SafeLife-X Safe Life Extension management of aged infrastructures networks and industrial plants

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement no. 608813

D1.1: Identification of the needs to improve aging management

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Stuttgart, May 13, 2014

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1 Introduction

1.1 Background of the survey –

In relation with the initiative developed by the EU FP7 project SafeLife-X, the participants were invited to take part in the second round of the survey to provide information to identify the needs related to safe lifetime extension and aging management, as expressed by the various stakeholders involved in the project, i.e. the industry from various sectors (construction, transport, energy, industrial plants, pipeline networks…), from service to industry companies dealing with inspection and certification, from public authorities and from research organizations.

1.2 The web-based survey tool used

The survey was created and designed by using EU-VRi/Steinbeis-R-Tech web based tool. EU-VRi /Steinbeis-R-Tech has a website dedicated to the survey assigned in any EU-VRi project. The website is available at http://www.safelife-x.eu-vri.eu.

Survey tool is accessible through the Member Area of the web page. Each member can create and manage their own surveys; however only administrators can launch/open/close surveys. Survey tool allows a creation of fully customizable surveys, conducting surveys and evaluating the results.

The survey was conducted by sending the link of the survey directly to the target groups by emails. The answers from each participant were evaluated by this survey tool.

2 Survey performance

2.1 Launch/End of the survey

This survey was launched early December 2014 and will foreseeably end in May 2014.

2.2 Participants

The survey was carried out with participants from different countries who are the stakeholders of the value-chain. Among participants, there are not only people who work at universities or research institutes but also people who work in different sectors of industry. Due to differences among participants, we could see the different opinions from different groups.

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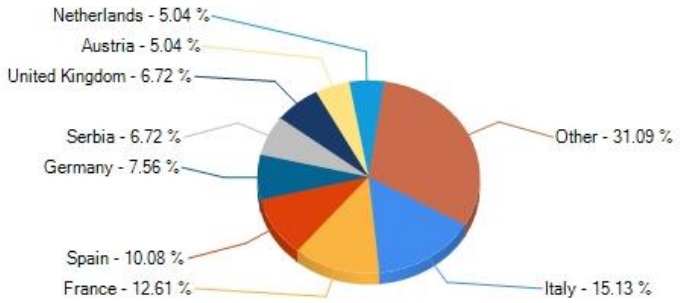
3 Survey results

3.1 Statistics of responses

As on May 5, 2014 there have been 119 answers from 26 countries (see Figure 1).



Color	Name	Value	Percent
	Italy	18	15.13 %
	France	15	12.61 %
	Spain	12	10.08 %
	Germany	9	7.56 %
	Serbia	8	6.72 %

Color	Name	Value	Percent
	United Kingdom	8	6.72 %
	Austria	6	5.04 %
	Netherlands	6	5.04 %
	Other	37	31.09 %

Figure 1: Countries of survey participants

The countries from which we got most answers are

- Italy (18)
- France (15)
- Spain (12)
- Germany (9)

what reflect largely the interest in the topic of the SafeLife-X project.

3.2 More about your background...

What is your domain of expertise?	No. of answers	Percent (%)
Risk analysis and risk assessment	58	49
Technology for monitoring and sensors, data acquisition	29	24
Risk-based inspection	36	30
Structural modelling (degradation models, structural analysis, engineer tools...)	32	27
Statistic and data processing, including uncertainties	20	17
Multi-criteria decision making	20	17
Standardization and regulation	24	20
Technology for mitigation	16	13
Other, please specify	27	23
No answer	5	4

Table 1: Domain of expertise

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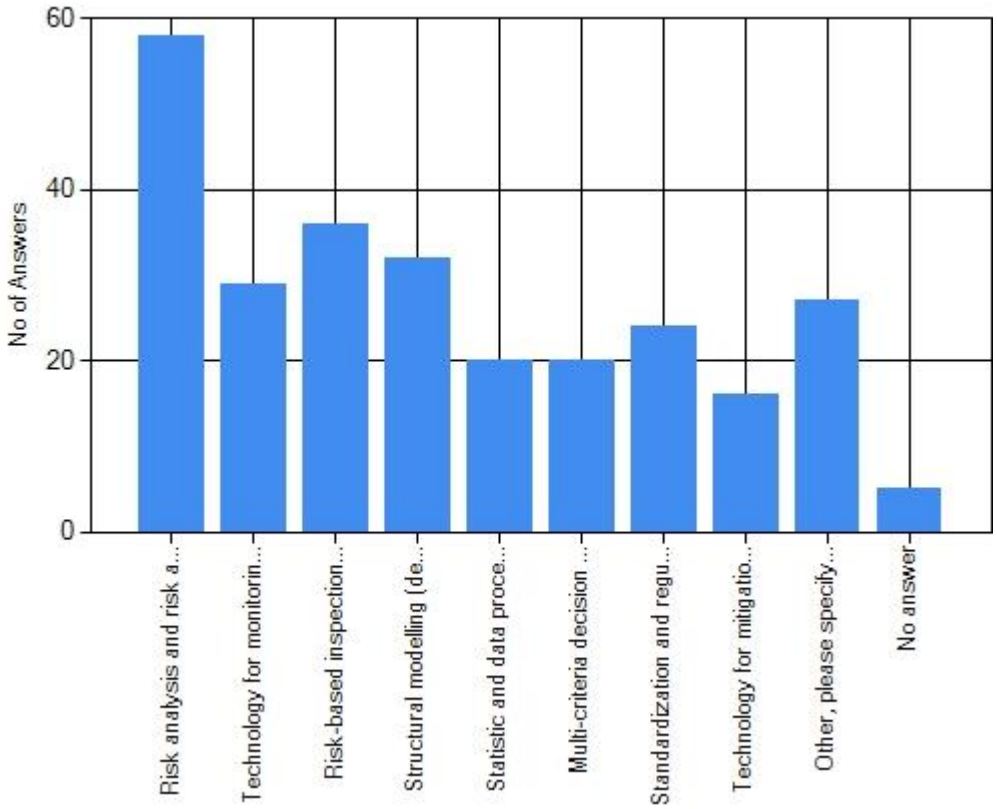

