Technical University of Denmark

Survey and Characterization of User Profiles and User Requirements
RTLabOS D2.2

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

DTU Electrical Engineering

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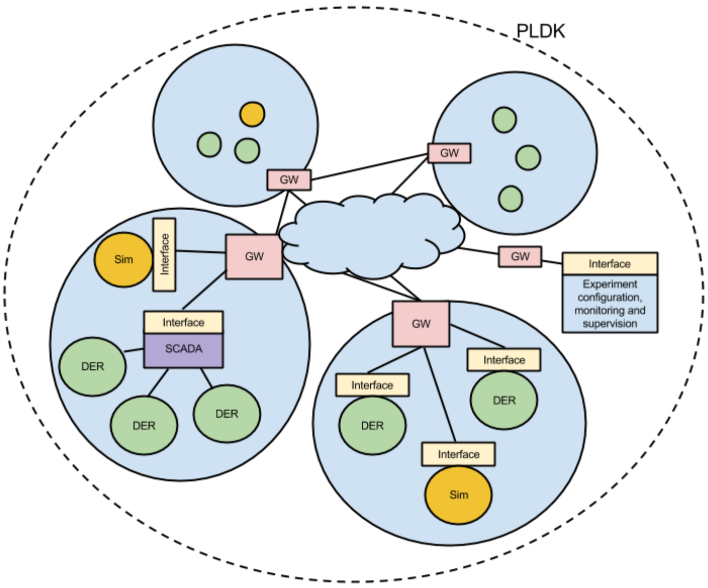

Junjie Hu and Kai Heussen

August 2014

D2.2 Survey and Characterization of User Profiles and User Requirements

Report RTLabOS-D2.1
2014

By Junjie Hu and Kai Heussen

Based on survey questionnaire by Evgenia Dmitrova and Kai Heussen

Cover illustration: Anna Magdalena Kosek

Published by: Department of Electrical Engineering,
Technical University of Denmark

Request report from: www.dtu.dk

Summary

This report presents the analysed results of the online questionnaire conducted in the Center of Electric Power and Energy (CEE), which operates PowerLabDK. The survey of around 40 questions that covered five perspectives including research focus and activities, tools, models and data, teaching, lab practice and knowledge sharing, which have been answered by 44 participants. To summarize the results of the survey, the five research groups of CEE are used to cluster the participants, leading to five generic user profiles identified in line with the research groups ELMA, ELSY, ELCO, ERES, ESOM. The user profiles are presented in chapter 2. Chapter 3 presents the results regarding simulation and computational tools, models, data, control software development, information sharing etc. related issue. In Chapter 4, the relation between teaching and labs is discussed. The lab practices are presented in Chapter 5.

Finally, Chapter 6 summarizes the results and provides suggestions for improved internal collaboration and knowledge sharing.

Content

1. Introduction

1.1 Scope

This report is part of the project 'RTLabOS: Phase 1' and presents the summary of the lab user profiles which are analyzed based on a survey conducted in November 2013.

1.2 Purpose

The purpose of this survey is to characterize several generic user profiles for PLDK lab users. Of the survey respondents most fall into the group of academic users, considering the classification provided in [1]. With the generic user profiles, the purpose is to present exemplary insights of users' needs for future use.

Besides, the information presented could be also useful for the following stakeholders and lab users:

- *Administrators*: it provides insights to the owner of the lab such as what kinds of activities[1] are most performed in the lab. Besides, problems such as causing the delay of the experiment encountered by the lab users can be provided to the administrators for further improvement.
- *Technical support*: The information collected from the survey can provide practice lab user experience to the technical supporter and therefore the technical supporter can maintain and monitor equipment in an easier but more effective way.
- *Vendors:* the information collected from the survey can provide the comments from the users regarding their using of the equipment, the software tools. For example, it is found that Matlab and PowerFactory are widely used among the respondents.

1.3 Methods

The survey is carried out internally in the Center of Electric Power and Energy with 43 respondents.

For this survey, designed by Evgenia Dmitrova and Kai Heussen, 42 questions have been formulated and categorized into 7 types which include: basics, research interests, tools, teaching, lab facilities and lab work, administrative aspects, and data and knowledge sharing. Detailed questions of the survey are included in the Appendix.

The survey results are analyzed based on different grouping methods that in general fall into two kinds of principles. The two clustering principles were *research focus* and *seniority*. For *research focus*, the five types are: Electric component engineering, Power system performance and its monitoring and control, Distributed energy resources and its system integration, Active distribution grids and its automation and Electricity market and end users. For seniority principle, three user groups are identified including the PhD student/research assistant group, the Postdoc/Assistant professor/Research (scientist)/Technician, engineer, the associate professor/senior research/Group leader/Scientific leader/TAP leader.

After identification of the user groups, the individual user group's profiles are characterized from the survey result. To characterize the user profiles, the important features of the individual user group of the lab users are discussed.

Details regarding the user groups are presented in Chapter 2. The results are presented in Chapter 3, 4, and 5. Specifically, Chapter 3 presents the results related to tool, model and data utilization. In Chapter 4,

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[1] Eight activities have been identified in the report [1].

profiles related to teaching activity are made. Chapter 5 presents the experience of lab practices. Finally, discussion and conclusions are given in Chapter 6.

2. Characteristic user groups

2.1 By research focus

For the group of users with different research focus, we aim to present and compare the results when different characterizing methods are applied to each group. Most important, we firstly present the research activities that each group is working with that is illustrated in Fig. 1. Furthermore, other features[2] such as the tools, models and data, lab experience will also be summarized for the user groups.

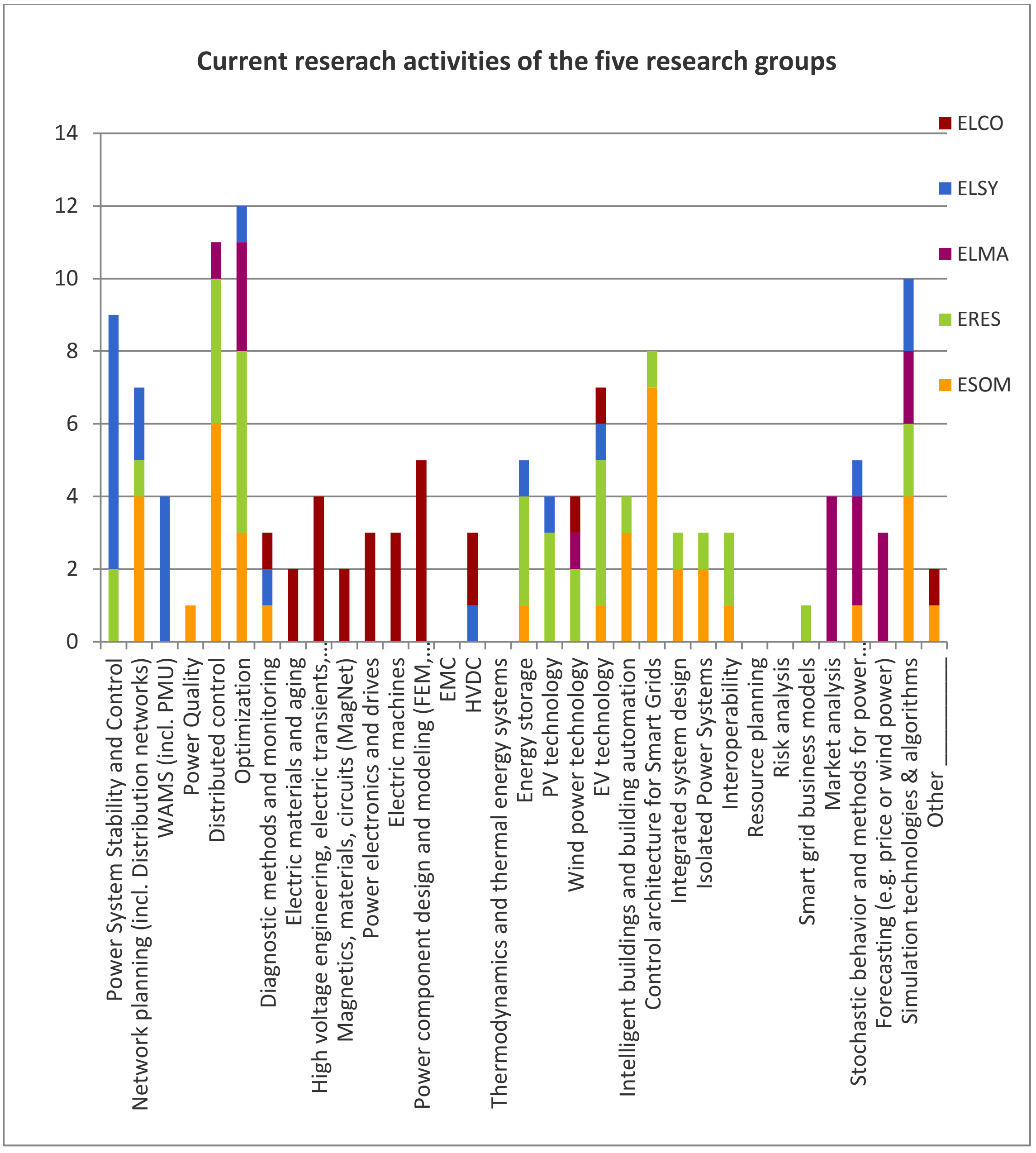


Figure 1: Current research activities of the five research groups

[2] The details of these features will be presented in Chapter 3, 4, and 5 separately.

Table 1: Overview of the respondent of the survey

Group by research focus	Number of respondents	Group size	Note
ELCO	7	11	Electric component engineering
ELSY	7	17	Power system performance, monitoring and control
ERES	7	11	Distributed energy resources and their system integration
ESOM	10	14	Active distribution grids and their automation
ELMA	4	10	Electricity markets (now: Energy analytics)

2.1.1 ELCO User profile

It is seen from Fig.1 that the main research activities of this group include: power component design and modeling, high voltage engineering, electric transient, lightning protection, power electronics and devices, electric machines, HVDC.

Associated with the research activities, the most common types of models used are electrical systems, electrical components, and thermal models.

The most common software tools used in this group include Matlab, Powerfactory, PSCAD, COMSOL Mulitphysics, Labview.

2.1.2 ELSY User profile

The main research activities of this group include: Power system stability and control, WAMS (incl. PMU), HVDC, energy storage, simulation technologies and algorithms, network planning, optimization and PV technology.

Associated with the research activities, the most common types of models used comprise electrical systems and electrical components.

2.1.3 ELMA User profile

The main research activities of this group include: market analysis, stochastic behavior and methods for power systems, forecasting (e.g., price or wind power), and optimization.

Associated with the research activities, the most common types of models used are economical, meteorological and statistical models.

2.1.4 ERES User profile

The main research activities of this group include: Optimization, EV technology, distributed control, energy storage, PV technology, interoperability.

Associated with the research activities, the most common types of models used consist of electric systems, electric components, and (Electro-)chemical.

2.1.5 ESOM User profile

The main research activities of this group include: Control architecture for smart grids, distributed control, simulation technologies and algorithm, intelligent building and building automations, optimization, integrated system design.
Associated with the research activities, the most common types of models used are electrical systems, electrical components, thermal, and statistical.

Analyzing the research activities of the five research groups, some research activities such optimization, simulation technologies and algorithms, EV technologies are touched by nearly every group, but the pronounced research activities of each group are also very clear. For example, ELCO has strong interests on the activities of power component design and modelling, high voltage engineering, electric transients, lighting protection, electric machine, ELSY has much focus on power system stability and control, ELMA research a lot on market analysis and forecasting, ERES has strong interests on EV technology, ESOM works intensively on distributed control, control architecture for smart grids, and simulation technology.

2.2 By seniority

Three user groups are identified according to seniority. They are labeled as *junior users* including the PhD student and research assistant, *experienced user* including PostDoc, Assistant professor, Research (scientist) and Technician, engineer, and *senior user* including associate professor, senior research, group leader, scientific leader and TAP leader. Table 2 overviews the respondent of the survey.

Table 2: Overview of the respondent of the survey

	Number of respondents	Group Members
Junior user	16	PhD student, Research assistant.
Experienced user	15	PostDoc, Assistant prof., Researcher, Technician and Engineer.
Senior user	10	Associate Professor, Professor, Senior Researcher, Group Leader, TAP leader.

In this section, we aim to understand and present the three groups' user profile. The profile includes the average number of project they have involved, the teaching activities they have undertaken as well as other features.

Table 3: Average number of projects by seniority

Groups	Average project number	Note
Junior users	1.2	PhD student:18 Research assistant:1
Experienced user	2.4	PostDoc:22 Assistant prof.:5 Researcher:7 Technician and Engineer:4
Senior user	4.4	Prof: 10 Asso. Prof: 28 Senior scientist: 6 *not included in calculation:* Group leader: 20 & TAP leader: 1

Table 4: Teaching activity by counting their participation in various course

Groups	Average number of course involvements per user	Note
Junior users	0.75	One third of PhD students not involved in teaching
Experienced user	0.6	Half of the post-docs & researchers do not participate in course teaching
Senior user	1.4	Majority: associate professor

Table 5: Time spent in lab

Groups	Up to % of work time spent in lab	Note
Junior users	13%	
Experienced user	22%	Half of post-docs spend up to half the time, the other half doesn't go to the lab.
Senior user	10%	Professor: 0%

2.2.1 Junior users

The people of this group generally only focus on 1 project and less than half of them undertake teaching activity. Half of the Phd students spend up to 25% of their time in the lab.

2.2.2 Experienced users

The experienced users in average work on more than two projects. More than half of them take teaching activity. About half spend a significant amount of time in the lab.

2.2.3 Senior users

The senior users in average work on more than four projects. Most of them have teaching activity and most (Senior scientists, associate professors) spend at least a small amount of time in the lab.

