

Leonardo  
ENERGY 

 LEONARDO  
POWER  
QUALITY  
INITIATIVE

Why EU industry annually loses €150bn

Pan-European Power Quality Survey

Jonathan Manson - European Copper Institute

[jonathan.manson@jel-consulting.com](mailto:jonathan.manson@jel-consulting.com)

Roman Targosz - European Copper Institute

[cem@miedz.com.pl](mailto:cem@miedz.com.pl)



**9th International  
Conference.  
Electrical Power  
Quality and Utilisation.  
Barcelona, 9-11  
October 2007**



europaean  
**COPPER**  
institute 

# Power Quality Survey – 68 respondent organisations + 15 project partners

## Academic

- Belgium - Katholieke Universiteit Leuven
- Poland – AGH University of Science and Technology in Cracov
- Portugal – Universidade de COIMBRA
- Slovenia - University of Ljubljana
- Spain - Universidad Politécnica de Madrid – Escuela Técnica Superior de Ingenieros Industriales
- Spain - Universidad Politécnica de Catalunya – Centre d' Innovació Tecnològica en Convertidors Estàtics i Accionaments
- UK - University of Manchester (formerly UMI ST)



## Industrial

- Bovis LendLease España
- Corporate Risks Associates (UK)
- ECD Italy
- Edu Watt, France
- EPRI USA,
- Laborelec (Belgium)
- APC-MGE (EU)
- Schneider Electric (EU and Spain)



Critical Power and Cooling Services



# A study into the impact of power quality on energy critical industrial sectors

- Why industry loses €150bn annually
- Industry – 16 key industrial sectors
  - 70% of the EU-25's financial outputs
  - 74% of the final non-residential energy demand
- The costs
  - Down time
  - Equipment damage
  - Irrevocable raw material & sales losses
  - Various penalties.

# A study into the impact of power quality on energy critical industria sectors

- Industry – the sectors
  - Pharmaceutical - Pulp paper - Oil chemical - Continuous manufacturing – Semiconductor Food beverage – Metallurgy - Newspaper publishing – Manufacturing – Hospitals – Banks Hotels – Telecom – Retail – Transport – Services & transport
- Major research project
  - 68 face to face interviews
  - 8 EU nation states
- Questionnaire
  - 5 sections data gathering
  - 6<sup>th</sup> section comprising 11 case scenarios

# Sources of power quality issues

**Capacitors**

**Contacts and relays**

**Electric motors**

**Electronic equipment**

**Lighting equipment**

**Processing equipment**

**UPS uninterruptible power supplies**

**VSD and other static converters**

**Welding and smelting equipment**

# Main sources of power quality issues

<b>% responses</b>	<b><i>Industry</i></b>	<b>% responses</b>	<b><i>Services &amp; Transport</i></b>
<b>63</b>	<b>Electric motors</b>	<b>57</b>	<b>Electronic equipment</b>
<b>61</b>	<b>VSD – static converters</b>	<b>38</b>	<b>Lighting equipment</b>
<b>37</b>	<b>Electronic equipment</b>	<b>33</b>	<b>Electric motors</b>
<b>29</b>	<b>Processing equipment</b>	<b>29</b>	<b>VSD – static converters</b>
<b>24</b>	<b>UPS</b>	<b>29</b>	<b>UPS</b>

# Main consequences experienced from power quality issues

**Circuit breakers**

**Computers lock up**

**Computers / other electronics damaged**

**Data loss**

**Electric shocks**

**Lights flicker or dim**

**Loss of synchronization of processing equipment**

**Motors /other process equipment malfunction**

**Motors /process equipment damaged**

**Noise interference to telecom lines**

**Relays /contactors nuisance tripping**

**Transformers/ cables overheating**

# Main consequences experienced from power quality issues

<i>% responses</i>	<i>Industry Group</i>	<i>% responses</i>	<i>Services &amp; Transport Group</i>
61	Loss of synchronisation	57	Circuit breakers tripping
54	Relays & Contacts tripping	48	Data loss
54	Computers lock up	43	Lights flicker
51	Computers / other electronic equipment malfunction	43	Computers lock up
51	Data loss	38	Computers / other electronic equipment damaged
51	Motors / other process equipment malfunction	33	Transformers / cables overheating
37	Motors / process equipment damaged	19	Relays & Contacts tripping

