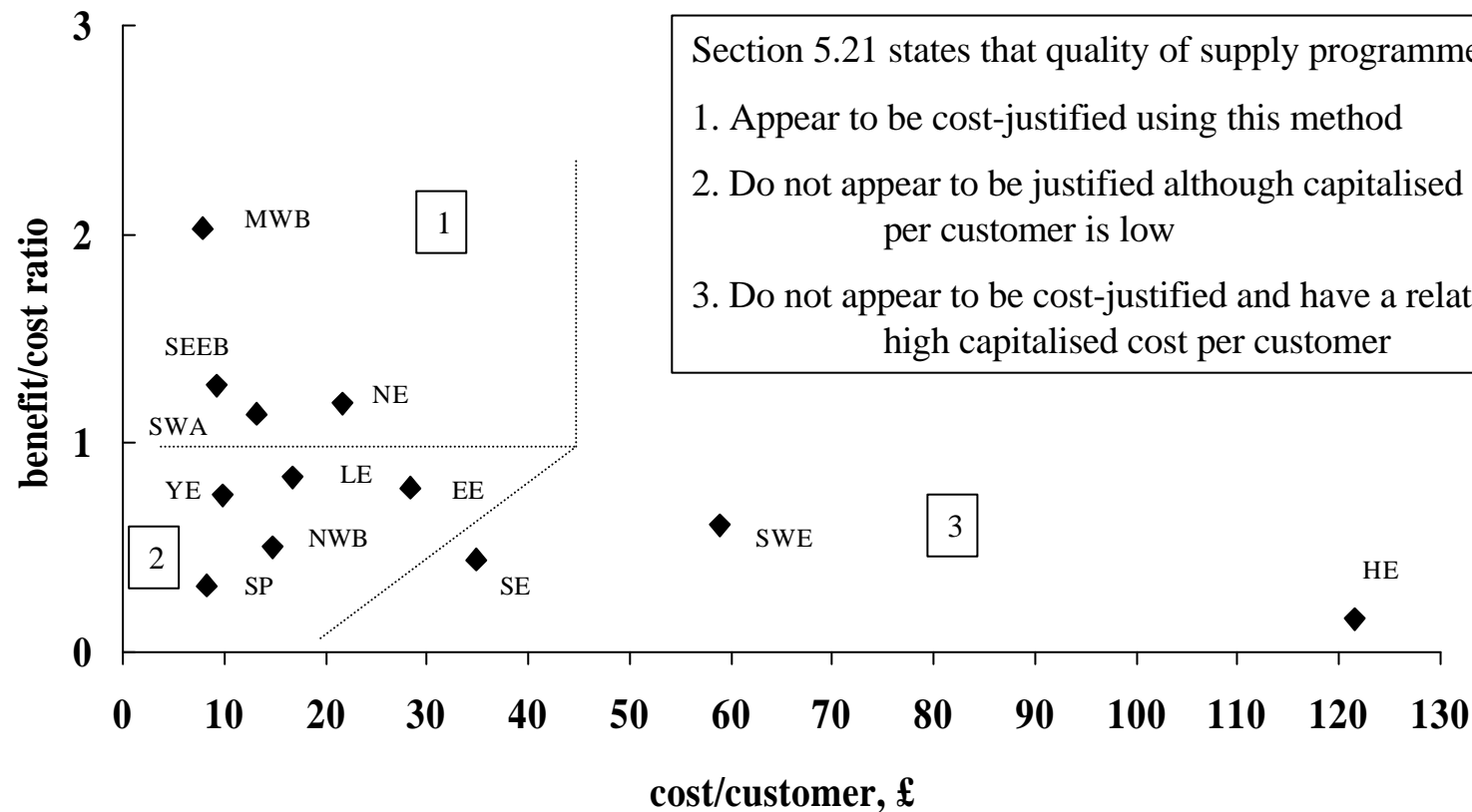
Effect on COC of Proposed Changes

| Costs £ | Existing system | | Proposed system | | Δ COC £ | |
|------------|-----------------|-------|-----------------|--------|-------------------|--------|
| | Bus 3 | Bus 4 | Bus 3 | Bus 4 | Bus 3 | Bus 4 |
| COC | 43300 | 42900 | 200400 | 187000 | 157100 | 144100 |
| SCOC | 86200 | | 387400 | | 301200 | |