3. Tools, models, and data

3.1 Simulation & computation tools

In this section, we firstly present the types of software tools that are used to investigate various models such as electrical system model, electrical component model and thermal models. Then, we compare the common software tools which are used in five research groups. Furthermore, the coupling tools used in the research are also listed in this section.

Type of software used in five research groups (Q10)

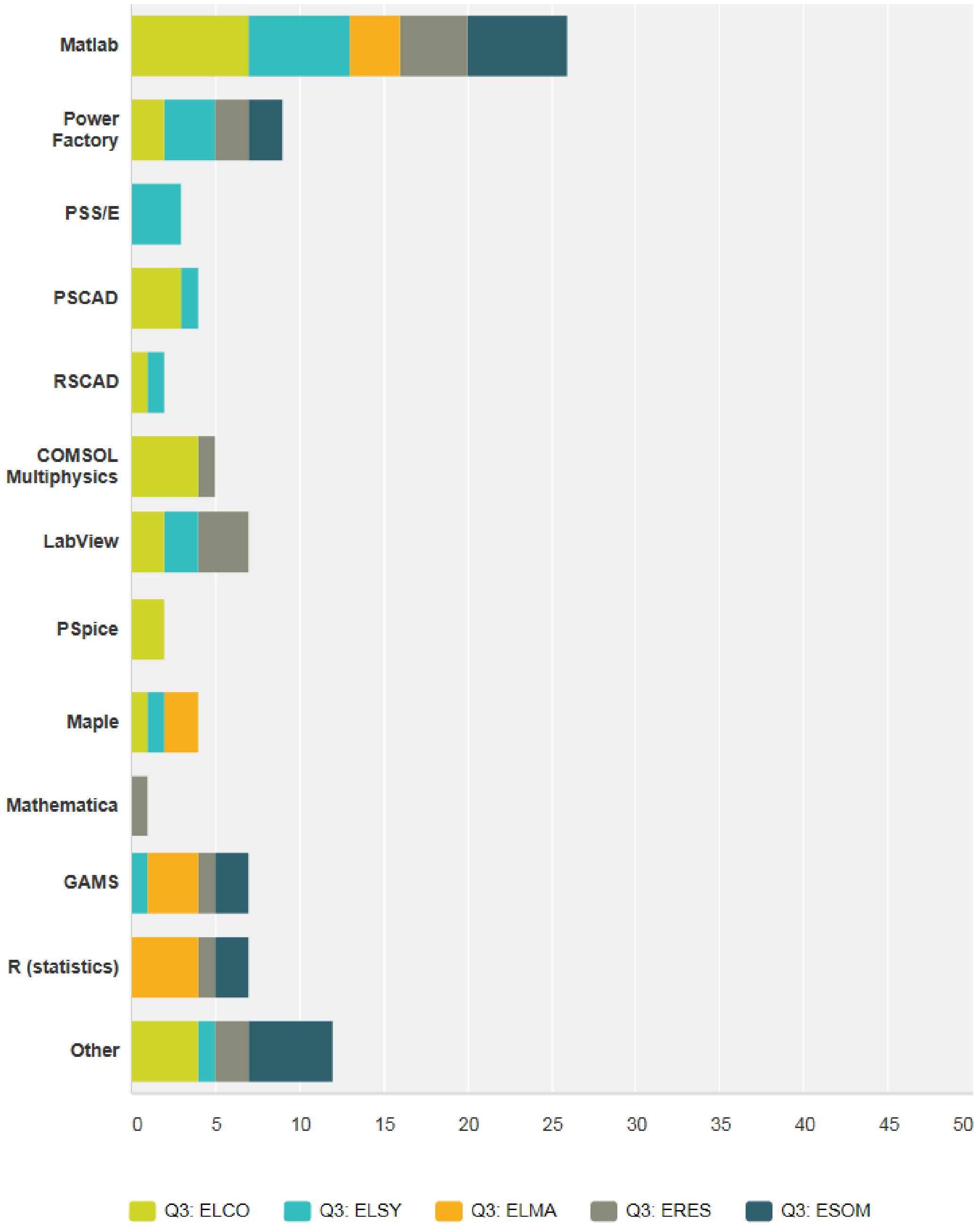


Figure 2: Type of software tools used in five research groups

Figure 3 illustrates that Matlab and PowerFactory are commonly used in these five research groups. Besides, specifically, in ELCO group, COMSOL Multiphysics and PSpice are used; in ELSY group, PSS/E is an important tool; in ELMA group, GAMS and R (statistics) are common used tools; in ERES, Labview is used; in ESOM group, besides the one indicated in the figure, IPSYS, OpenDSS are used.

Coupling of tools & life data exchange (Q14)

Tools coupling	Note
Matlab<-> JACK	JACK is used for multi-agent study
NEPLAN<->Matlab<->PowerFactory	
Matlab<>Gams	

It is found that matlab and gams are combined quite often for advanced computing. Similarly, NEPLAN, Matlab, PowerFactory are also combined for power system simulations. Besides, the multiagent based technology is also getting popular such as JACK and matlab are combined for doing agent based study.

In conclusion, the most popular tool is Matlab which has been used for different research purpose in five research groups. Besides, some tools such as NEPLAN, Gridlab-D, IPSYS and OpenDSS are also significantly recognized and used by people from ESOM group. This is because this group focuses on distribution system automation and its DER integration, the conventional tool such as Matpower, PSS/E are not flexible enough to accommodate the simulation requirements of this group.

3.2 Models, origin, access & sharing

In this section, we aim to present the standard models that exist in each modelling area. Mainly, it is found that in electrical power system modelling field, some standard models exist and the standard models are different for each research group. Then, the origin of the models is studied. Furthermore, we also present the models that are exchanged between the tools.

Type of models that are investigated in the groups

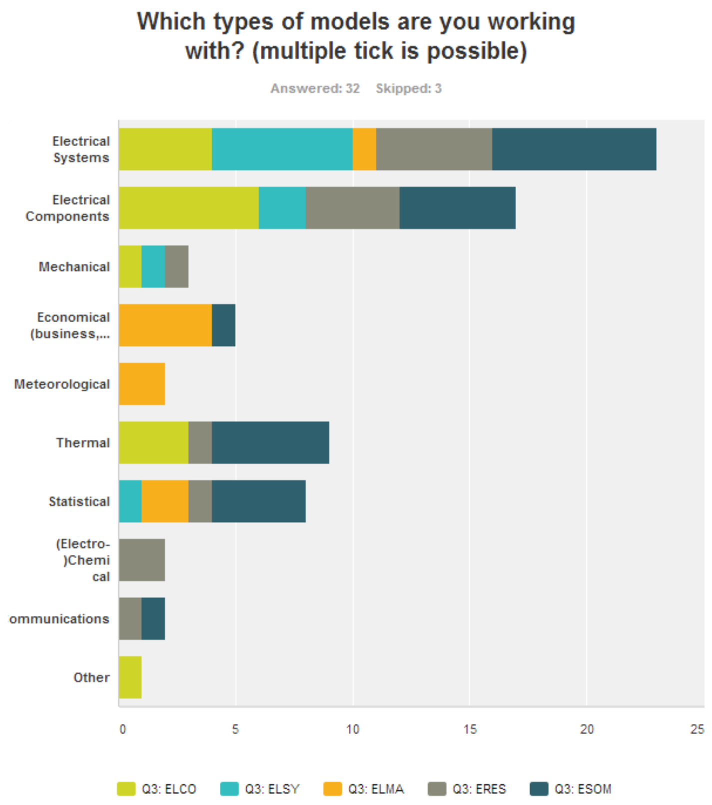


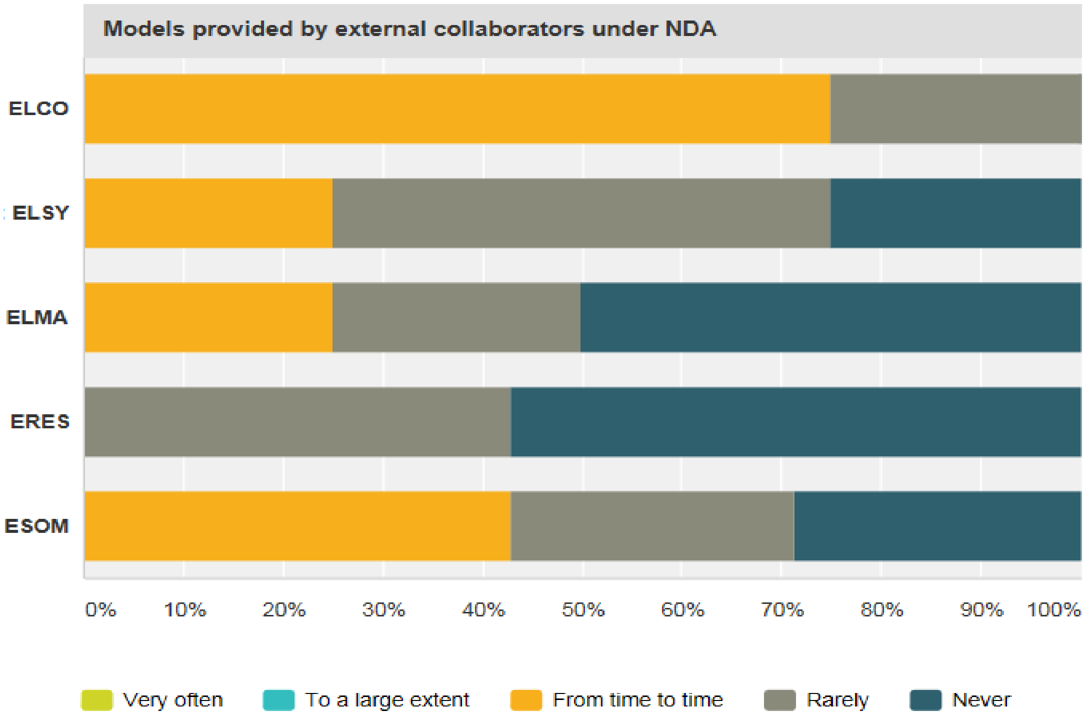
Figure 3: Models investigated in five research groups

Seen from the above figure, it is quite obvious that electrical power systems and electrical components are the mostly studied models.

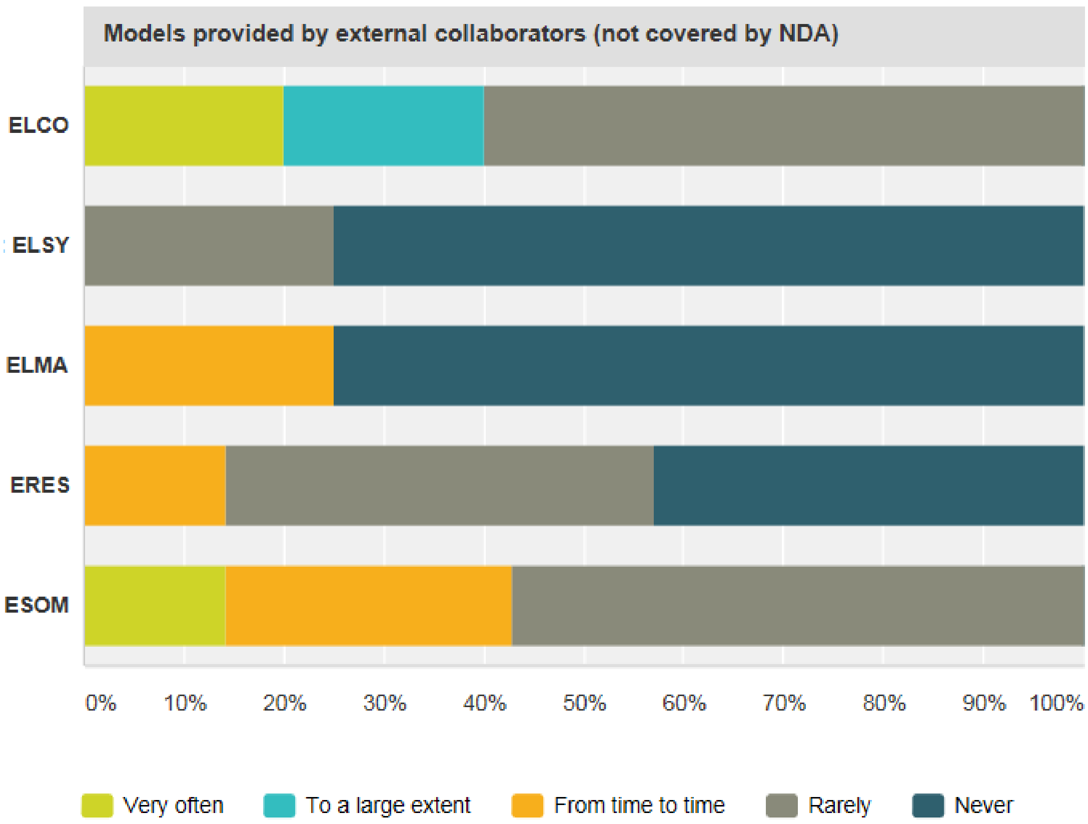
Standard Models (Q12)

	Standard Models
ELSY	• IEEE-14 bus, Nordic32 (future IEEE standard) • Matpower power flow cases • New England & New York IEEE 68 bus Western Electricity Coordinating Council • WECC 9 bus
ELMA	• IEEE RTS power systems
ERES	• CIGRE' networks as reference LV/MV networks • Governor and AVR IEEE standard models • IEEE standard system selected real radials with full details available • F# type providers, e.g. R type provider allowing F# to interface with R or CSV data interface, Phom homology package for R, Javaplex homology library written in Java, Linear algebra libraries for F# and C++
ESOM	• PNNL Taxonomy MV, LV feeders (Describe North American systems well, Europe not so much)