# Power Quality Solutions adopted

- Backup generator
- Dynamic voltage restorers
- Harmonic filter
- Isolation transformers
- Line conditioners or active filters
- Multiple independent feeder
- Oversizing equipment
- Shielding and grounding
- Site generation capable of substituting supply
- Static transfer switches
- Static Var Compensator
- Surge protectors on key pieces of equipment
- Uninterruptible Power Supply UPS devices
- Voltage stabilisers

# Power Quality Solutions adopted

## Overall – most common solutions:

- Back up generation
- Multiple independent feeds
- Shielding & grounding
- UPS

## Services:

- Redundancy
- Security of supply

## Industry:

- More reacting to events
- Ad hoc solutions

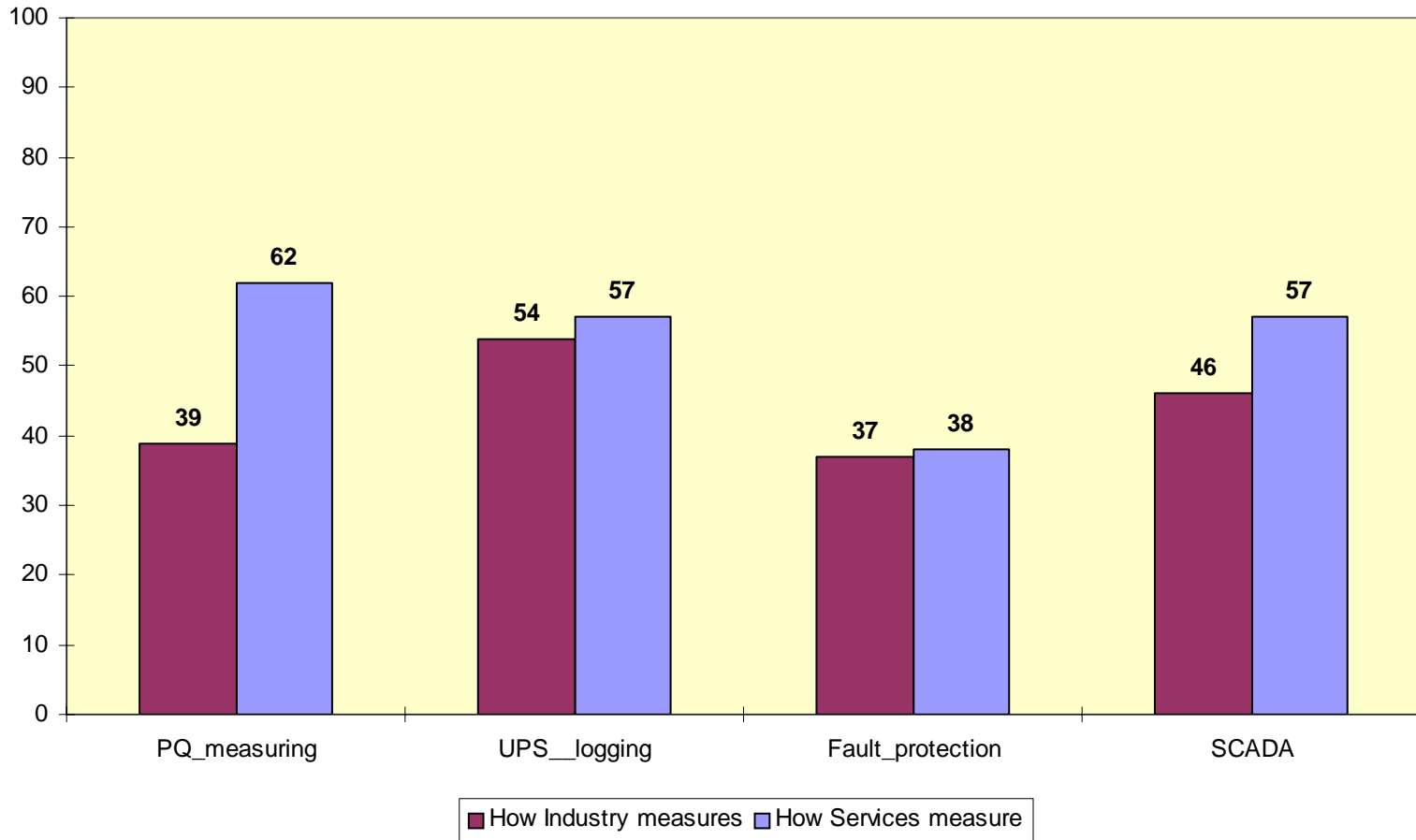
# Power Quality Solutions adopted

- Annual investment into power quality “solutions” measured by this investigation - €298 million.
- An EU-25 equivalent of ~€50bn pa.
- “Services” sectors tend to invest more into original designs
- “Industry” sectors often have to adapt existing possibly older installations to cope with current demands
- Sectors that cannot allow for power interruptions tend to design reliability & resilience into their systems.