Figure 2: Domain of expertise

The people who answered are involved in following topics (see Table 2: Topics, Figure 3: Topics, Figure 4: Topics)

Option	Design	Operation	Maintenance	Monitoring	Dismantling
Roads	3	6	11	13	1
Railways	7	5	1	11	1
Tunnels	3	4	1	13	0
Bridges	4	4	13	10	2
Power plants	22	14	28	34	4
Chemical plants	19	12	21	29	3
Dams	5	1	6	4	0
Pipeline networks	12	8	12	17	2
Gas grid	4	3	4	6	2
Electricty grid	1	1	5	6	2
Offshore platforms	9	8	10	9	3

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Table 2: Topics

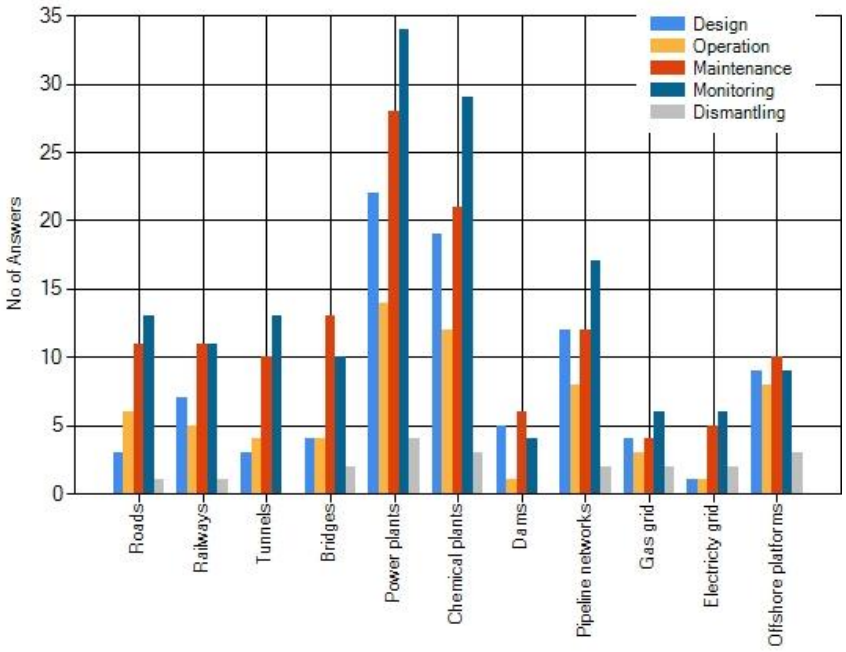

Figure 3: Topics

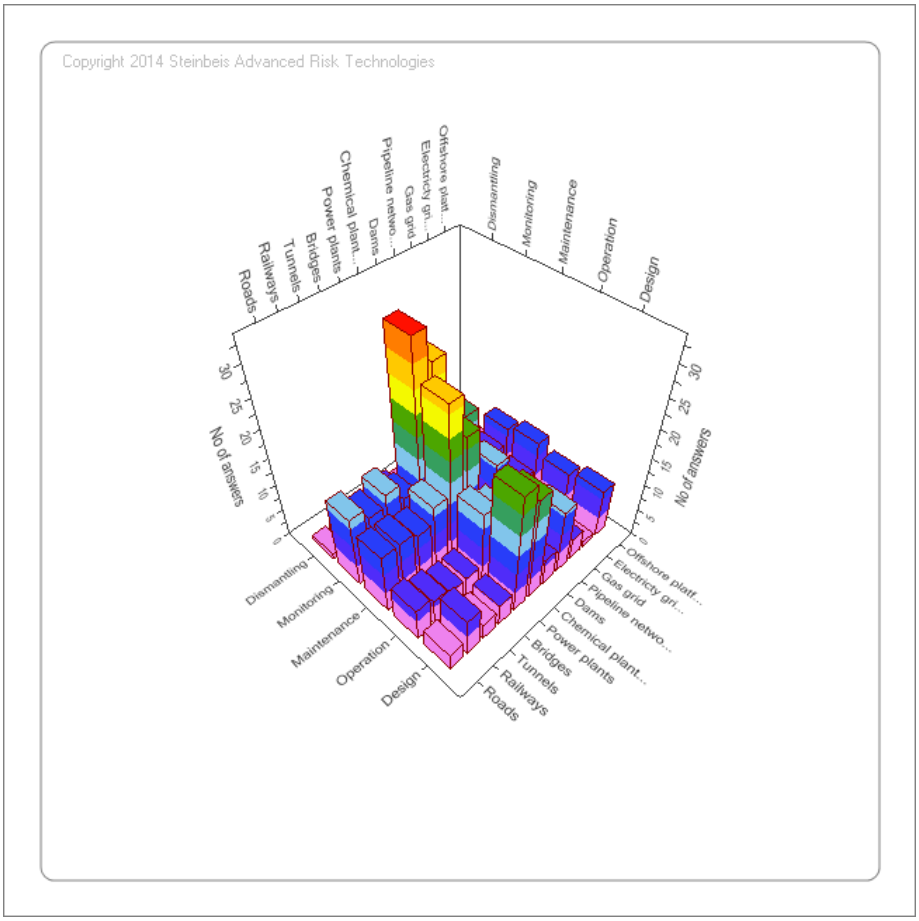

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Figure 4: Topics

3.3 Identification of the needs

119 of 119 Participants (100%) answer the question to provide their views and suggestions on the needs related to maintenance (where 5 means "highly needed").