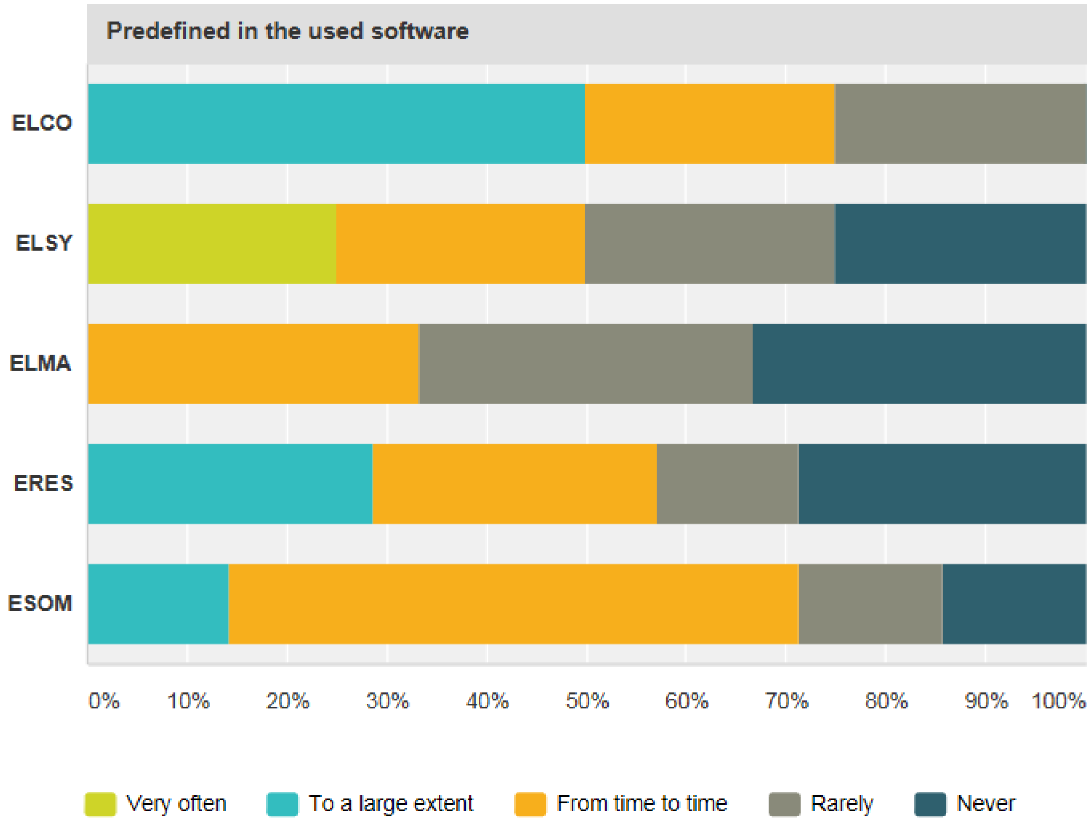
Models sources and data protection (IP) (Q11)



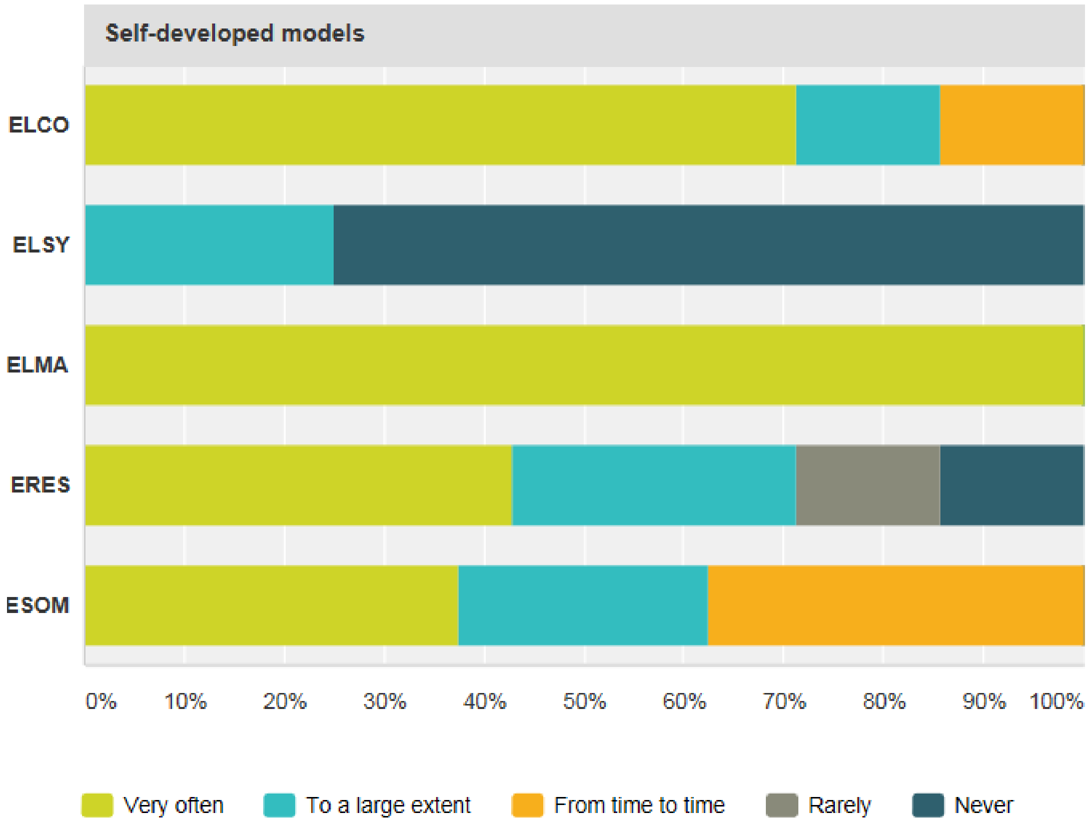
(a) Models provided by external collaborators under NDA



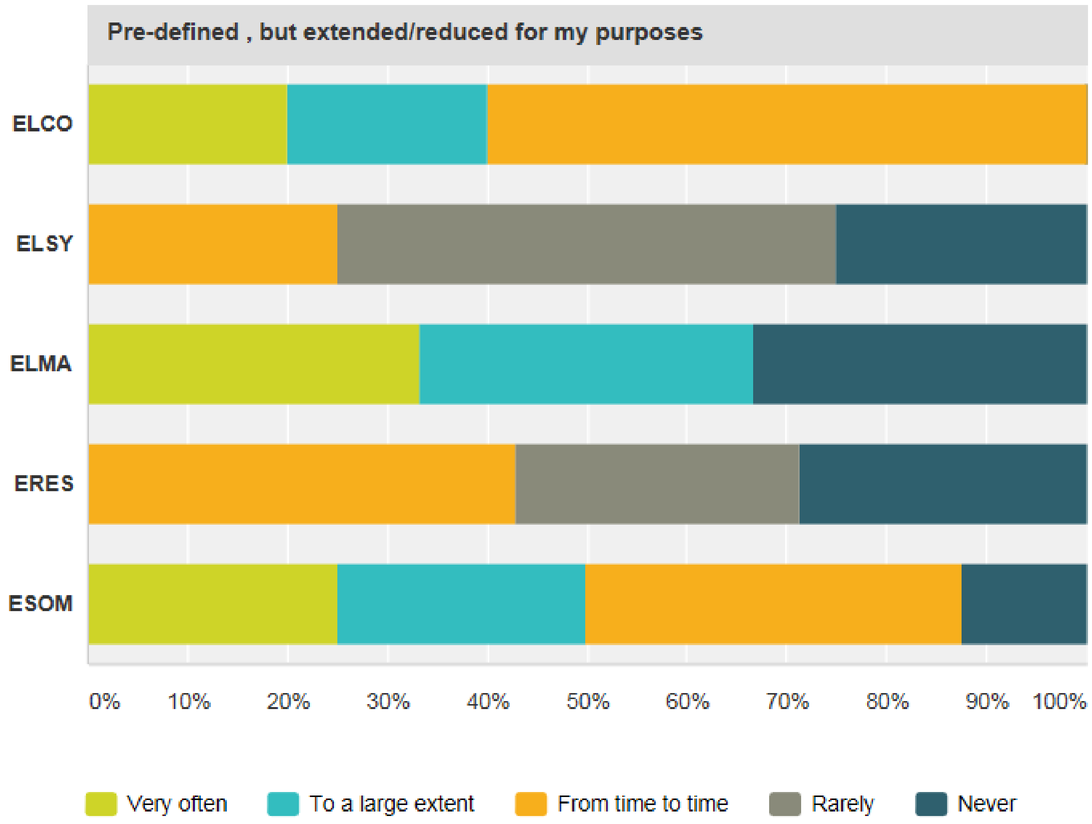
(b) Models provided by external collaborators not covered under NDA



(c) Predefined in the used software



(d) Self-developed models



(e) Predefined, but extended/reduced for my purposes

Figure 4: (a-e), model sources

Figure 4, (a-e) indicate that researchers prefer to use self-developed model instead of models provided by external collaborators.

Model Exchange between tools (Q14)

Table 6: Experiences regarding model exchange

Model exchange between tools	Note
Visio <-> Jess <-> MFM ModelBuilder	Used for intelligent system reasoning
Neplan <-> Matlab/MatPower <-> PowerFactory	Power system simulation
Matlab <-> PowerFactory	Power system simulation
PSS/E<->RSCAD	Own format: very time consuming.
PowerFactory <-> PSS/E	
PSS/E<->RSCAD:	Feasible but difficult to get it completely right.

Table 5 presents the models those are exchanged between the tools as well as the experience.

3.3 Data origin, storage and exchange

In this section, we aim to answer the following questions, which type of data is used by the researcher in each research group. Besides, we want to figure out what kind of tools is used in the Lab to store the experimental data. Afterwards, the data base system and the way of exchanging the data are also presented.

Type of data and data sources (Q13)

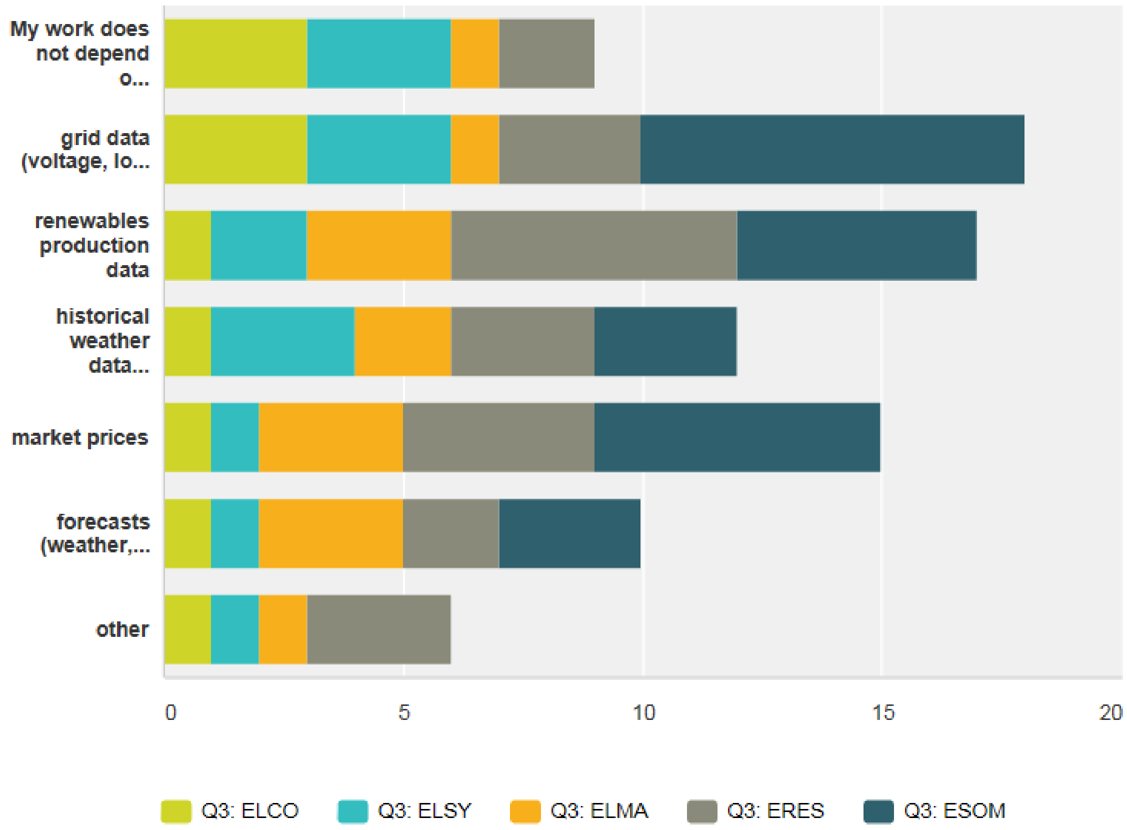


Figure 5: Type of data & data sources

It is seen from figure 5 that grid data (voltage, load, frequency, etc.), renewable production data, historical weather data (e.g. wind, solar irradiation, etc.), market price, and forecasts (weather, prices, etc.) are equally used in five research groups. Besides, user behaviours such as driving patterns, EV and charging spot data are also required.

Form of storing the data obtained during the experiments in the Lab (Q30)

Table 7: Forms of storing the data obtained during the experiments in the lab

	N/A	Paper notes	Files on my PC	University "O" drive	Using information sharing platforms, e.g. dropbox, etc.	CEE shared databases (ELSPEC, SCADA, repositories)	Public shared databases (e.g. winddata, PV data stores)	Other	Total
ELCO	0.00% 0	57.14% 4	85.71% 6	42.86% 3	28.57% 2	0.00% 0	0.00% 0	0.00% 0	15
ELSY	75.00% 3	25.00% 1	25.00% 1	25.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	6
ERES	14.29% 1	0.00% 0	85.71% 6	28.57% 2	42.86% 3	0.00% 0	14.29% 1	14.29% 1	14
ESOM	14.29% 1	0.00% 0	71.43% 5	28.57% 2	28.57% 2	28.57% 2	14.29% 1	14.29% 1	14

From the table, it is observed that paper notes play important role in ELCO group. While for other forms such as files on my PC, University "O" drive are nearly used by each group. Specifically, SYSLAB databases and SYSLAB SCADA are used in ESOM group.