# Measuring Power Quality

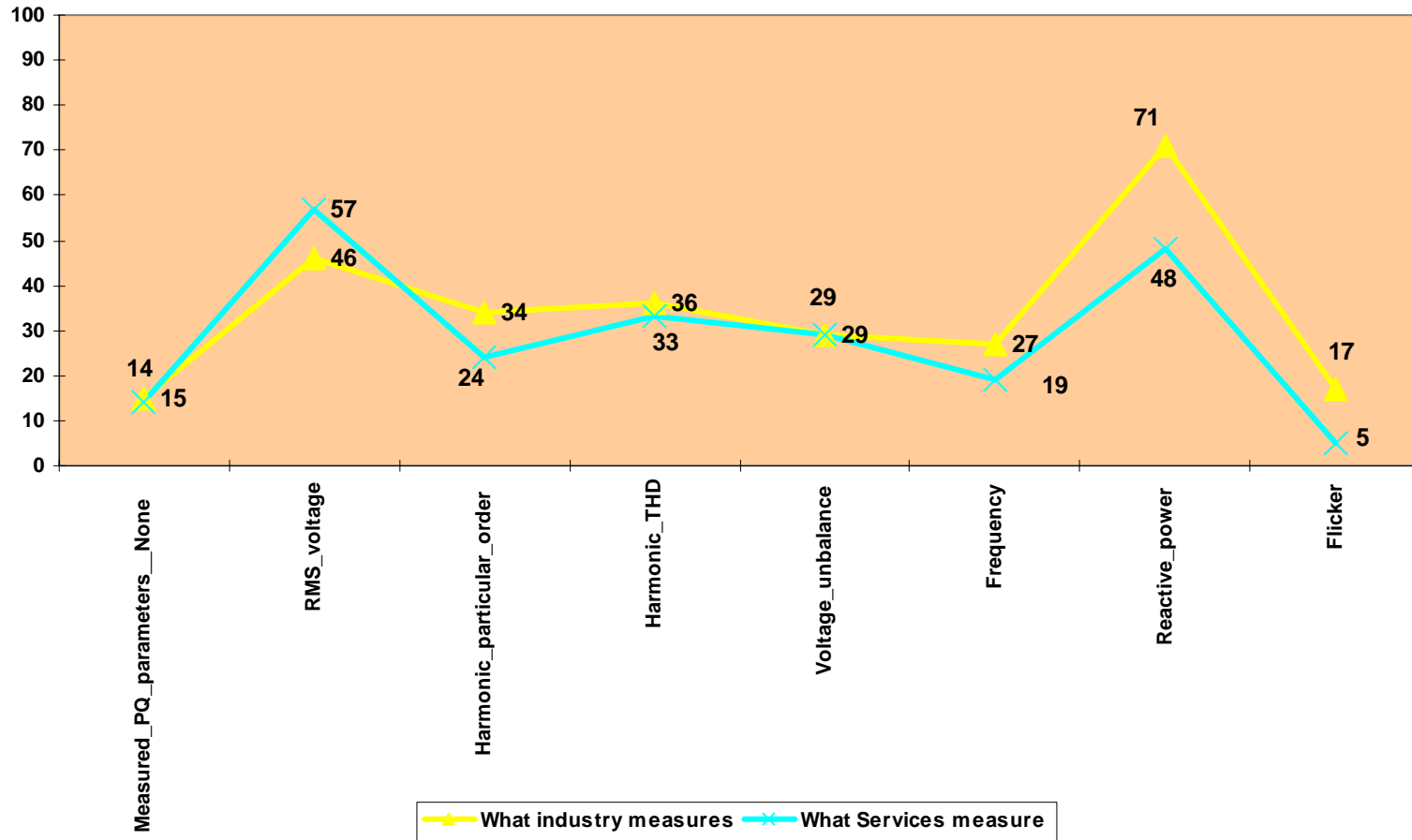
- Measurement should be fundamental and key to all these industrial sectors
- Measurement is the starting point to ensure that everything works correctly
- This investigation addressed
  - How respondents measured and ...
  - What they were measuring.