MAINTENANCE: Please provide your views and suggestions on the needs related to maintenance	1-MIN	1-AVG	1-MAX
Technologies/tools	0.2	3.6	5
Methods	1.8	3.92	5
Guideline documents	0.5	3.53	5
Regulations	0.1	3.04	5
Aging community	0.6	2.97	5
Education	0.8	3.84	5

Table 3: Maintenance

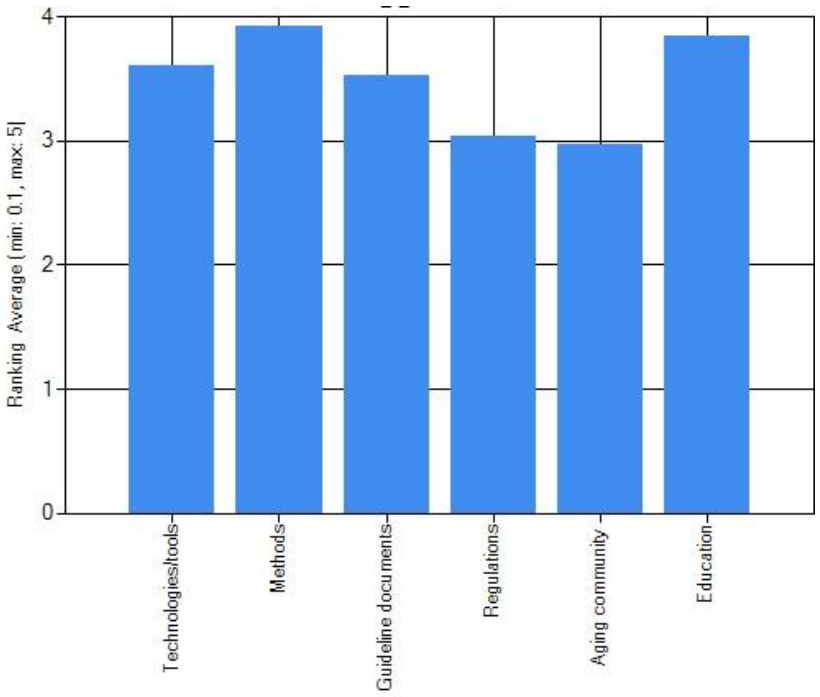

Figure 5: Maintenance

119 of 119 Participants (100%) answer the question to provide their views and suggestions on the needs related to inspection (where 5 means "highly needed").

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INSPECTION: Please provide your views and suggestions on the needs related to inspection	1-MIN	1-AVG	1-MAX
Technologies/tools	2	4	5
Methods	1	4.07	5
Guideline documents	1	3.77	5
Regulations	1	3.37	5
Aging community	1	3.22	5
Education	1	3.84	5

Table 4: Inspection

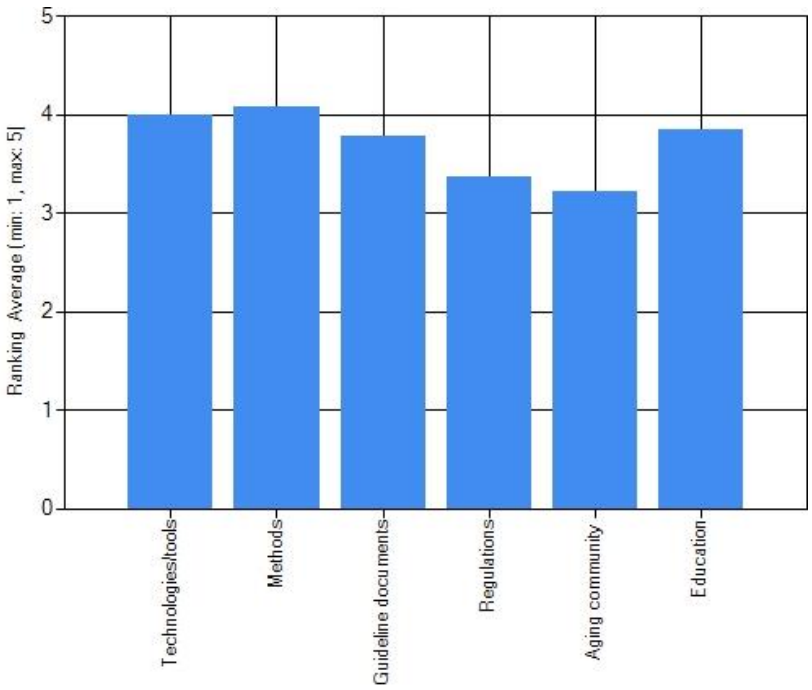

Figure 6: Inspection

Nearly all of the participants 118 of 119 (99%) answer the question to provide their views and suggestions on the needs related to monitoring (where 5 means "highly needed").

Please provide your views and suggestions on the needs related to monitoring	1-MIN	1-AVG	1-MAX	
Technologies/tools	0.9	3.86	5	- (6) YES - (30) 3 - (37) Very high potential of pre-designed and optimized risk and reliability based monitoring systems!

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Please provide your views and suggestions on the needs related to monitoring	1-MIN	1-AVG	1-MAX	
				- (43) Drones, Robots collecting data. Use the data to calibrate and better understand the digital models - (46) 5 - (57) Smart sensors associated with new communication technologies - (63) needs for cheap and reliable sensors - (73) currently on an as required basis - (88) remote sensing - (100) 5 - (108) new to be added - (114) Common indicators, dedicated "on-line and integral" technology
Methods	0.5	3.77	5	- (6) YES - (30) 2 - (37) Very high potential of pre-designed and optimized risk and reliability based monitoring systems! - (43) Follow the army developments - (46) 4 - (73) need to educate design house engineers - (100) 5 - (103) real-time data processing - (108) merging of different methods - (114) concrete actions
Guideline documents	0.2	3.2	5	- (6) YES - (30) 2 - (37) Guidelines should be produced for the first two items - (46) 5 - (73) need to educate owners - (100) 4 - (108) comparison different methods - (114) Concrete instructions
Regulations	0.5	2.89	5	- (6) YES - (30) 4

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Please provide your views and suggestions on the needs related to monitoring	1-MIN	1-AVG	1-MAX	
				- (43) Take care of personal information captured by the monitoring system ; - (46) 4 - (63) need for mandatory monitoring - (73) current UK regulations not understood by industry - (100) 4
Aging community	0.2	2.89	5	- (6) NOT RELEVANT - (30) 4 - (46) 4 - (73) networks would help with dissemination of knowledge - (100) 5
Education	0.7	3.26	5	- (6) NOT RELEVANT - (30) 4 - (37) For the methods above - (46) 5 - (73) Program required for owners and design engineers - (100) 5