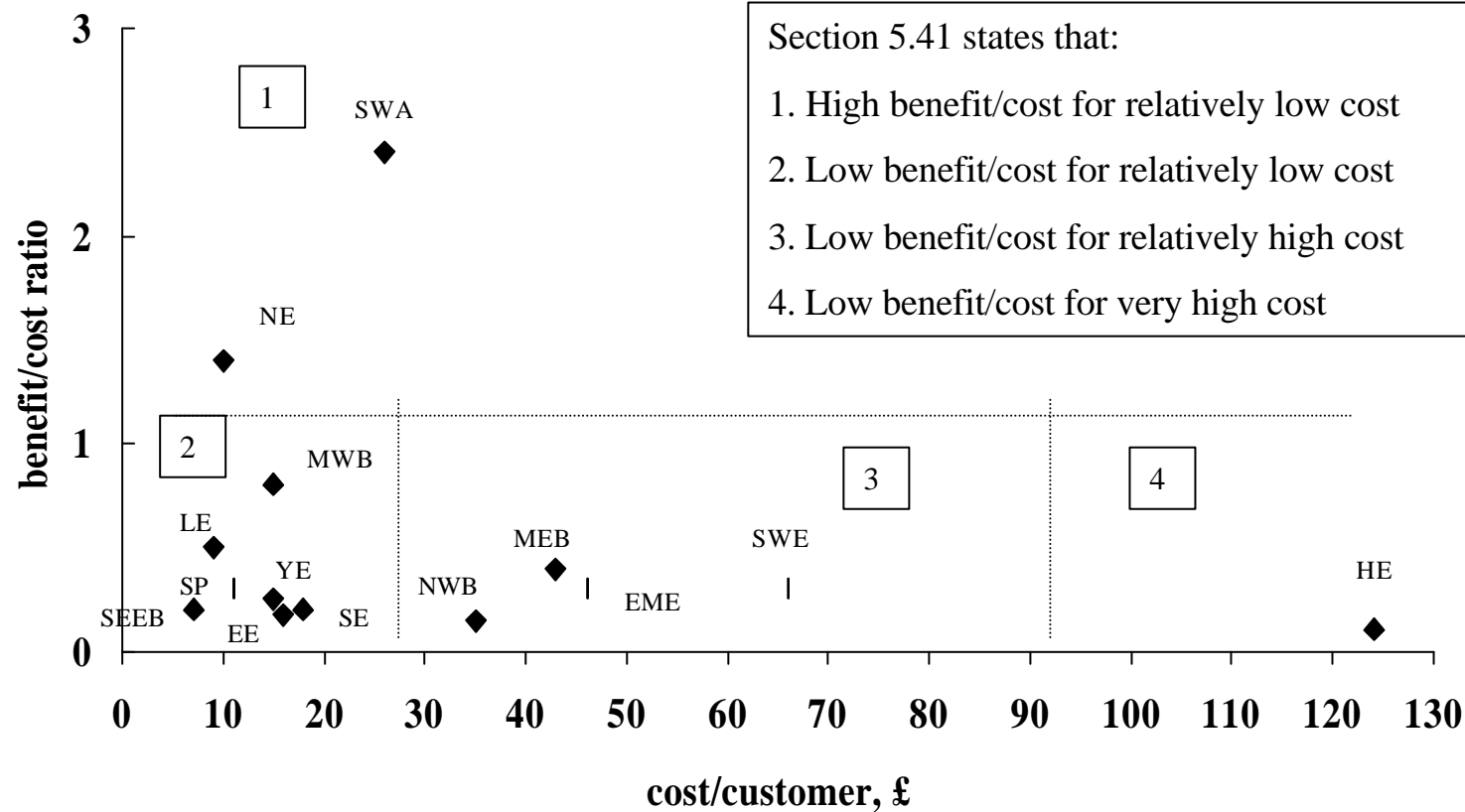
Regulator & Quality of Supply- 1999

- In the Distribution Price Control Review Consultation Paper of May 1999, OFFER has evaluated the value to customers of improvements in quality of supply
- approach used based on the concept of SCDFs and SCOC (system customer outage costs)
- see Sections 5.17-5.23 and 5.37-5.41 of Review

Benefit/Cost Ratios of Quality Measures 95/96 to 99/00



Benefit/Cost Ratios of Quality Measures 00/01 to 04/05



Value of Lost Load - VoLL

Was used in the UK from 1990 to 2001

Value set at: £2.000/kWh to be increased annually by the retail price index (RPI) i.e. inflation.