# Measuring Power Quality – how respondents measured



- 38% of the "Services" group undertook no measurement
- 46% of the "Industry" group undertook no measurement

# Measuring Power Quality – how respondents measured



# Measuring Power Quality – how respondents measured

## Industry

- RMS voltage – 57% of the 54% that measure anything

## Other parameters

- reactive power
- voltage unbalance
- harmonics – [THD] & specific orders 5<sup>th</sup> & 3<sup>rd</sup>

## Services

- Reactive power – 71% of the 62% that measure anything

## Other parameters

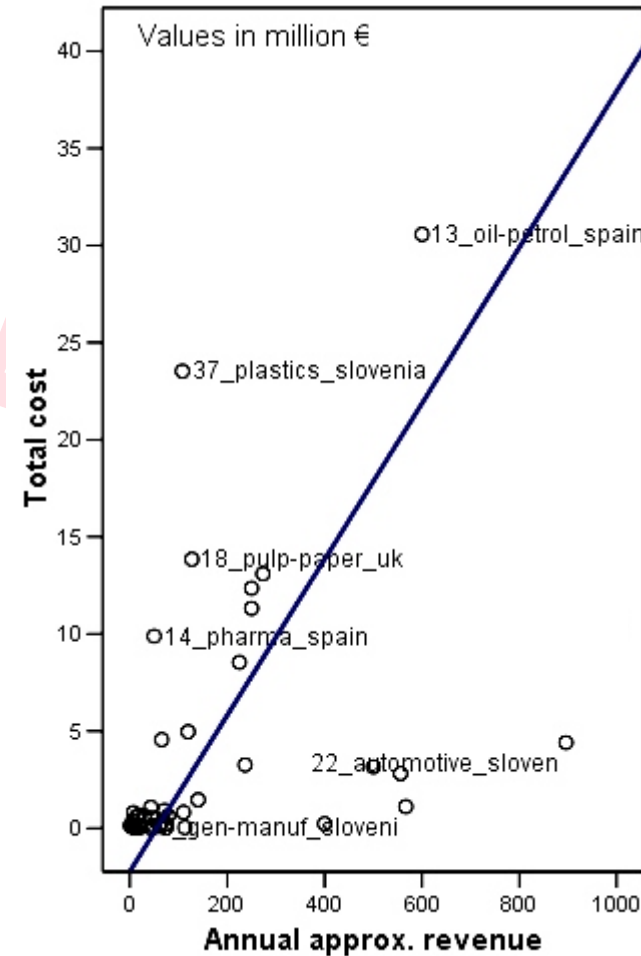
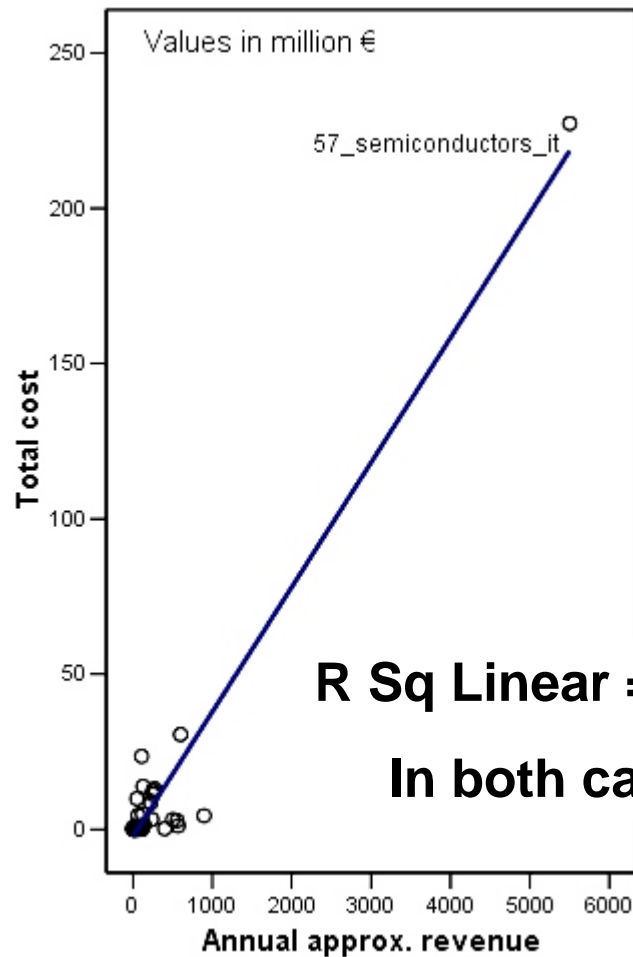
- same precedence
- Flicker – 17%

# Power Quality Survey – data confidence

- Are these data representative?
- Application of the data to a pan EU-25 scenario.
- “Industry” & “Services” sub-samples.