Table 5: Monitoring

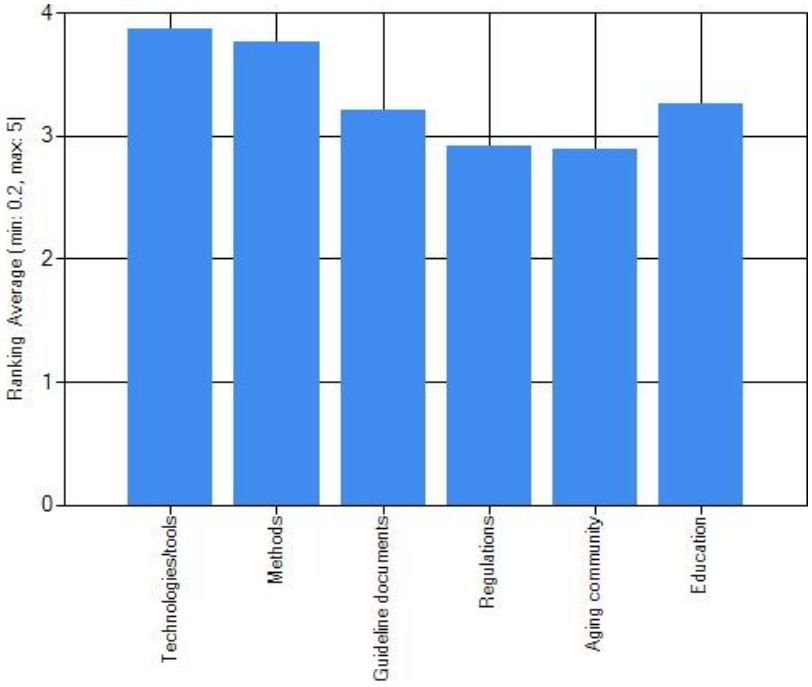

Figure 7: Monitoring

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All of the participants 119 of 119 (100%) answer the question to provide their views and suggestions on the needs related to safety protocols (where 5 means "highly needed").

Please provide your views and suggestions on the needs related to safety protocols	1-MIN	1-AVG	1-MAX	
Technologies/tools	0.8	3.2	5	- (6) YES - (30) 3 - (43) Drones and robots in hazardous areas - (46) 5 - (57) stress and fatigue assessment - (100) 4
Methods	0.6	3.36	5	- (6) YES - (30) 3 - (43) Modeling of safety protocols with digital mock-ups, to validate (the developer) and to learn to be efficient when it happens (see aeronautics protocols) - (46) 5 - (63) need for standards on sampling and analysis - (100) 4
Guideline documents	1	3.57	5	- (6) YES - (30) 2 - (46) 5 - (73) more guidelines appear to be required by industry - (100) 5
Regulations	0.4	3.15	5	- (6) YES - (30) 4 - (43) More constraining - (46) 4 - (73) these are fine in the UK but not understood by industry - (100) 5
Aging community	0.4	2.81	5	- (6) YES - (11) special safety protocols should exist for this - (30) 4 - (43) Include their limited behavior - (46) 4 - (73) network would help improvements

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Please provide your views and suggestions on the needs related to safety protocols	1-MIN	1-AVG	1-MAX	
				- (88) self-explanatory - (100) 4
Education	0.6	3.24	5	- (6) YES - (30) 4 - (46) 5 - (73) Design houses where everything originates have poor knowledge - (100) 4

Table 6: Safety protocols

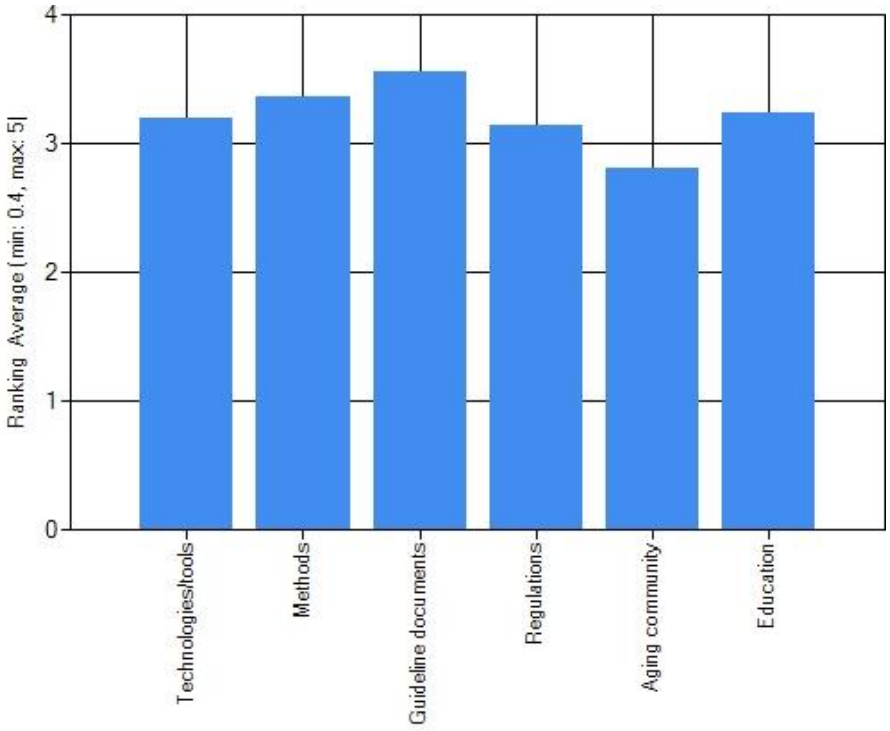

Figure 8: Safety protocol

All of the participants 119 of 119 (100%) answer the question to provide their views and suggestions on the needs related to aging risk mitigation (where 5 means "highly needed").