It is calculated to 3 decimal places.

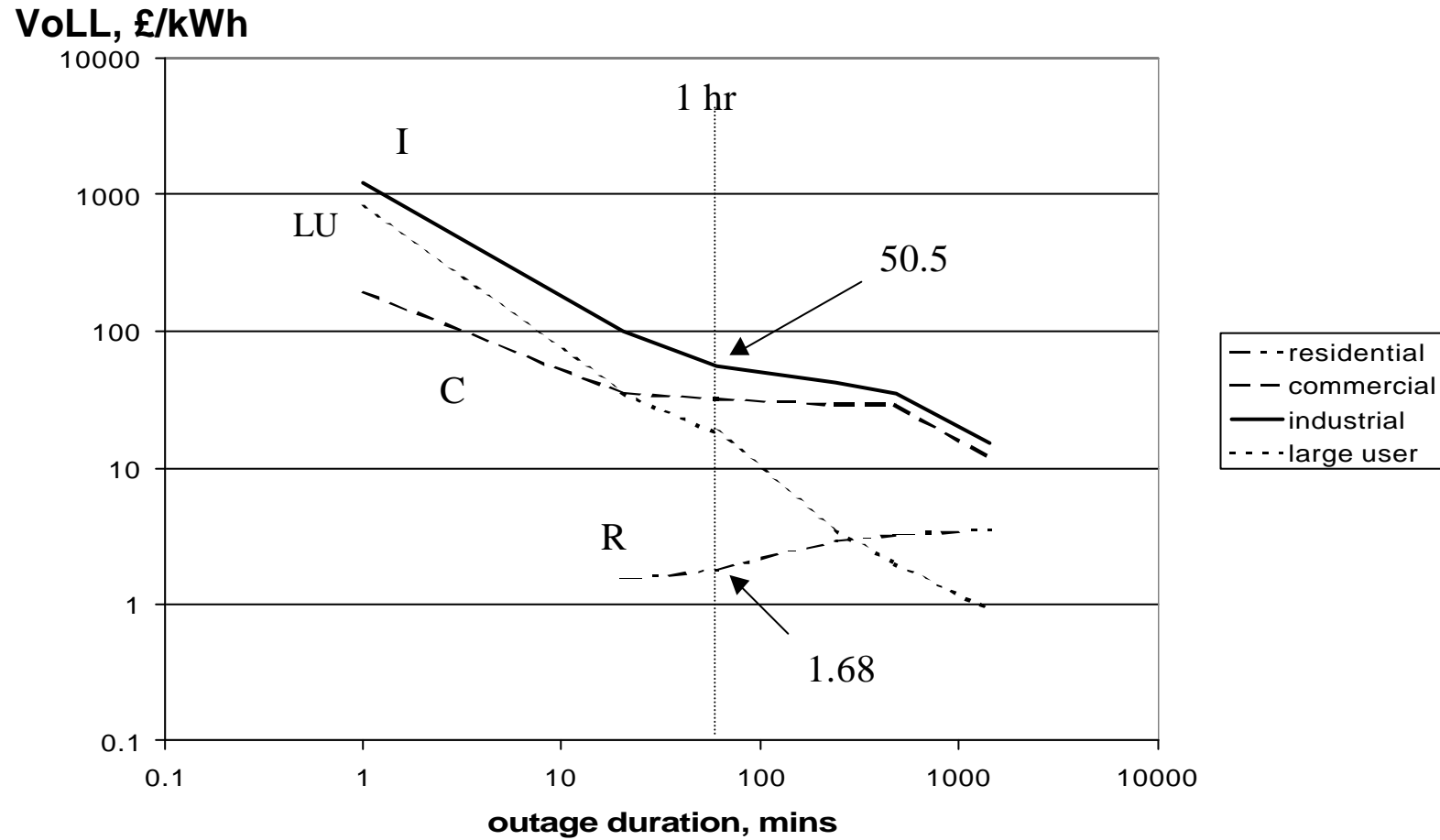
Questions About Concept & Value

- Is the concept valid?
- Is the value used for VoLL valid?
- Is there a functional relationship between “worth of supply” and “energy not supplied”?
- Is VoLL only a proxy to worth of supply?