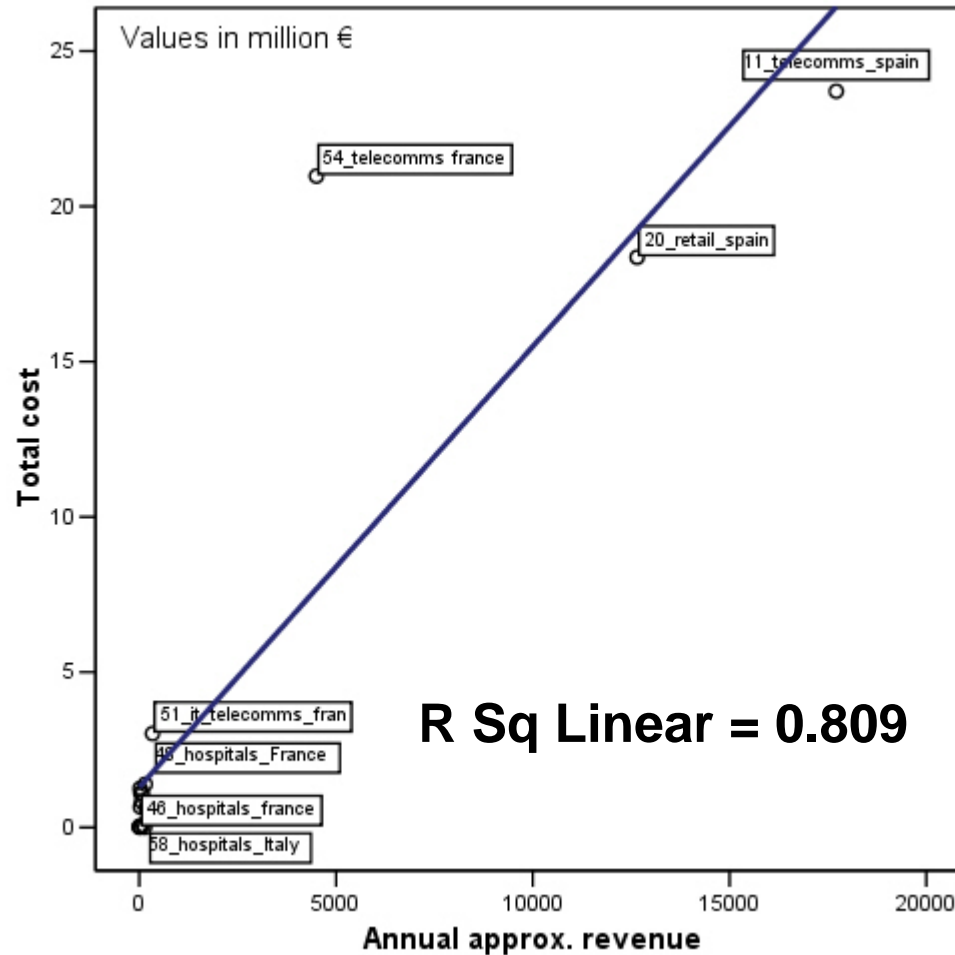
# Power Quality Survey – data confidence

“Industry”