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Please provide your views and suggestions on the needs related to aging risk mitigation	1-MIN	1-AVG	1-MAX	
Technologies/tools	0.9	3.66	5	- (6) YES - (30) 3 - (37) Technologies should be further developed as a part of life cycle assessment and optimization - (46) 5 - (62) strain gauges - (100) 4 - (103) sensors
Methods	0.8	3.77	5	- (6) YES - (30) 1 - (37) Methods for life cycle assessment and optimization of risks and costs - (46) 4 - (100) 4
Guideline documents	1.1	3.6	5	- (6) YES - (30) 1 - (37) High requirements especially to emerging methods - (46) 4 - (100) 5
Regulations	0.5	2.99	5	- (6) YES - (30) 3 - (46) 4 - (100) 5
Aging community	0.3	3.15	5	- (6) YES - (30) 4 - (46) 4 - (100) 4
Education	0.4	3.45	5	- (6) NOT RELAVANT - (30) 4 - (46) 5 - (100) 4

Table 7: Risk mitigation

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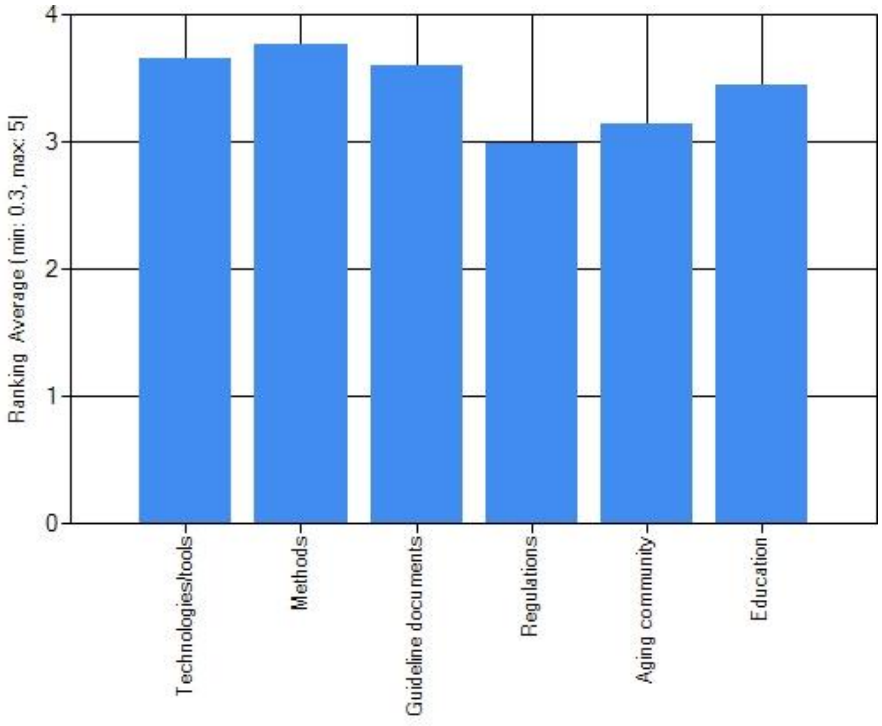

Figure 9: Risk mitigation

3.4 Needs identified during the workshop

All of the participants 119 of 119 (100%) answer the request to provide their views and suggestions on the needs identified during the SafeLife-X Workshop "Identification of the needs" (where 5 means "highly needed") with following option :

- Combination of failure modes:

  How to integrate multiples damage mechanisms?

- Innovative and low cost solutions to extend lifetime of structures and related monitoring

  Due to cuts on funding, the aging problem must be addressed with innovative and low cost solutions capable to extend the lifetime of the aged structures. Since these solutions are new, their performances must be monitored in order to fully define their behaviour.

- "Intelligent" design of new structures taking into account future ageing

  Ageing occurs to any type of structures and requires upgrade of the structure by means of retrofitting techniques. New structures should be designed in a way to efficiently allow retrofitting that at some point will be necessary due to structural ageing.

- Improved methods for inspections and monitoring of critical structures/locations

  For example, challenges appear for NDT in offshore windmills to inspect deep subsea structures covered with biomass crust and no inspection access from inside. More generally, there is a challenge to link inspection and monitoring data to the governing damage and failure mechanisms for critical structures and locations. Improved (health) monitoring methods and sensors are also needed for critical components that operate under severe environments.

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- Improve methodologies for assessing the remaining loading capacities of structures and lifetime prediction

  Infrastructures are aging; the effective remaining loading capacity is unknown and there are not satisfactory methodologies that allow to assess it. The need to investigate in that direction is considered as primary in this sector. Assessing the remaining loading capabilities will also enable an accurate lifetime prediction.

- Change of operational mode

  For example, the increasing share of unrestricted wind and solar power tends to make the overall electricity supply more fluctuating and increases the fatigue type loading to the rest of the plants in the system, if not fully balanced by e.g. fast responding hydro capacity and spinning reserves. This results in increasing fatigue-related aging in thermal plants, and can also make the previous inspection data and experience (e.g. for RBI) largely redundant.

- Life(time) extension

  For example, the rules and practices are not always clear for recalculating margins or safety factors to deal with uncertainties in loads that aging structures are subjected to. Similarly, significant uncertainties appear in the response to these loads by aging structures, and in the predicted life, when aiming for life extension.

Please provide your views and suggestions on the needs identified during the SafeLife-X Workshop "Identification of the needs"	**1-MIN**	**1-AVG**	**1-MAX**	
Combination of failure modes	1	3.74	5	- (6) 5 - (11) big question is whether to combine them via automated process or to use human judgement, each alternative has it's good sides but also risks - (30) 4 - (37) Actual research topic which we (SAFEINFRA) are active in - (41) Rating does not seem to work - (46) 4 - (54) of concrete and metallic structures - (88) Monte Carlo method? - (100) 4
Innovative and low cost solutions to extend lifetime of structures and related monitoring	1	3.91	5	- (6) 5 - (11) some kind of open innovation approach could be used here, to gather creative ideas - (30) 3 - (34) da ngerous when money takes over safety - (37) Actual research topic which we (SAFEINFRA) are active in - (46) 5