Calculation of VoLL

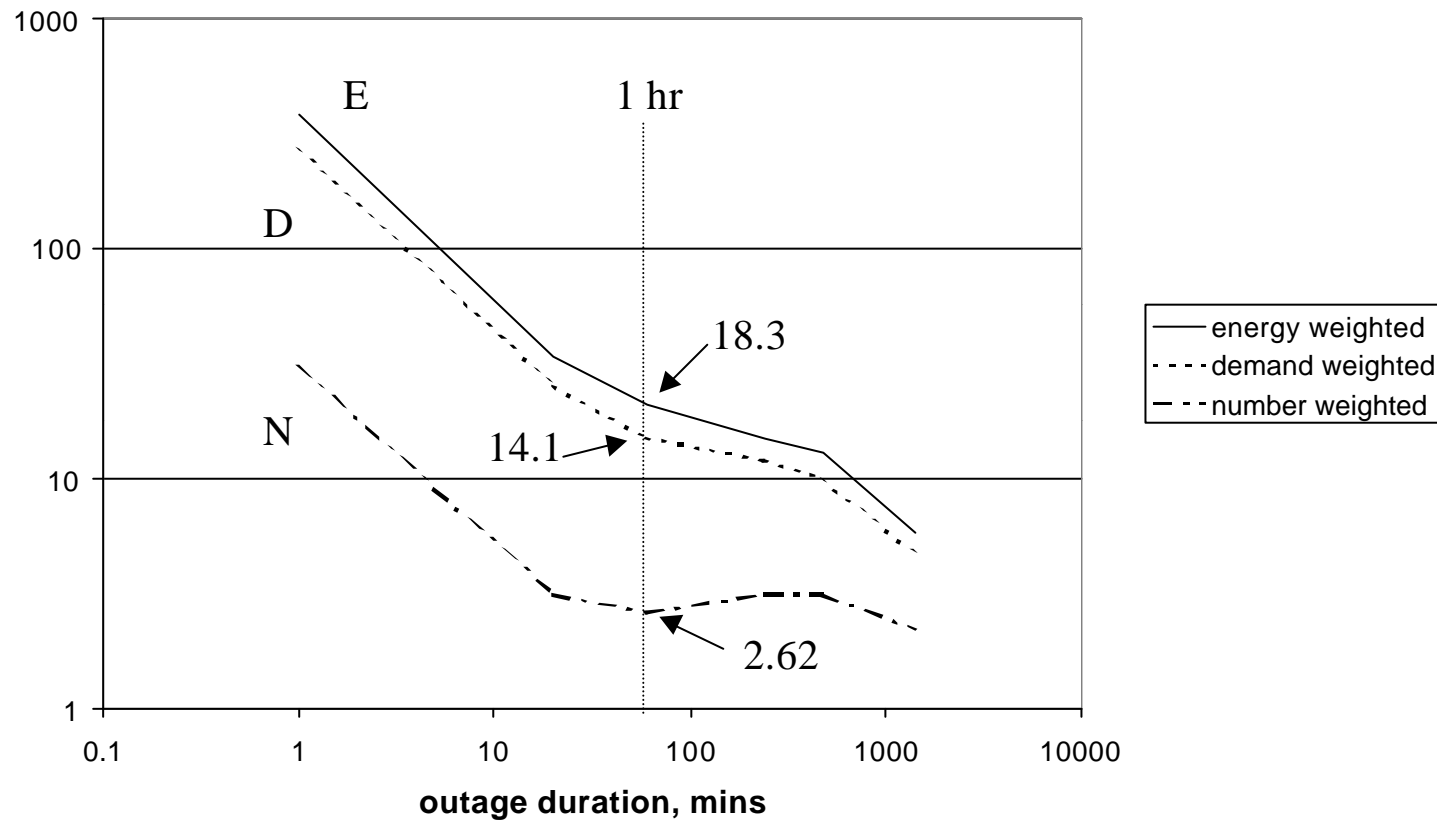
- The principle is to:-
 - summate relevant COCs of affected customers
 - summate energy not supplied to these customers
 - divide one by the other to give VoLL
 - best done sector by sector, then aggregating