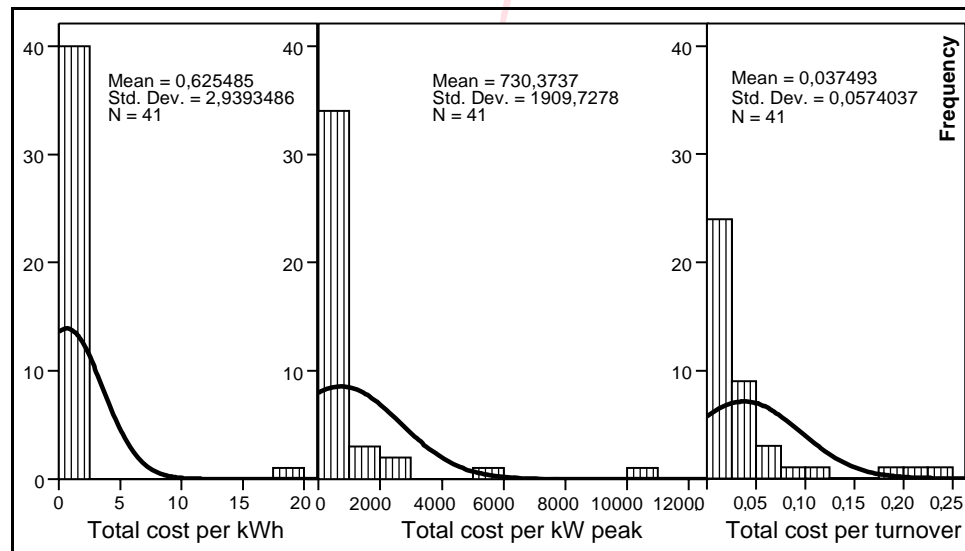
# Power Quality Survey – data confidence

## “Services”



# PQ cost indices (industry)

	Total cost per kWh €/kWh	Total cost per kW peak €/kW	Total cost per turnover (ratio)	Total cost per electricity bill (ratio)	Total cost per employment €/employee	Cost / kWh dip & short interruption €/kWh	Cost / kWh long interrupt. €/kWh	Cost / peak kW dip & short interrupt. €/kW	Cost per peak kW long interruption €/kW
Mean	0,625	730,37	0,0374	7,530	8158	0,1352	0,0802	147	323
Std. Error of Mean	0,459	298,24	0,0089	5,330	2995	0,0922	0,0469	57	260
Median	<b>0,031</b>	<b>95,57</b>	0,0109	<b>0,413</b>	<b>1218</b>	<b>0,0098</b>	<b>0,0012</b>	28	4,18
Std. Deviation	2,939	1909,72	0,0574	34,163	19181	0,5903	0,3008	371	1670
Variance	8	3 647 060	0,0030	1 167,000	367 922 790	0,3490	0,0910	137 717	2 789 088
Minimum	0	0	0	0	0	0	0	0	0
Maximum	18,861	10 681	0,2375	218,552	113 638	3,7720	1,7090	1 771	10 681



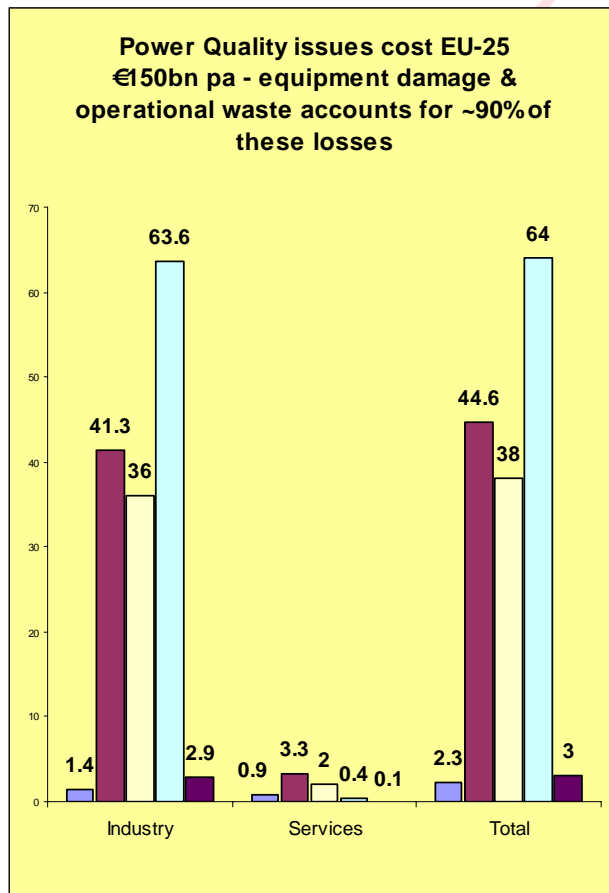
[www.leonardo-energy.org](http://www.leonardo-energy.org)