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Please provide your views and suggestions on the needs identified during the SafeLife-X Workshop "Identification of the needs"	1-MIN	1-AVG	1-MAX	
				- (57) cost should be related to the extend lifetime (not necessary low cost) - (88) remote sensing - (100) 4
"Intelligent" design of new structures taking into account future ageing	1	3.97	5	- (6) 5 - (11) can we measure intelligent design in some way? that should be useful - (30) 3 - (37) Actual research topic which we (SAFEINFRA) are active in - (46) 5 - (88) modular design, self healing - (100) 5
Improved methods for inspections and monitoring of critical structures/locations	1	4.12	5	- (6) 4 - (11) this should be a standard, anything that is not perfect is not acceptable here - (30) 3 - (37) Actual research topic which we (SAFEINFRA) are active in - (46) 4 - (100) 5 - (108) early stage diagnosis
Improve methodologies for assessing the remaining loading capacities of structures and lifetime prediction	2	4.23	5	- (6) 4 - (11) you need all sorts of oppinions here, since this is a multidimensional problem - (30) 3 - (37) Acttractive research topic - (41) Methodologies are depending on technological possibilities - (46) 4 - (100) 5 - (108) pre experiment needed
Change of operational mode	1	3.39	5	- (6) 4 - (30) 4 - (46) 5 - (89) usually difficulty to change - (100) 4
Life(time) extension	1	3.92	5	- (6) 4

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Please provide your views and suggestions on the needs identified during the SafeLife-X Workshop "Identification of the needs"	1-MIN	1-AVG	1-MAX	
				- (30) 4 - (37) Very attractive to owners - (46) 4 - (100) 4

Table 8: "Identification of the needs"

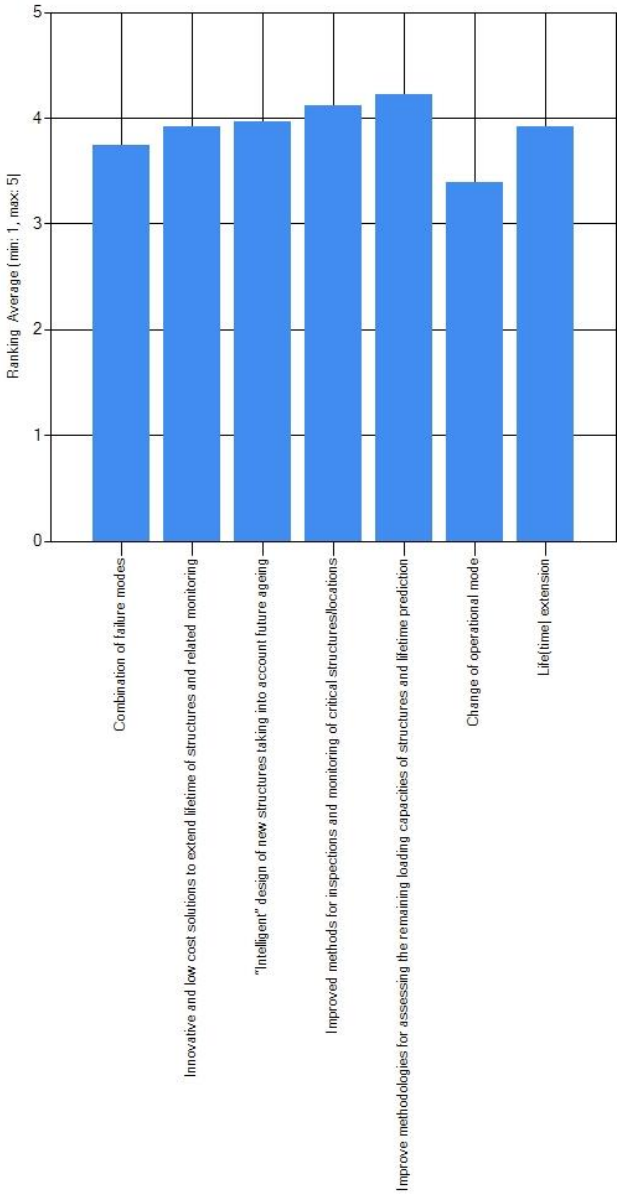

Figure 10: "Identification of the needs"

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3.5 Enabling technologies

All of the participants 119 of 119 (100%) answer the request to rate the need for the development of these enabling technologies (where 5 means "highly needed")

Please rate the need for the development of these enabling technologies	1-MIN	1-AVG	1-MAX
Integration online hazard assessment techniques	0.4	3.29	5
Infrastructure inventory techniques	0.8	3.05	5
Early warning systems	0.6	3.84	5
New smart sensing and communication technologies	0.8	3.67	5
Data collection, processing and aggregation systems	1.4	3.52	5
Advanced non-linear modeling capabilities	0.8	3.17	5
Multi-scale and multi physics modeling techniques	0.8	3.25	5
Lifecycle engineering (LCE) including aging management	1	3.77	5
Probabilistic asset management methodologies	0.8	3.29	5
Hybrid simulation methods	0.6	2.92	5
Advance decision support tools	0.3	3.32	5
Utilization of high performance computing	0.6	2.83	5
Sustainable model of the system of systems	0.6	2.93	5
Communication tools	0.9	3.08	5
Research on the improvement of the technology transfer	0.7	3.32	5