Size of the data sets and the central storage/data bases (Q16)

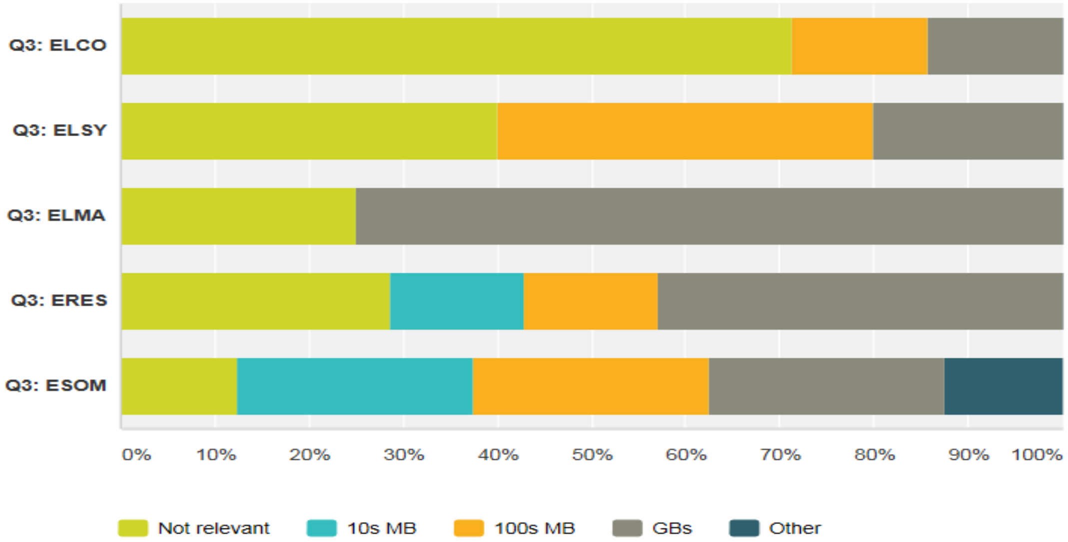
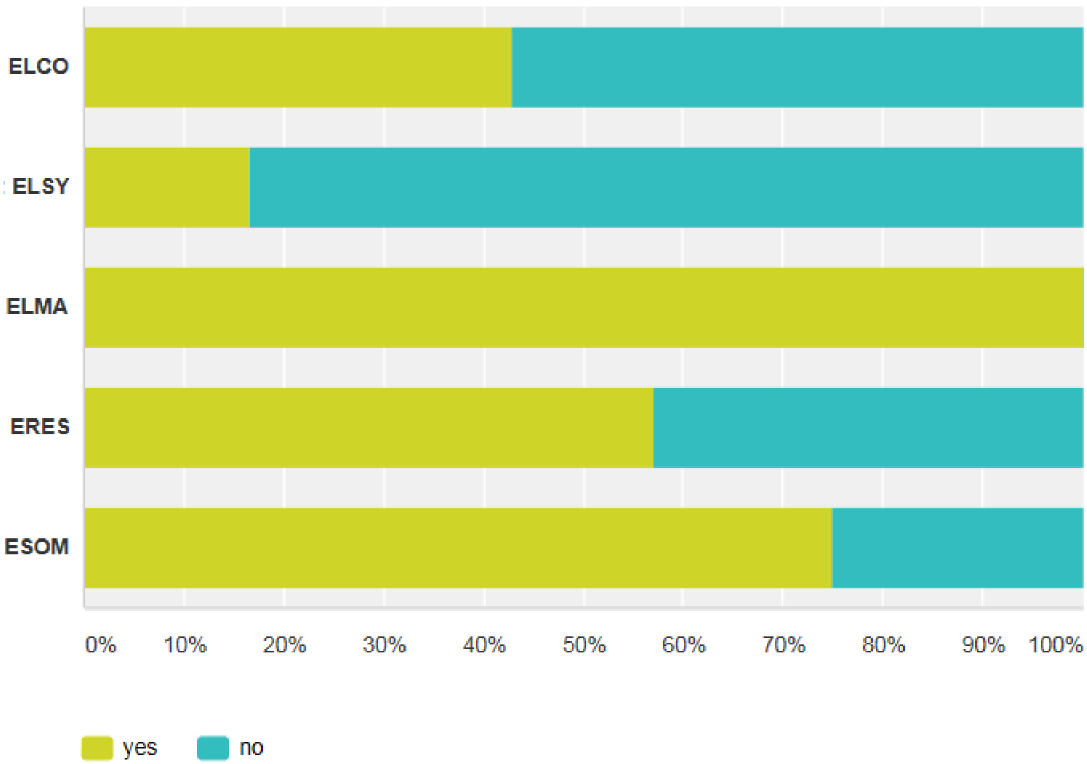


Figure 6: Size range of large data sets

Regarding the size of the data used in each group, it is seen that ELCO people does not use much data, e.g., comparing to ELMA people. In ESOM group, different sizes of the data are used. The methods used for data bases are presented in Table 7.

Use data bases in research? (Q15)



It is clearly indicated that ELMA, ERES and ESOM people prefer to use database comparing to ELCO and ELSY people. Table 7 lists the data base method.

Table 8: Data bases methods

Research groups	Data bases
ELCO	Department Drive; Sharepoint; M drive
ELSY	Git (hosted at gbar for version control within project); git (hosted at bitbucket for version control of personal projects); dropbox (for collaborative editing of sospo website); google drive (for personal use); Folder with restricted access on O-drive (for exchange of large files within project); Campusnet (for exchange of project deliverables); Mysql DB (hold system information of simulated models)
ELMA	CSV files; dropbox for backup; DMI EcoGrid Shared Services NordPool FTP; Energinet FTP; Enfor FTP PowerLab.dk Scada; Data in files: netcdf, csv, or mat files
ERES	SQLite (mostly for prototyping); PostgreSQL MSSQL (from time to time), Windows SQL Server 2008; dropbox
ESOM	SYSLAB database; cvs files; DFR database (interfaces through website); ELSPEC SCADA DFR-project; dropbox; SYSLAB and Flexhouse databases (Postgres and flat file); energinet.dk's ftp: operation data on 5min basis; Enfor's ftp: forecast data energinet.dk 's online access for power market data.

<u>Transfer between tools (Time series & other data sets)</u>

Table 9: Data exchange

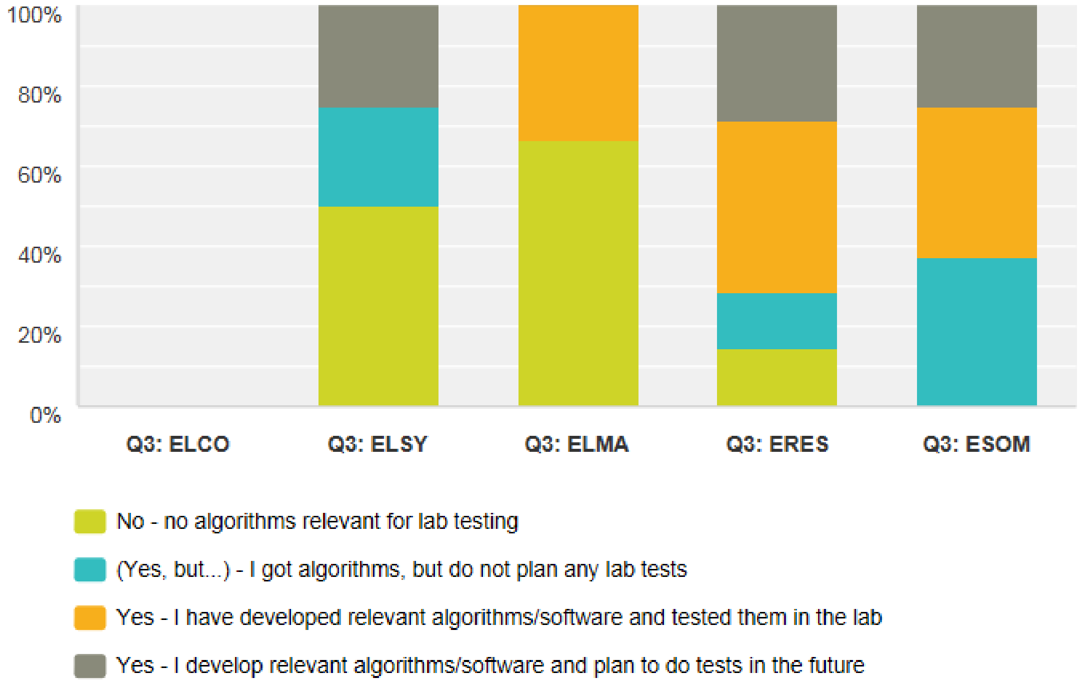
Data exchange	Note
csv<->matlab<->excel <->access csv<->matlab csv <-> excel <-> Relational DB SAS<->Excel<->Matlab Matlab<-> Excel<-> R Models	Using CSV files are not too time consuming, neither do I believe that JSON (JavaScript Object Notation) would be.
Matlab <-> ipsys Matlab<->Origin Matlab<->Comsol Matlab<->R	
daily/hourly data (.txt) <->data with longer Horizon (.mat)	
PowerFactory<->excel PSS/E <-> MATLAB PSCAD/RSCAD <-> matlab/maple/excel RAMSES <-> MATLAB	Export the data from the power system simulation tool to matlab or excel for further visualization

Table 8 shows different ways of exchanging the data within the research groups, it is seen matlab is used quite often, e.g., for different purpose such as calculating and visualization. Besides, CSV is mentioned many times for its fast processing time.

3.4 Control software development & deployment

In this section, we present the results related to control software and algorithms development in each group. Furthermore, we aim to understand whether the agent based control technology is investigated by researcher of these five groups.

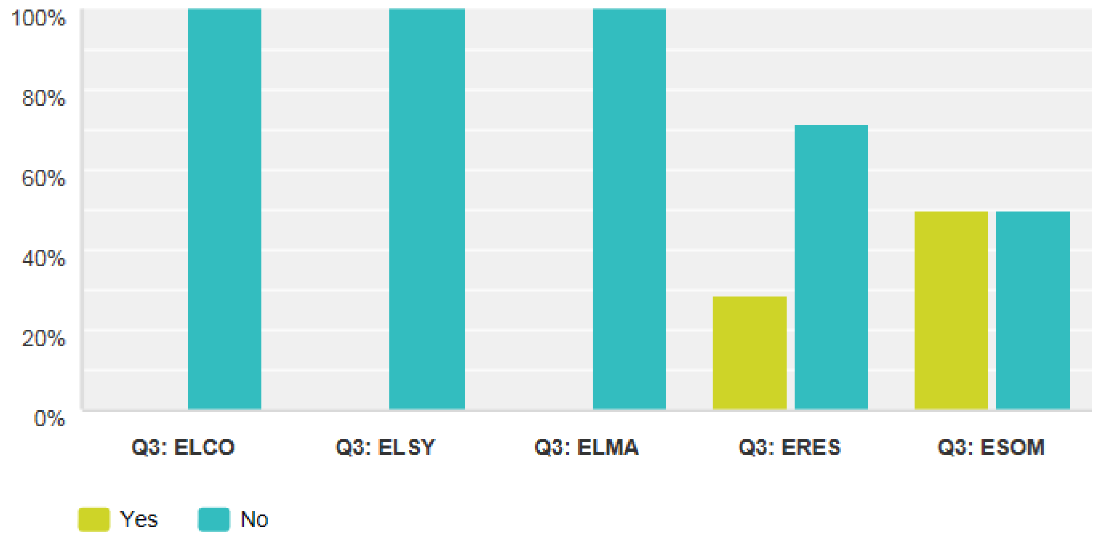
Develop control software and algorithms (Q19)



It is seen from the above figure that people from ERES and ESOM group mainly develop relevant algorithms/software and test them in the lab. Specifically, in ERES group, IEC61850 (/RestFul) plus various "homemade" protocols are used to test the charging control for electric vehicles, syslab/java is combined to develop and test the control algorithm.

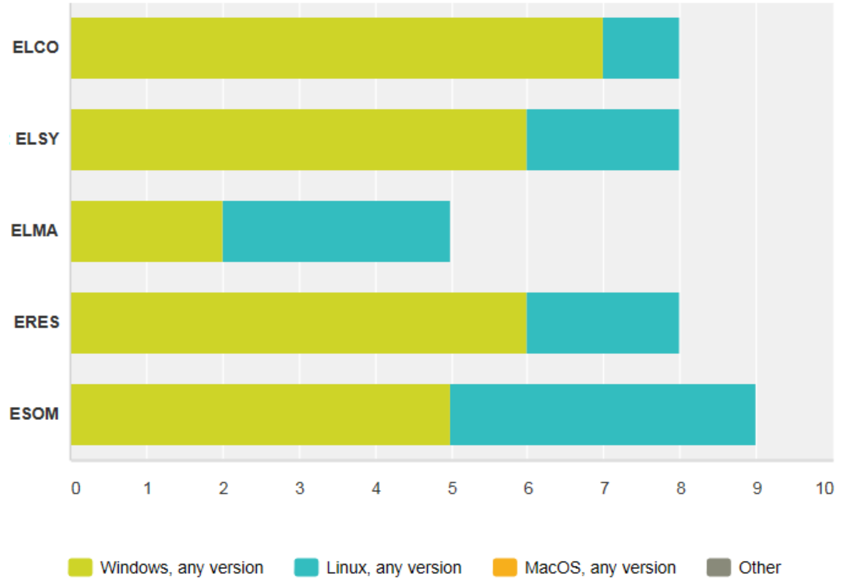
In ESOM group, SYSLAB/Java is combined to develop and test the control algorithm. Electric Lab is the normal place where the ESOM researcher carries on their lab activitiy. In term of control object, all available DERs could be of interest. ARM and ATMEL are also interested by the people from this group.