# Power Quality Survey

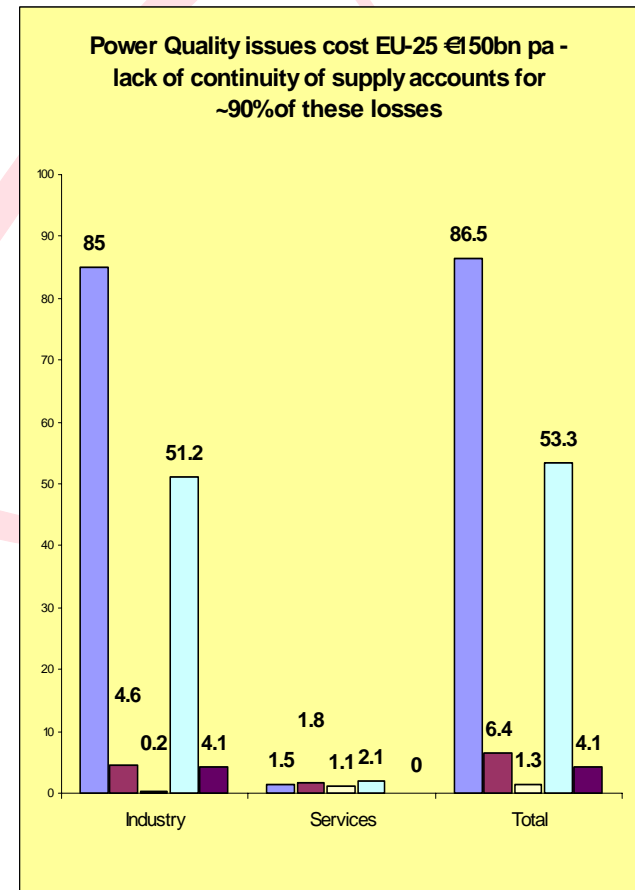
## Assessing the impact through 11 key case scenarios

- Voltage dip
- Short interruptions
- Long interruptions
- 4 x Harmonics
  - Additional energy losses and related problems
  - Overheating N conductor
  - Nuisance tripping protective devices
  - Malfunctioning PLC devices & other control systems
- Surges & transients
- Flicker
- Unbalance
- Earthing & EMC

# Power Quality costs EU-25 €150bn pa



- Labour losses
- WIP
- Process slow down
- Equipment damage
- Other costs



- Dips & SIs
- LIs
- Harmonics
- Surges & transients
- Flicker, unbalance & earthing

# Power Quality Survey – what does €150bn represent?

- 5% of a notional 15% net profit margin
- The €300 million invested into power quality solutions is:
  - $\cong$  33% of these annual EU-25 losses
  - $<$  3% of the net profit
- These data consistent with other studies in other regions  
eg EPRI CEIDS USA [2000]

# Power Quality Survey – what does €150bn represent?

- **Electrical energy**

- >70% of final electrical energy consumed by these sectors
- 1½ times EU-25 2020 annual reduction in energy consumption targets of €100bn pa ... NOW!
- 115% pa of predicted cumulative cost of 110GW installed wind power by 2012 [DEWI 2007]
- +10 times current carbon credits in circulation

# Power Quality Survey – what does €150bn represent?

- **Social costs**

- 4 months to repay the World Bank's highly indebted countries' debt of €54bn
- 2 hurricane Katrinas .. every year

And all this is just the EU-25

# Power Quality Survey – what does €150bn represent?

- **Business efficiency**

- 47% of the EU-25 annual investment into R&D
- 187% of the EU-25 annual investment into Life Long Learning
- ~ 5% of the reviewed sectors' annual profit margin

# Today's conclusions and actions to be taken

- Power quality costs EU-25 significantly
- End users' own installations are the main source of this wastage
- It lies within their gift to do something about it.
  
- Driving these lessons home – including end users presenting and applying data within their own organisations
- Intention to put this data to work:
  - For the benefit of EU as a whole,
  - For industrial competitiveness
  - And for our environmental objectives.

Leonardo  
ENERGY 

 LEONARDO  
POWER  
QUALITY  
INITIATIVE

Why EU industry annually loses €150bn

Pan-European Power Quality Survey

<http://www.leonardo-energy.org>

Jonathan Manson - European Copper Institute

[jonathan.manson@jel-consulting.com](mailto:jonathan.manson@jel-consulting.com)

Roman Targosz - European Copper Institute

[cem@miedz.com.pl](mailto:cem@miedz.com.pl)



**9th International  
Conference.  
Electrical Power  
Quality and Utilisation.  
Barcelona, 9-11  
October 2007**



europaean  
**COPPER**  
institute 