Figure 11: Enabling technologies

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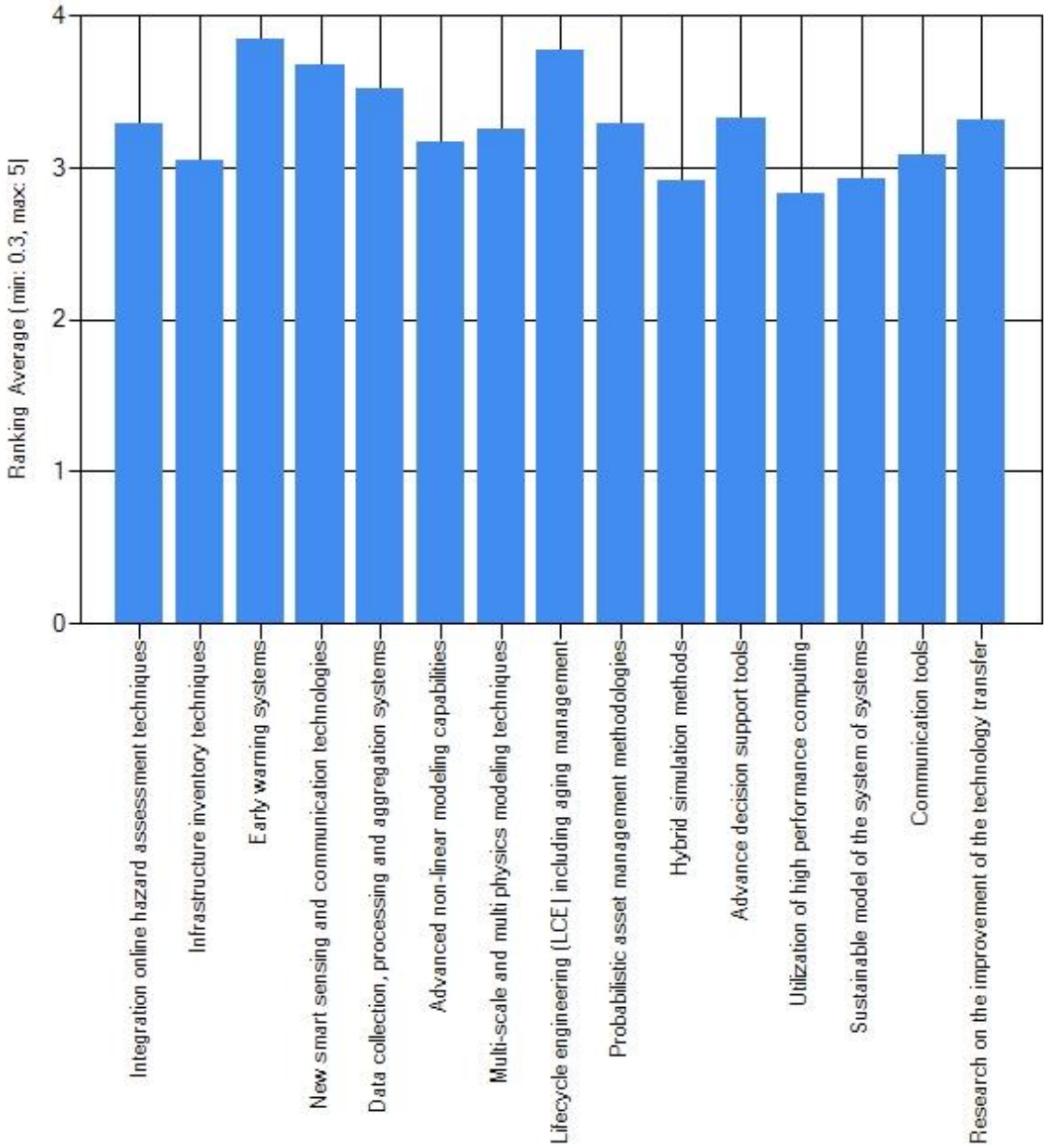

Table 9: Enabling technologies

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4 Conclusion

The final conclusions were made after the discussion of the results, during the workshop in Paris on May 21, 2014.

1. One of the biggest problems of safety is the degradation of materials. A good knowledge on the degradation mechanism is crucial to be able to warn and evaluate properly the resilience of the system. I think that experimental campaigns about material degradation are needed. Especially for new materials like composites where fatigue and damage perform different from other studied families like metals.
2. To be part of further discussions and workshop meetings with regard to the scope of CW 15740 (RIMAP) would be very much appreciated. The need for integration of this processes into the overall management system processes is more important than the control via Third Party inspection. This means the controlling and confidence of statutory compliance of risk based methods should be via ISO 17021 system audits, instead of ISO 17020 third party inspection
3. Considering Energy industries (Power Plants, Chemical Processing Industries, Oil Refineries etc.) special attention should be paid to several topics; starting from developing (and regular updating of already developed standard procedures, not only in general topics and HSE, but also in the framework of Energy Efficiency standards, too), through Operation & Maintenance, to the whole range of LCA(E) analyses and tools.
4. A few technologies (e.g. smart sensors, RFID, internet of things) are able to improve pressure vessels and pipes inspection and maintenance and to mitigate risks associated with critical equipment. The added value of RFID is mainly derived from its introspection capabilities: "self-conscious" intelligent objects (e.g. pipes and vessels) become easier to monitor and control.
   RFID based Smart systems may be valuable for inspection and maintenance (e.g. remote measurement and control of pipes, external wall thickness and fitness, regulatory reporting, planning maintenance strategy). Smart systems provide a lot of information about equipment condition, which has to be exploited to increase and share knowledege.
5. Research and creation of models that describe the physical processes of aging of equipment is essential for safe lifetime extension and aging management. This entails researching, appropriate monitoring equipment, education and later regulatory considerations.

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Annex 1 Comments from survey

A.1.1 Selected indicative detailed answers and comments

A.1.1.1 Comments to specific questions

- Question 1: What is your domain of expertise?
  - (2) Life Cycle Engineering
  - (6) ENERGY MANAGEMENT, BUILDING AUTOMATION
  - (8) geotechnics
  - (11) business communication
  - (15) environmental management
  - (16) material science expertise
  - (26) Combustion, Consequence Analysis
  - (27) Health, Safety Environment
  - (52) language technology
  - (63) Standardisation/Certification
  - (65) policy and inspectorate advice on major hazards and occupational safety
  - (66) General Mechanical Engineering
  - (67) materials design
  - (71) International management, project management, human factors in aeronautics, navaids systems, EU framework programmes for RTD.
  - (77) Advanced NDE (e.g., UT, Guided waves), for deffect assessment.
  - (79) NanoSafety
  - (83) System Reliability Modelling, Reliability Centered Maintenance, Probabilistic Risk Assessment, Maintenance Management
  - (103) ICT, software engineering
  - (114) Automation
  - (118) replace-reconstruct-maintain issues in the light of changing performance demands

- Question 2: I am involved in...
  - (2) smockestacks, retaining walls, culverts,
  - (6) BUILDING TECHNOLOGY PLANTS AND ENERGY INFRASTRUCTURES
  - (18) waste water traetment plant
  - (22) Local area network and devices
  - (27) Waste Recycling company
  - (28) Education Industry
  - (33) Battery
  - (48) Ships
  - (49) machinery
  - (51) Pressure Equipment in general
  - (52) Data infrastructures (design+operation+maintenance+monitoring+dismantling)
  - (54) grain storage (design, opération, maintenance, monitoring)
  - (71) All aeronautics-related themes; navaids, airports, aircraft. I have had experience in all five fields indicated above.
  - (76) RADAR and SENSORS
  - (77) Note: Involvement on these assets is part of overall ISQ business.
  - (82) heat exchangers
  - (104) educational institution
  - (110) Monitoring of all kinds of industrial facilities.