Agent-based control algorithms (Q20)



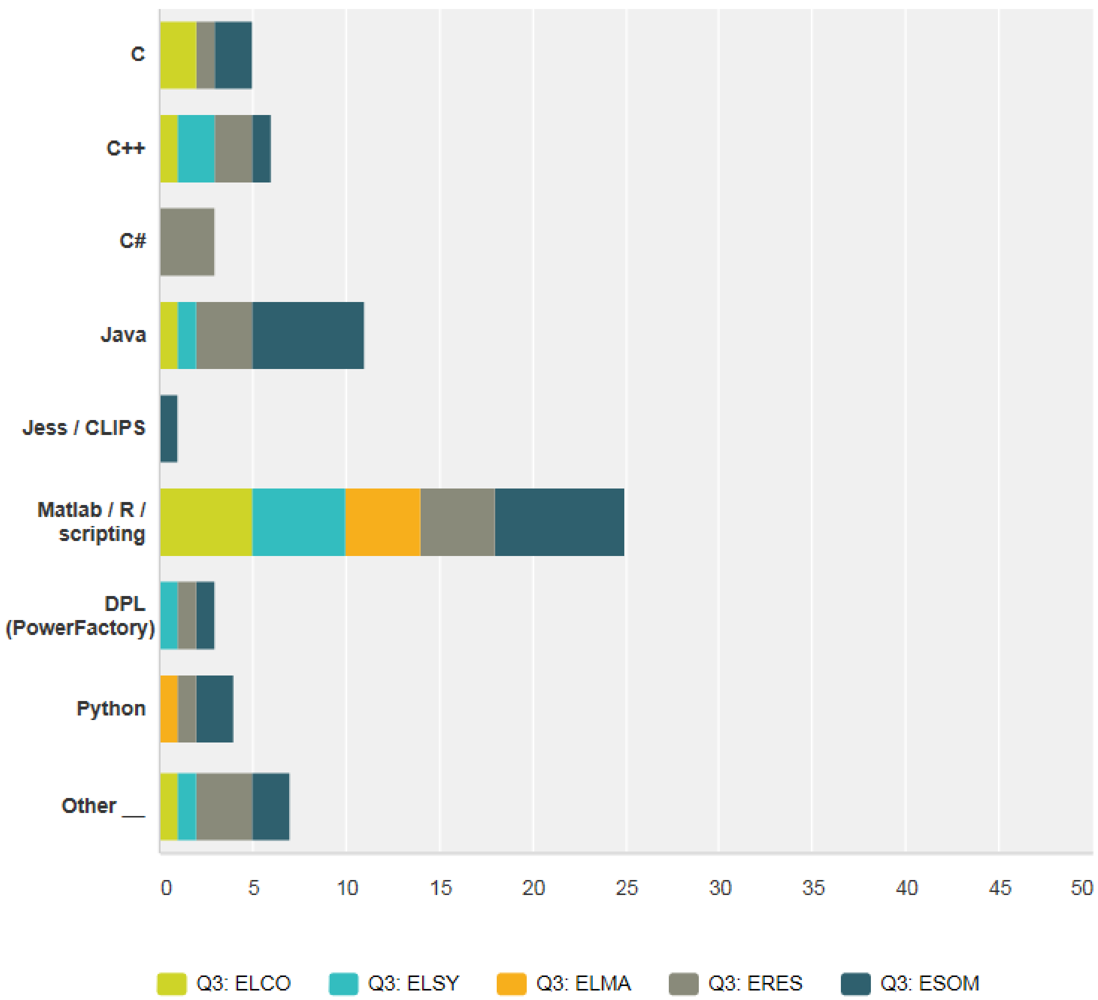
From the figure, one can see that ERES and ESOM people have interests in the agent based technology. Among those people who use agent based technology, JACK, Jade and JCSP are often used software.

Operating system (Q17)



Regarding the use of the operating system, it is seen that Windows and Linux are used in every group. Mostly, people use windows operation system.

Programming languages used in research (Q18)

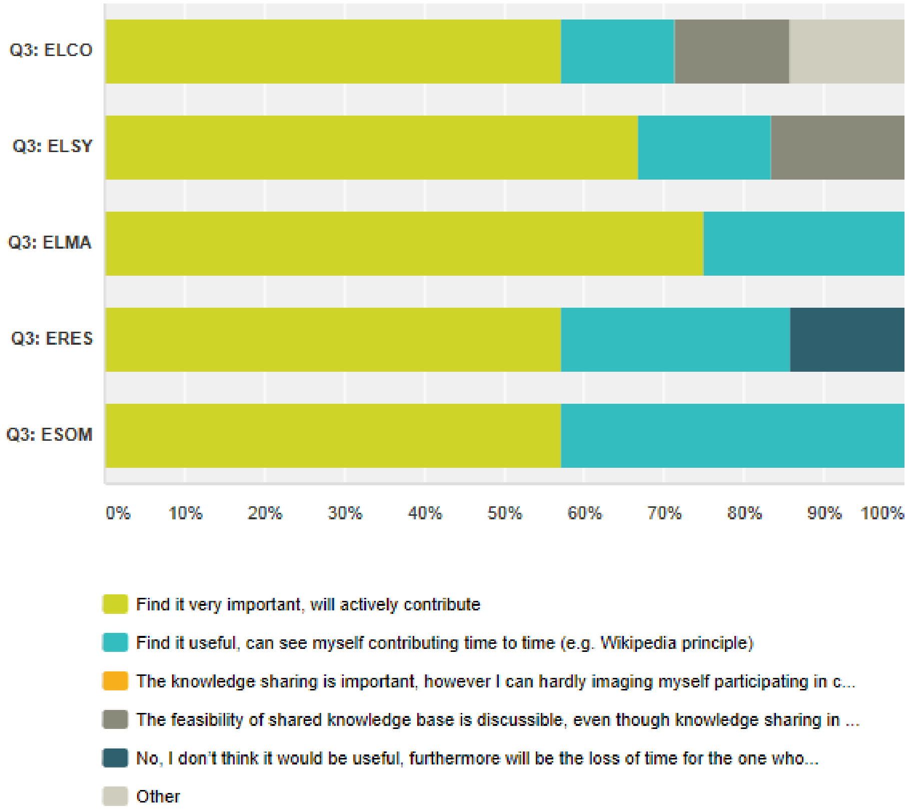


It is seen from the figure that Matlab/R/scripting is the most used programming language among those groups.

Other languages include: Javascript for web based visualization, LabView, F#, Bash, Sed, Grep, Octave, Assembly, GAMS, SAS.

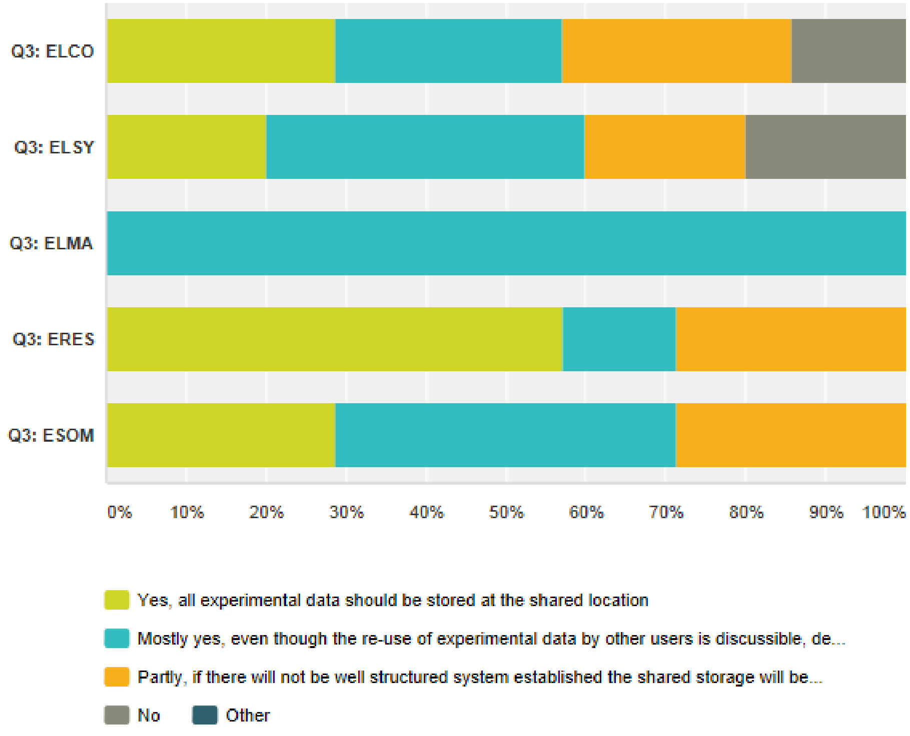
3.5 Knowledge sharing opinion and the methods to share information

How important is knowledge sharing on your opinion? (Q36)



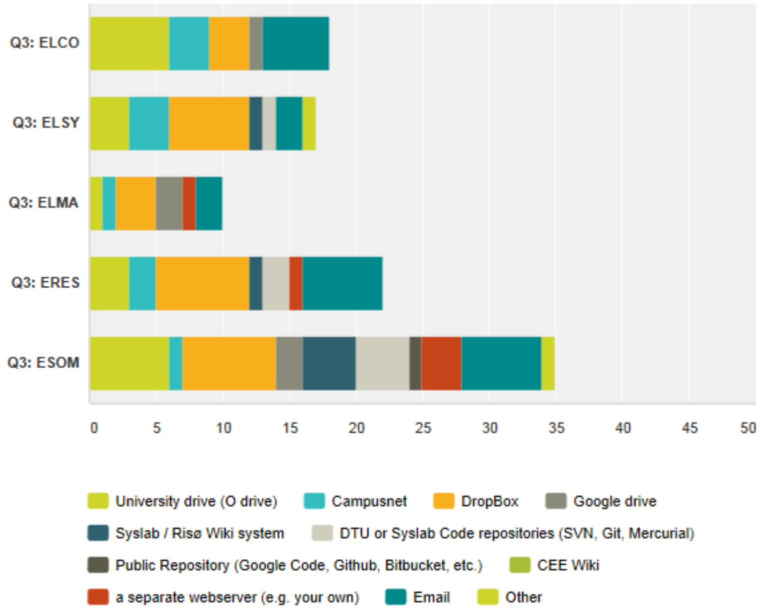
Nearly everyone agree that it is very important to share knowledge and they will actively contribute to promote cooperation.

<u>Whether it is useful to have experimental data shared at the common access location (Q37)</u>



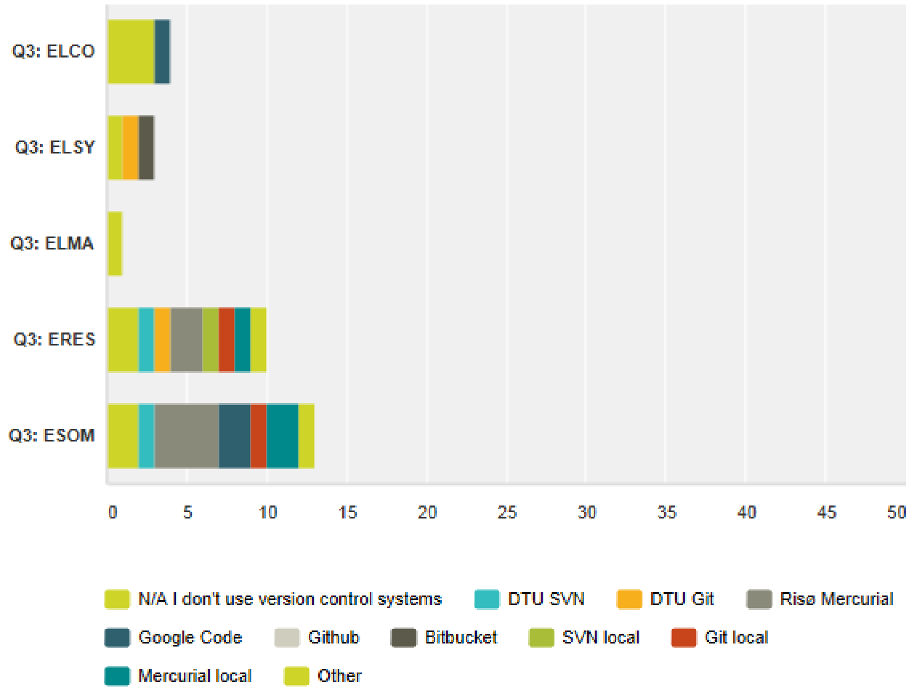
People in general tend to agree that it is useful to have experimental data shared at the common access location.

Tools used for sharing information with colleagues (Q41)



The most common one used for sharing information with colleagues include: University drive (O drive), dropbox, and email.

Platforms for code sharing and version control (Q42)



Version control is used quite often for the people coming from ERES and ESOM. The above figure presents the common tools for sharing and version control.

4. Teaching

Teaching is undertaking certain tasks or activities and the intention is to induce learning. Such activities includes courses teaching, student project supervision (Special, BSc, MSc). In this chapter, survey results regarding courses that using labs and type of teaching activity in Lab are presented.