Sector VoLL Curves



VoLL Curves

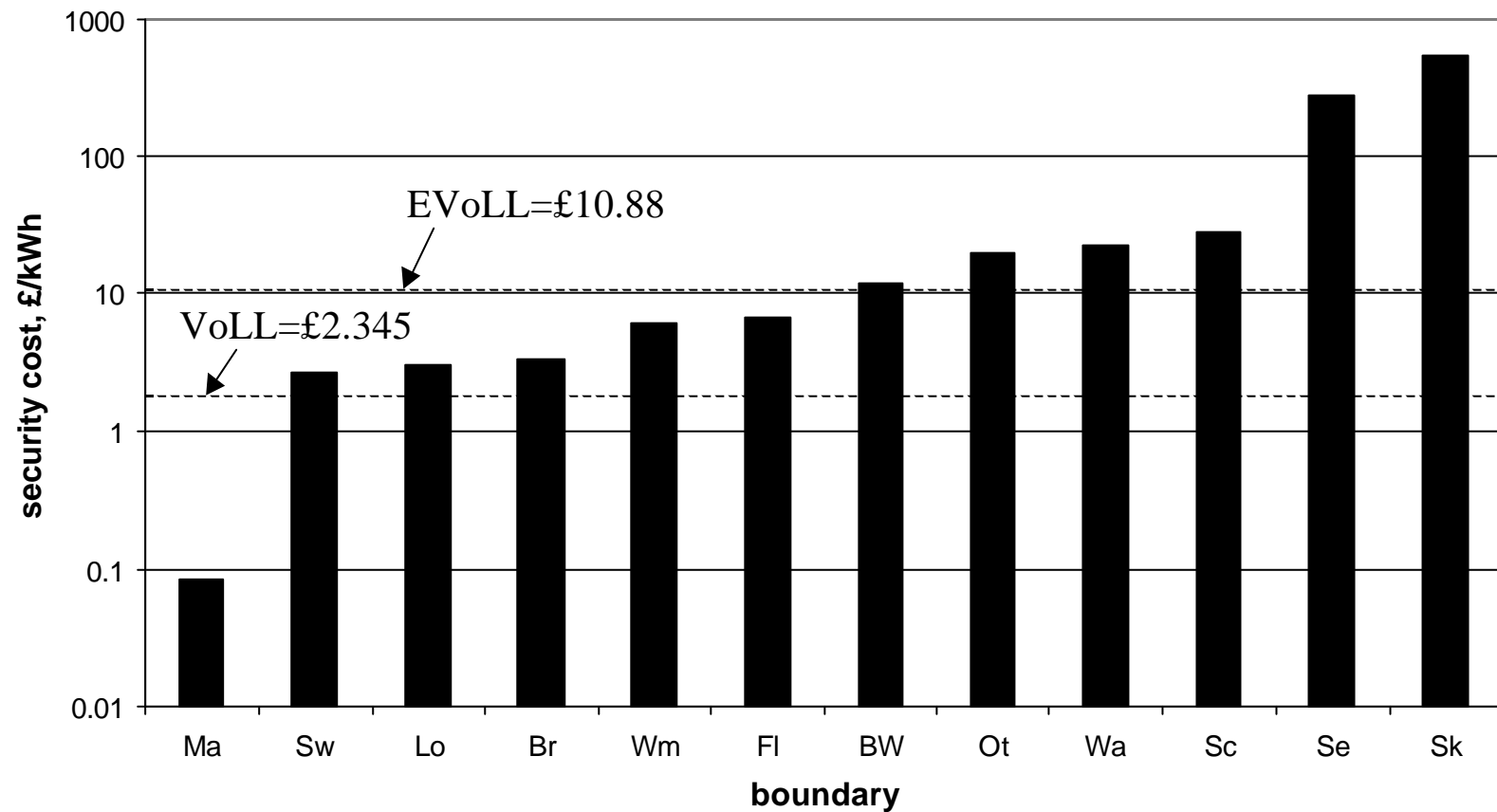
VoLL, £/kWh



Value of Lost Load - £/kWh

| Weighting | VoLL | REC A | REC B | REC C | Combined |
|---------------------|-------------|-------|-------|-------|----------|
| Energy consumed | EVoLL | 9.4 | 12.3 | 11.5 | 10.9 |
| | VoLL at 1hr | 18.6 | 20.1 | 20.8 | 18.3 |
| Number of customers | EVoLL | 2.1 | 2.4 | 3.3 | 2.7 |
| | VoLL at 1hr | 2.1 | 2.6 | 3.2 | 2.6 |

Security Costs of System Boundaries



Applications

- Useful as one parameter in planning, design and operation
 - planning and expansion decisions
 - choosing new or modified generation
 - selecting transmission equipment
 - comparing network alternatives
 - renovating/replacing obsolescent plant
 - maintaining reliability levels
 - adopting/adapting operational policies
 - devising maintenance policies
 - comparing emergency strategies