- Question 3: MAINTENANCE: Please provide your views and suggestions on the needs related to maintenance

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- (34) legacy systems and personel must be conserved otherwise one looses traceability
- (35) It needs better use of observation and of the result to collect reliability data
- (38) Need of management system and IT-tools
- (52) Data infrastructures live in a continuously evolving technological environment, which means that maintenance=adaptation
- (57) Needs are more related to the correct combination of different pieces of informations (sometimes contradictory or unconsistent) than the global amount of information
- (71) These suggestions are applicable to point 2
- (77) Maintenance activities are performed within ISQ group.
- (83) Replacement of systematic preventive maintenance for predictive manintenance.
- (89) The most important things are methods, tools and technologies.
- (97) Integrated management and operation plans
- (101) Sharing experience is highly needed
- (106) LACK OF EDUCATION AND REGULATION, IS EVIDENT IN CRO / SLO
- (108) Not a skill of mine

- Question 4: INSPECTION: Please provide your view and suggestions on the needs related to inspection
  - (6) PERFORMED BY EXPERTS
  - (38) Need of regulations on the periods of (periodical) inspections
  - (52) Our data infrastructure is highly distributed, which requires continuous inspection and quality assurance of many components sitting at different sites
  - (57) Inspection and maintenance are quite similar problems
  - (63) Standardised methods on inspection, leading to possible certification
  - (71) These suggestions ar applicable to points 3 to 6
  - (73) engineers in design houses are often very ignorant of requirements in-service
  - (83) Inspection oriented to predictive maintenance, risk based inspection and aging analysis.
  - (89) The most important things are methods, tools and technologies. Other things are needed to help those to be used properly.
  - (101) Tecnologies develop, using them is behind

- Question 5: Please provide your view and suggestions on the needs related to monitoring
  - (34) I don't understand the difference between maintenance, inspection and monitoring, it is the same thing
  - (52) We require 24/7 operation, and continuous moniring and redundancy is required
  - (73) The value of real time monitoring is rarely understood by owners
  - (77) New sensors, comunication systems (fiberoptics,GSM, others), data aquisition with decision making systems.
  - (83) It is the base
  - (89) The most important things are methods, tools and technologies. Other things are needed to help those to be used properly.
  - (101) Help is needed in fiding right methods

- Question 6: Please provide your view and suggestions on the needs related to safety protocols
  - (37) Not commonly used for structures; introduction could be considered
  - (52) safety protocols are needed to prevent hacking, data theft and unauthorized access to restyricted data
  - (63) This will lead to safer aged infrastructures
  - (73) Design engineers have very poor knowledge
  - (77) Easy to understand, friendly and short reaction time.
  - (89) Guideline documents and regulations is the most important needs. Other things are relevant.

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- (101) continuous education
- (108) not a skill of mine

- Question 7: Please provide your view and suggestions on the needs related to aging risk mitigation:
  - (34) replacement as an option must be included. However, big thinking is needed to decide if replacement of parts must be identical to original or using up-to-dat technology, including compatibility issues
  - (52) The effects of aging of data and tools can be mitigated by using stable standards and platform-independent tools wherever possible
  - (63) needs for technologies specifically designed to extend safe aging
  - (73) Owners and design engineers need more education on how to mitigate risks - the "bow-tie" diagram and "Swiss Cheese" models are rarely understood
  - (83) Prevention is better than mitigation
  - (89) The most important things are methods, tools and technologies. Other things are needed to help those to be used properly.
  - (101) Undervalued
  - (108) is not a skill of mine

- Question 7: Please provide your view and suggestions on the needs related to economics
  - (34) safety first
  - (52) Not sure what it means in our case
  - (73) Not considered properly by Owners and extensions are made in very short periods which gives a distorted view of the needs related to economics
  - (77) Must be part of the risk assessment in all the steps to optimize decisions.
  - (89) Grideline documents, regulations help the aging community to use technologies and methods properly via education.
  - (101) Tools are needed to justify the needs

- Question 8: Please provide your view and suggestions on the other needs
  - (10) New materials performance at a long term
  - (52) No specific comments
  - (73) There are serious short comings which Owners do not understand. Also very few current engineers have sufficient competencies - the major omission is that they are incapable of recognising that there are "NEW HAZARDS" in the ageing process
  - (77) Risk assessment is a dynamic concept using self learning methods, so there is always a need of new tools and methods to decrease uncertainty and resilience.
  - (83) Methods to evaluate uncertainty in a Risk Assessment, Procedures and methods to resilience monitoring.
  - (89) I don't understand the points of the second and the third terms

- Question 9: Please provide your view and suggestions on the needs identified during the SafeLife-X Workshop "Identification of the needs"
  - (52) No comments
  - (77) Actual and future operating conditions are more difficult to forsee, introducing new damage mechanisms and uncertainty; as an example the actual power plants are not working anymore in a base-load mode.Even combined cycle power plants are exploited today within random operating conditions reducing life time or increasing maintenance costs.
  - (89) Almost all those things are highly needed

- Question 10: Please rate the need for the development of these enabling technologies
  - (38) Expert systems

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- (77) Question mark: what is the correct meaning of "Sustainable model of the system of systems"?

(108) All of them are important. I have consdered those in