In which courses are we using labs and what kind/which of lab facilities are required by the course? (Q22)

Course	**Lab**
31770 High voltage engineering	High voltage lab 329, databar
31774 (?)	Student lab in 329. Students are performing lab work on DC-IM machine setup taking measurements and reporting the results.
31773 Transients in power systems	Student lab
31036 Electrical energy system	Hsplab LabVIEW + National Instruments hardware (Windows + Mac)
31786 Wind turbines electrical design	Aircon generator
31003 Electric Circuits	Student lab
46400 Wind Turbine Measurement Techniques	LabVIEW + National Instruments hardware + hardware developed at Risø (Windows)
31380 Intelligent Systems	robots 31380 electric lab (sometimes / remote) project syslab
30170 (?)	databar only

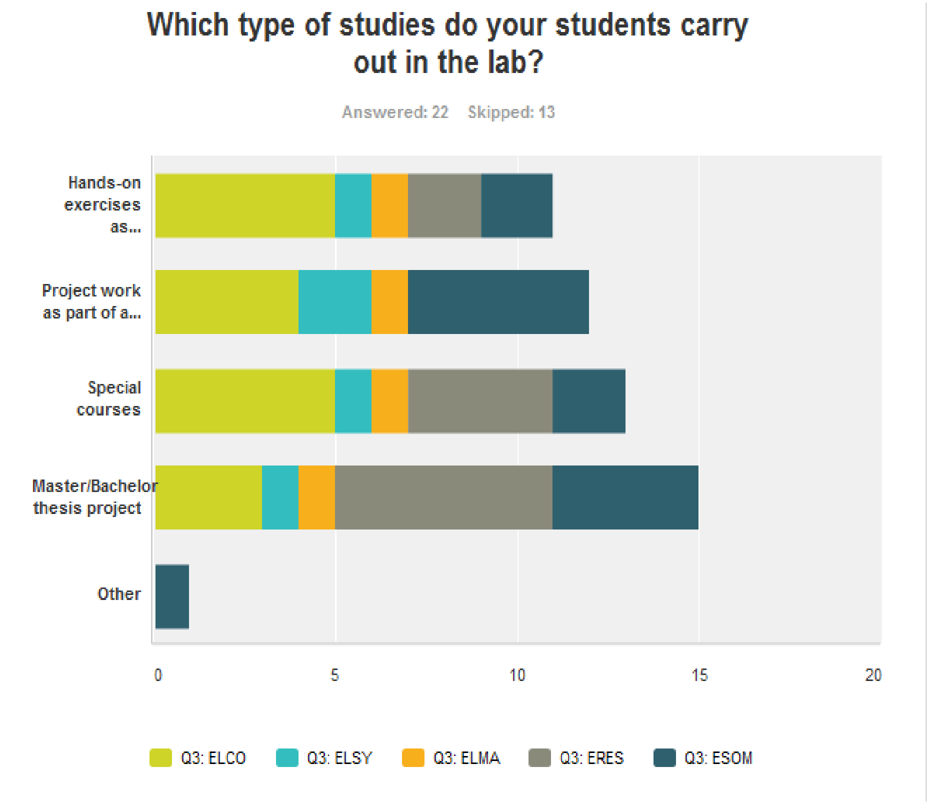
It is concluded that Lab exercises are part 50% of courses (9 of 20 courses in total). Besides, we also notice that teaching activities in the lab are quite asymmetrical across groups:

- ELMA & ELSY don't use labs for course teaching.
- ELCO and ESOM use labs to a large extend.

Type of teaching activity in lab (Q23)

Seen from the following figure, it is observed that types of studies are varying in groups:

- ELCO is more rather equal on all types.
- ERES and ESOM project-type and activities dominate.


Which type of studies do your students carry out in the lab?
Answered: 22 Skipped: 13
Hands-on exercises as...
Project work as part of a...
Special courses
Master/Bachelor thesis project
Other
0
5
10
15
20
Q3: ELCO
Q3: ELSY
Q3: ELMA
Q3: ERES
Q3: ESOM

5. Lab practice

In this chapter, we present the lab practice of various group users. These lab practices include maturity of lab experience, time associated with lab works, factors that cause the delay of the lab work and awareness of labs and relevant information.

Lab users and their experience (Q26)

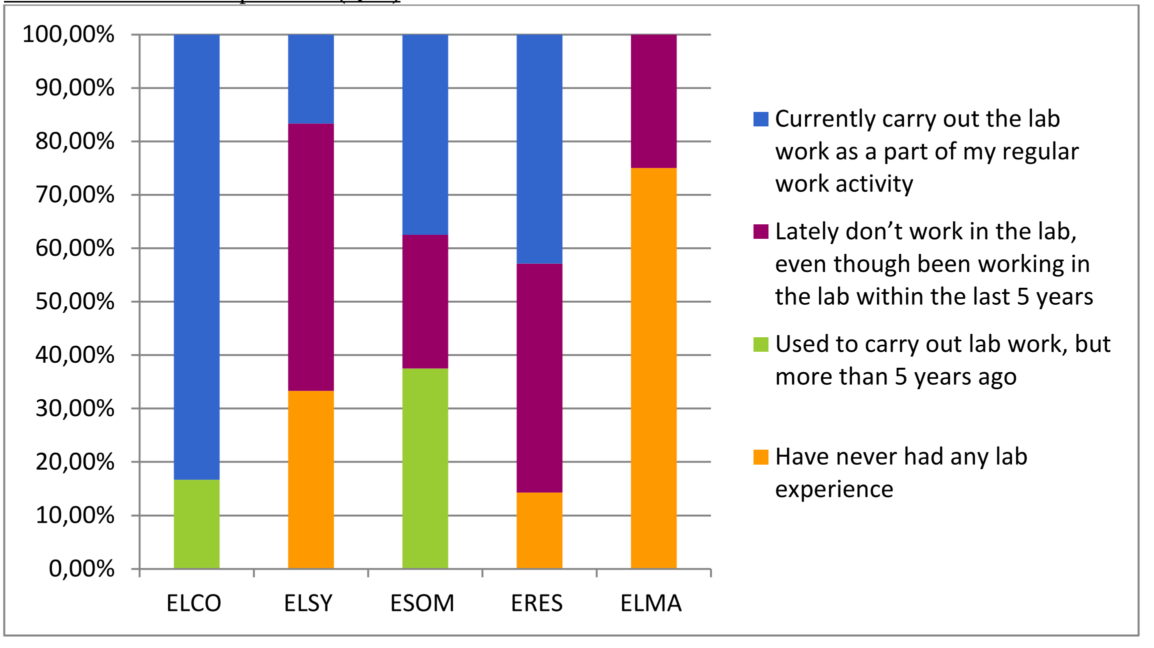
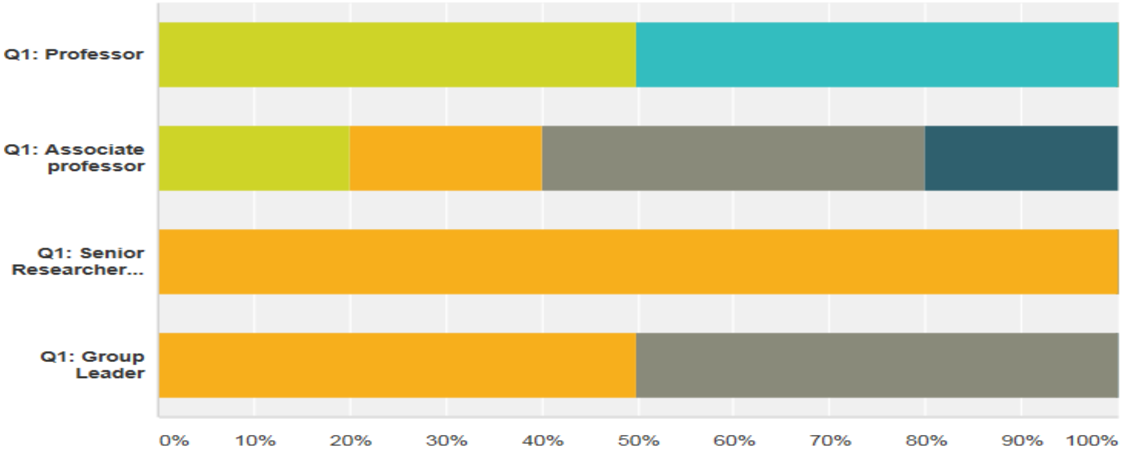


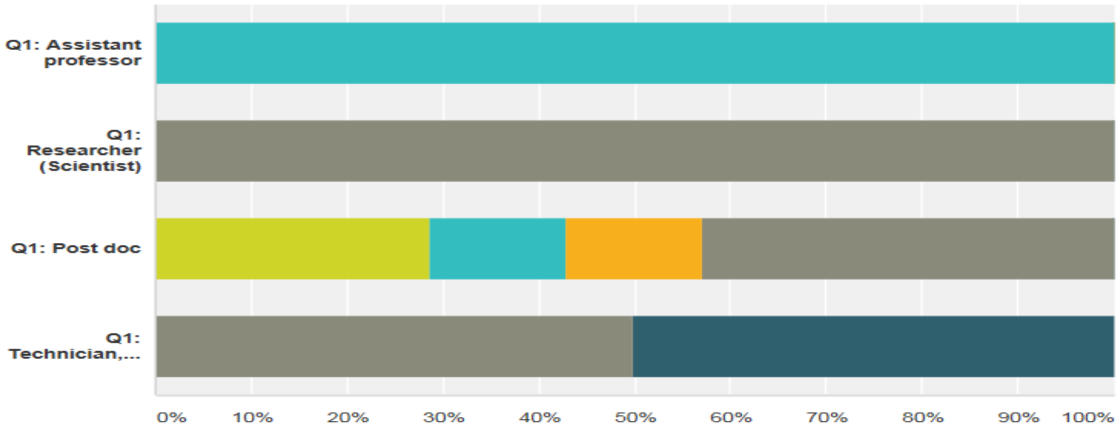
Figure 7: Maturity of lab work experience by research groups

It is seen from the figure that ELMA people basically does not have any lab work. In a contrary, ELCO people carries out a lot of lab activity. For ESOM and ERES group, they share similar pattern in term of the option ‘currently carry out the lab work as a part of my regular work activity’. For ELSY people, more than half of them have lab experience while few people are currently taking lab work as regular activity.

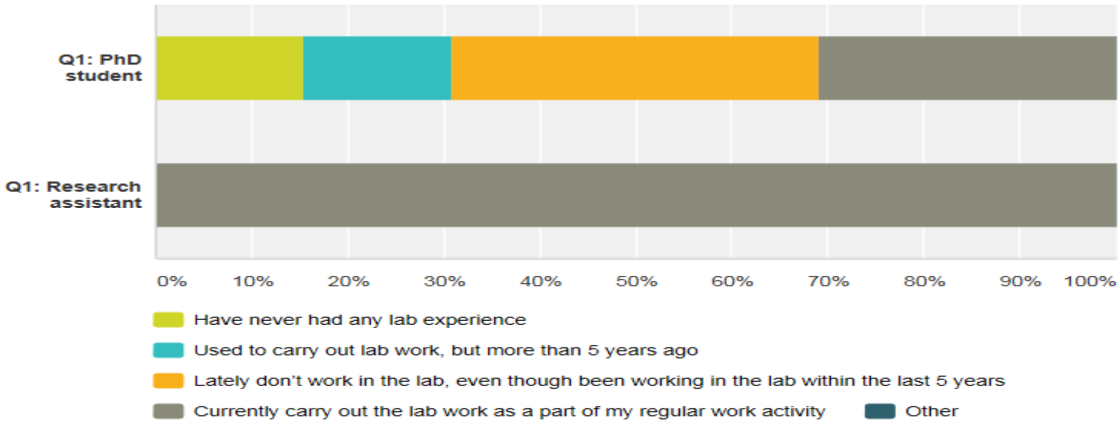
In addition to this, we also present the maturity of lab work experience of three user groups, i.e., senior user, experienced user and junior user.



(a) Senior users



(b) Experienced users



(c) Junior users

Figure 8: Maturity of lab work experience of three types of users.

Figure 9 presents each group's maturity of lab work.

<u>Time associated with lab work (Q27)</u>

By research groups:

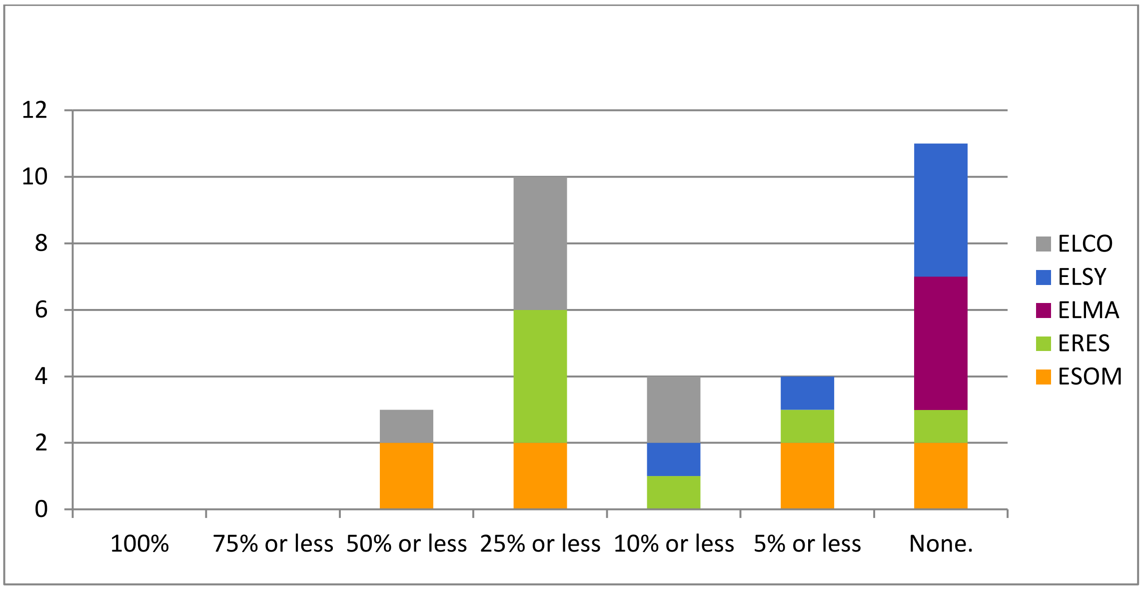


Figure 9: Time associated with lab work

Figure 8 illustrates that ESOM, ELCO and ERES spend more time in the lab than other two groups.
By seniority:

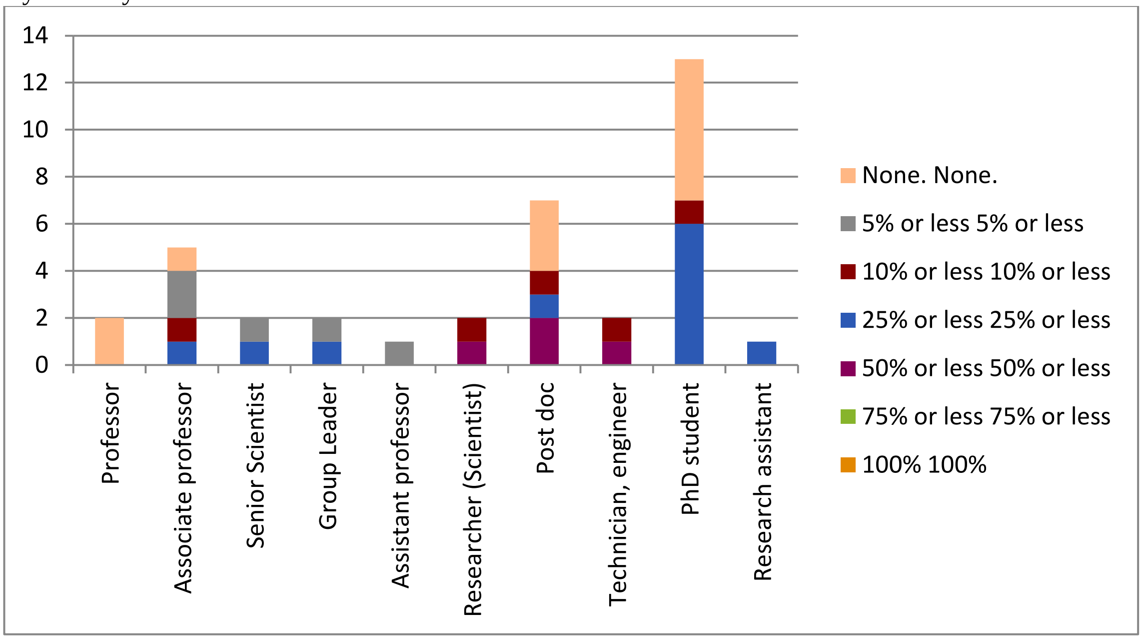
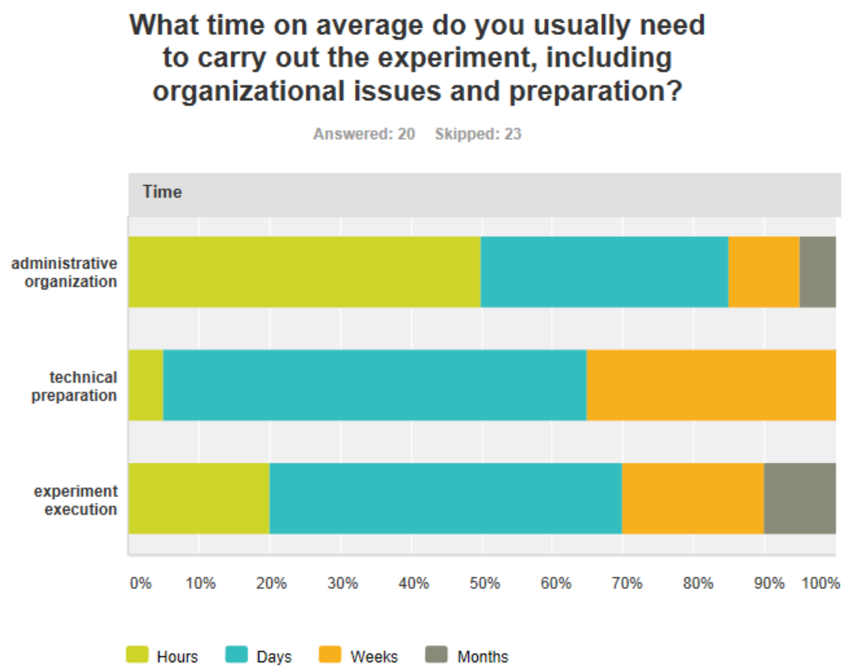


Figure 10: Time associated with lab work

If we are looking the time associated with lab work from the seniority's perspective, it is found that PostDoc in general spend more than other people.

Time on average usually need to carry out the experiment, including organizational issues and preparation. (Q28)



Factors causing the most difficulties and time delay for experiment preparation and execution (Q29)

In term of this question, we quote the answers from the survey directly and cluster them into four types of reasons that causing the delay.

- ***Hardware and software testing***

  Deployment,

  Debugging with hardware

  Software bugs

  Buying components, designing the hardware and implementing it.

  Mechanical modifications to the setup

- ***Lack of knowledge and assistance and Document incomplete***

  Lack of knowledge of programming language and skill, and lack of knowledge of the details in the whole system.

  Assistance with mechanical workshop orientated issues

  In addition, lack of technical documentation and in-house competences about resources we should have available was surprising find I encountered in past 2 years.

- ***Administrative issues***

  Finding out who is responsible for what and to get reliable information.

  Administrative organization

  The disconnect between organizational level of lab responsible and people working with the equipment is often source of problems.

  Getting permission

- ***Other issues***

  Unfavorable weather conditions

  Hardware breakage

  Development of missing features in lab infrastructure

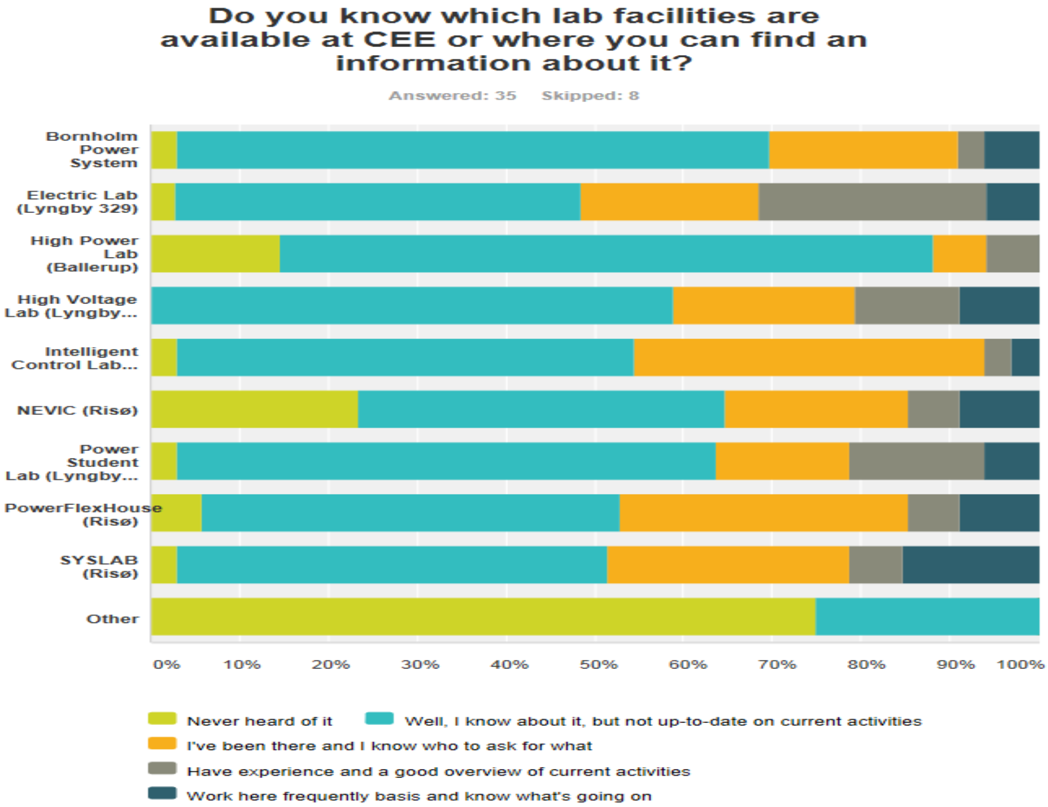
  SCADA system not finished. Only 2 people can operate it.

  Technical preparation

  Finding calibrated measurement equipment

This has changed in last few years form very flexible experimental research with only few activities to a more structured resource and more active research activities with structured allocation and all due to new WSP procedures.
Software version changes and incompatibility OS issues Windows/Mac access priorities and firewalls (and who that can provide access)

Awareness of Labs and relevant information (Q25)



From the figure, it is seen that people in general has a good awareness of the labs, however, they just know it and only a small fraction of the CEE staff have experience and a good view of current activities.

Information inquiring (Q31)

	It's hard, it could be anywhere;	Just ask the right person;	Once you get a feel for it, there is a kind of system;	Strictly organized, Structured folders;
Hardware	29.17% 7	45.83% 11	25.00% 6	0.00% 0
Software	20.83% 5	58.33% 14	16.67% 4	4.17% 1

From the table, we notice a significant fraction feels lost with regards to information inquiry, but a majority of people is able to find the information they want, most commonly by asking specific people. The following table lists the "right persons" collected from the survey:

Per Munch Jakobsen	more general term
Daniel Arndtzen	hardware in SYSLAB

Oliver Gehrke and Anna Kosek	SYSLAB programs
Nils Nielsen	software and server from Lyngby, Blade server
Jonathan	simulation software licenses
AIT or CET IT support	software
Trine or Arne	Lab 329

<u>Have you faced to the unavailability of the documentation for the equipment/hardware/software you have been using/intended to use? If yes, specify which equipment/hardware/software it was.</u> (Q32)

Respondents stated the following:

- SYSLAB program is not so well documented.
- Know very little about the hardware and software in Lyngby side.
- ABB SCADA system documentation. Needed information on how to extract data.
- MicroCHP's, - found it by internet, or by contacting manufacturer.
- Technical information about water cooling system is missing.
- Information that for currents >63A our PAS 1500000 source can be connected only to a load directly with cables is new and not easily available. This places constraints which systems can be used in parallel with PAS.

6. Summary and Recommendations

In this section, the results analyzed from the survey are concluded from the following five aspects: research fields and common interest, sharing of knowledge, information and data, human to machine, i.e., how to support effective lab operation, and teaching.

6.1 Research Fields & Common Interests

It is apparent that the 5 groups are quite homogeneous in their research profiles. Besides, we find some overlap in the research interests, in particular w.r.t. ESOM and ERES group interests. The shared research interests include Control Architecture for Smart Grids, Interoperability, Isolated Power Systems, system design, Intelligent Buildings & Building automation between the ESOM and ERES group. Furthermore, we found out that there are quite a few potential overlaps existed in research fields. It is recommended that further collaboration in these fields can be enhanced among different groups. These potential research overlaps are listed in a sequence according to their distribution among the research groups and the number of people interested.

It is found that three research topics including optimization, simulation technology & algorithms, and EV technology are interested by nearly every group. Besides, the following table presents the topics that are interested by people from three research groups.

Research topics	**Groups**
Distributed control	ESOM, ERES, ELMA
Network Planning	ESOM, ERES, ELSY
Stochastic methods	ELMA, ESOM, ELSY
Energy Storage	ESOM, ERES, ELSY
Wind power	ERES, ELMA, ELCO
Diagnostic methods & monitoring	ESOM, ELSY, ELCO

Furthermore, people from group ERES and ELSY have interests on Power System Stability & Control; HVDC is investigated in ELSY and ELCO group. For further details, please see section 2.1 in chapter 2.

Based on the findings, *we recommend* that the following approaches could be considered for further collaborations.

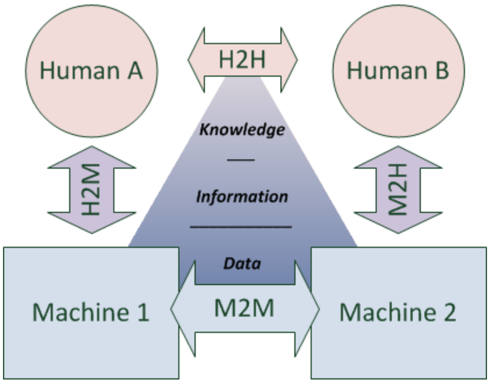
- Establish "collaboration Space" in form of workshops or wiki sites, or email lists etc. around the above subjects (could be on Journals, conferences, or results).
- Add coordination and incentivize collaboration for future research groups.
- Kernel that may motivate to look further into specific tools for general data & model-sharing.

6.2 Sharing of Knowledge, Information & Data

From the survey, it is concluded that people have great interests in knowledge sharing and would like to contribute to promote cooperation (please see section 3.5). However, some issues also exist due to the huge diversity in such a large center that might become a barrier for promoting the knowledge sharing. Furthermore, as illustrated in the following figure that three levels of sharing between knowledge exists:

- Knowledge
- Information
- Data

Data, information and knowledge are presented in a more to less structured form, therefore, support should be adapted to the levels where interests are shared.



6.2.1 Knowledge Sharing

Knowledge sharing is an exchange of skills due to common use of tools, programming language, etc. We aim to briefly discuss where is CEE internal knowledge sharing 'interesting' before giving the recommendations and we think that the interests comes:

- NOT IF peers in the same office with same tool (e.g. Matlab, Latex, Eclipse, PSS/E) and
- NOT IF alone with tool ('cause the 'friends' are online)
- BUT interesting for medium common tools: PowerFactory, GAMS, R, LabView, Maple, IPSYS as well as for medium common programming language: R, Python, Java, DPL (PowerFacotry), C/C++.

For more details, please see section 3.1, 3.4 in Chapter 3.

<u>Recommendations:</u>

1. Use shared interest groups (see above) to raise awareness of each other's competences.
2. Use online 'wiki' type platform to share relevant information e.g. links, HowTos, etc.

6.2.2 Information

"Information" is often tied to files, highly structured and very diverse. The information includes e.g. papers, books and models. The way to exchange the information includes:

- EXPORT & format conversion
- Model Exchange

It is found out that the most common types of models are Power system & components and thermal, economic & statistical models. Furthermore, in term of "standard" models, currently, only in the electrical power system modeling field it is mentioned and there are no overlaps across groups for Electr. Syst. This indicates that potential in-house 'standard models' could be developed for other modeling field e.g. statistical, economic & thermal models.

In addition, regarding the origin of the models, it is found out that people in general prefer to use self-developed model. In term of predefined model, it is usually extended or reduced for personal use. In house developed model is also used by the researchers. Normally, model provided by external collaborators either covered under NDA or not is not used often.

Interesting points w.r.t. software support include

– Sharing of models (access)

- Identification of existing, relevant & available information
- Format conversion tools
- Policy: reducing format diversity

For more details, please see section 3.2 in chapter 3.

Based on the above findings, *we recommend:*

1. get common place for sharing knowledge about existing models by type.
2. Consider how to standardize exchange if sufficient interest.
    a. Conversion tools? (what is out there? e.g. CIM)
    b. Common formats? (e.g. INFORM about most common tools)
3. Establish & share best practices, e.g from running projects (e.g. SOSPO); especially considered in STARTUP phase of project

ALL in all, consider more emphasis on sharing 'in-house' and non-NDA models.

6.2.3 Data

In the survey, we found out that several types of data are used quite common across groups and the types of the data include: grid data (voltage, load, frequency etc.), renewable generation data, historical weather data such as wind, solar irradiation, market price, forecasts, user behaviour (e.g., driving patterns), and EV and charging spot data.

Besides,
A) Data obtained via experiments
In ELCO group, paper notes and files on my PC play important roles.
In ELSY group, paper notes and files on my PC are equally important.
In ERES group, most people use the forms of files on my PC, University ‘O’ drive, and using information sharing platforms, e.g., dropbox.
In ESOM group, people prefer to use the form of files on my PC, University ‘O’ drive, using information sharing platforms, e.g., dropbox, and CEE shared database.

B) Size of data sets
More than half work with large data sets, but it is also seen that ELCO does not use large data sets, when compared to e.g. ELMA.
In general, people store large data sets in one of these ways:

- Files (e.g. csv-files): O-drive, dropbox, campusnet, GIT (SOSPO)
- several SQL databases: PLDK SCADA, my/MS/postgresSQL

For more details, please see section 3.3 in chapter 3.

The most interesting "common" data types are:

- grid data
- production, demand & weather data
- prices
- forecasts
- EV charging patterns (user behaviour) & Charging sport (GIS) data.

Based on the above findings, *we recommend*:

1. Find methods for Large-scale data sets sharing
    a. only databases for really 'standard' data (where to depart from 'flat files')

    b. ensure organization & retrieval via O-drive, not dropbox
2. NDA not so important for now - internal sharing!
3. Share knowledge about data sets:
   --> Conversion tools? Common formats?
   In most cases "howto" or "sample script" is the best form of documenting data

4. in context of 'knowledge sharing' establish & share best practices
   --> common place to identify locations of data sets & documentation practice

6.3 Human to Machine - How to support effective lab operations?

Only a fraction of CEE staff is practically involved in lab work. Even staff involved "on a regular basis" spends less than 50% of their time in the lab.
Awareness of labs: show good awareness of the lab, however, only a fraction of the CEE staff actively works in the lab.

- Lab work and time spent
  - preparation of lab work seems to take similar amount of time as experiment execution
  - Administrative overhead quite diverse
  - Administrative delays of several months are reported
- Common issues causing delay
  - <u>Administrative:</u>
    miscommunication between "upper/responsible" and "lower/executing" level
    awareness of procedures and responsibilities
  - <u>Practical/technical factors</u>
    incomplete documentation, in particular for software issues (several)
    bottlenecks w.r.t technical skills
  - Weather dependency
  - <u>Components:</u> procurement issues & broken equipment
  - Cascading delays (e.g. SCADA completion)

For more details, please see chapter 5.

Recommendations:
In general effective lab operations can be achieved by more clearly identifying responsibility and delegating as much as possible to people more closely involved with lab operations. Documentation issues in different forms should be addressed in the same way as
 or minimizing administrative preparation steps. are more interesting for labs that have a high utilization rate.

6.4 Teaching

Teaching in the lab is learning-by doing, i.e. via course hands-on exercises, course projects, special courses, BSc/MSc theses

- Lab exercises are part 50% of courses
  (9 of 20 courses in total)

- Teaching activities in the lab are quite asymmetrical across groups
  - ELMA & ELSY don't use labs for course teaching
  - ELCO , and ESOM use labs to a large extend
- Types of studies (courses vs. student projects) vary:
  - ELCO is more rather equal on all types
  - For ERES and ESOM project-type activities dominate

For more details, please see chapter 4.
Based on this analysis no specific recommendations are given.

Aside from the survey it has been observed that introduction to lab facilities takes a significant share of the project time, in light of tighter official requirements for the project time, a point of discussion arises: How could the actual lab-use more effectively integrated in teaching activities:

- What types of "packaged" software setups could facilitate lab-related student activities?
- Are 'standard' configurations of the lab meaningful for early stage student projects?

6.5 Conclusion

The survey reported many aspects that appear or 'obvious' as individual facts, which are nevertheless helpful to have 'on paper'.
Taking several questions in context of another, we observed some patterns which have been summarized above. Based on the summary data, we reported some insights and derived recommendations.

Let us conclude by summarizing possible answers to the question:

Where is CEE internal knowledge sharing 'interesting'?

A. The most interesting "common" data types are:

- grid data
- production, demand & weather data
- prices
- forecasts
- EV charging patterns (user behaviour) & Charging sport (GIS) data.

B. Knowledge sharing with respect to specific labs and within groups works well, via go-to persons. But there is much greater potential if shared interests are realized:

Research topics	**Groups**
Distributed control	ESOM, ERES, ELMA
Network Planning	ESOM, ERES, ELSY
Stochastic methods	ELMA, ESOM, ELSY
Energy Storage	ESOM, ERES, ELSY
Wind power	ERES, ELMA, ELCO
Diagnostic methods & monitoring	ESOM, ELSY, ELCO

- Similarly, it may not be necessary to develop knowledge sharing for the most common or rare tools, but it may be interesting for:

- medium common tools: PowerFactory / DPL, GAMS, R, LabView, Maple, IPSYS
- medium common programming language: R, Python, Java, C/C++. DPL

How could such knowledge sharing be realized?

Suggestions:

- Establish "collaboration Space" in form of workshops or wiki sites, or email lists etc. around the above subjects (could be on Journals, conferences, or results).
- Get common place for sharing knowledge about existing models by type.
- Add coordination and incentivize collaboration for future research groups in term of general data & model-sharing.
- Establish & share best practices, e.g. from running projects (e.g. SOSPO);
  especially considered in STARTUP phase of project.
- Consider how to standardize exchange if sufficient interest.
  - a) Conversion tools? (what is out there? e.g. CIM)
  - b) Common formats? (e.g. INFORM about most common tools)
- ALL in all, consider more emphasis on sharing 'in-house' and non-NDA models.
- Find common methods for large-scale data sets sharing:
  - a) only databases for really 'standard' data (where to depart from 'flat files')
  - b) ensure organization & retrieval via O-drive, not dropbox
  - c) provide "integration options", e.g. conversion tools, common formats;
  - d) in most cases "howto" or "sample script" is the best form of documenting data

Can something else be concluded about lab user requirements for support software?
The general line of the responses demonstrates that

a) academic lab users require very different types of experiments and setups for their research
b) most users spent only a small fraction of their time in the lab ('one-time users'), which means that
c) the load on 'go-to' persons, who are both researchers and technical staff is rather high to support these one-time users.

To facilitate these 'one-time' lab experiments and reduce the load on the go-to people listed above, the already recommended knowledge-sharing approaches will be helpful. Further, one could argue that lab software that balances the following requirements is desirable:

a. supports an API in a programming language "one-time users" are familiar with
b. flexible and adaptable to a large variety of setups (interfaces & configurations), and
c. facilitates lab configuration and deployment

Repeated types of experiments occur in context of courses and other teaching activities. Here more standardized software setups and lab configurations could also relieve teachers, lab technicians and improve the learning & research outcomes.

References

[1] A. M. Kosek and K. Heussen, “The requirements domain for laboratory software infrastructure RTLabOS: Phase I-Deliverable 1.1,” 2013.

Appendix A Questionnaire

Authors: Evgenia Dmitrova and Kai Heussen

SURVEY QUESTIONAIRE

This questionnaire aims to collect background and technical information about participating laboratories. The structure and background concepts of this survey have been outlined in the accompanying document "Domain Study" (RTLabOS Deliverable 1.1).

A summary evaluation of this survey's results will lead to a publically available report; a revision opportunity will be given to the survey participants before publication. If agreed, the full survey contents will be shared among participating laboratories.

Contact information

Organization & Laboratory (in the following 'the Lab'):

Contacts (persons filling out questionnaire and authorization responsible):

[ ] I agree to share the information provided in the following with other participating laboratories.

________________________________(authorization responsible)

PART I: Users and the Laboratory Environment

A) Lab Stakeholders & Ownership

Q1. Who is funding / owning / operating the Lab?

Funding:

Owning:

Operating:

Q2. Which stakeholders participate in Steering Committee / Advisory Board?

If possible group stakeholders into (Utility/ Governmental / Commercial / Academic)
Steering Committee:

Board of advisors:

B) Lab-Establishment

Q3. When was the lab established?

Funding Agreement:

Opening:

Q4. Classify the establishment process:

( ) incremental extension of an existing lab
( ) new facility based on new design
( ) re-design of a prior facility
( ) other: ___________________________

Q5. Indicate the scale of the laboratory of investment costs

Here the question is about scales rather than absolute numbers. Encircle the range.

Initial investment (Eur / US $): 10.000 100.000 1.000.000 10.000.000 100.000.000

Total (cumulative investment): 10.000 100.000 1.000.000 10.000.000 100.000.000

Q6. Qualify the essential drivers for the lab establishment:

<_____> Identified gap in research field
<_____> Identified gap in commercial testing needs
<_____> Lighthouse project as national priority area (attracting international attention)
<_____> General Government Policy
<_____> Commercial Interests

Q7. Please describe the key design objectives of the laboratory

Q7.1. Key applications/activities to be supported by lab
(e.g. Commercial testing & certification, research in systems / control, etc.; these activity categories are further defined in Section 2.2 of the "Domain Study"):

Please prioritize the first *3* activities in terms of their relevance in consideration during the design.

<_____> Demonstration
<_____> Experimentation
<_____> Testing and validation
<_____> Models development
<_____> Decision support and tool development
<_____> Maintenance and monitoring of equipment
<_____> Controller development and deployment
<_____> System Integration
<_____> Time series acquisition

Q7.2. List the top three specific key focus areas of the lab:

1.

2.

3.

Q8. Could you describe the design philosophy in a few words?

Q9. Please qualify the ambition level (e.g. scope of competitiveness) during the design:

Q10. Has there been a precursor to this Lab, i.e. is it a design evolution of a prior lab?

__yes *__ no*

Q10.1. If yes, please explain the evolution in terms of equipment and functionality:

C) Actual Lab Use

Q11. Users & Staffing:

Please quantify the number of staff (on average):

- *PhD Students:*
- *PostDocs:*
- *Senior Scientific staff:*
- *Visiting Researchers:*
- *Technical Staff (incl. operation & maintenance):*
- *Administrative Staff:*

Q12. Please quantify the operation cost (excluding staff) of the laboratory:

Maintenance:

Other Operation costs:

Q13. Funding Sources of Staff and Operating costs

Please associate an approximate percentage value with each category:

<_____> Fixed base funding
<_____> Long-term partnership based funding
<_____> Project -based funding (public)
<_____> Return from commercial use of lab
<_____> Other funding source:_________________________________.

Q14. Activities & Types of Experiments

Please prioritize the top *3* activities in terms of their relevance in actual lab use. (Scope: last 3 years)

<____> Demonstration
<____> Experimentation
<____> Testing and validation
<____> Models development
<____> Decision support and tool development
<____> Maintenance and monitoring of equipment
<____> Controller development and deployment
<____> System Integration
<____> Time series acquisition

Q15. Topical diversity of Projects

For the following topical areas indicate the current level of project activity associated with the lab. (Scope: last 3 years)

Activity Range: ***0*** *none;* ***1*** *sporadic;* ***2*** *occasional;* ***3*** *regular;* ***4*** *frequent;* ***5*** *continuously*

Electric components

<____> Electric materials and aging
<____> High voltage engineering, electric transients, lightning protection
<____> Power electronics and drives

<____> Electric machines
<____> EMC
<____> HVDC

Energy Conversion and Flexibility
<____> Energy storage
<____> PV technology
<____> Wind power technology
<____> EV technology
<____> Intelligent buildings and building automation
<____> Thermodynamics and thermal energy systems

Systems Integration, Automation & Controls
<____> Protection & Protection systems
<____> Interoperability
<____> (Distributed) Automation
<____> Controls Design

Systems-Modeling and Analysis
<____> Power System Stability
<____> Isolated Power Systems
<____> Stochastic behavior and methods for power systems
<____> Diagnostic methods and monitoring

Q16. External Users & Collaboration

In which field do you have collaborations with respect to actual lab activity?
Please provide indicative numbers and names collaborators if possible.

<___> Utilities:
<___> Vendors:
<___> Scientific:
<___> Public Sector:
<___> Other: ____:

D) Hardware / Overall Lab setup

Q17. Hardware Data Sheet

Please supply a 'data sheet' of your lab, stating relevant facts about the technical equipment, including electrical infrastructure, energy conversion units, communication networks, data acquisition infrastructure and major computing hardware, including possible data concentrators.

(please attach a data sheet if available, and use space below for comments:)

Q18. List the top three most distinguished capabilities of the lab:

1.
2.
3.

E) Other Factors

Q19. Strategic Software Competence

Q19.1. How strong are your staff software competences today?

Range: ***0*** N/A; ***1*** *Rare use;* ***2*** *Occasional Use;* ***3*** *Frequent Use;* ***4*** *Part-time Development;* ***5*** *Development focus*
Please use the left column for this reply.

<___|___> Simulation tools
<___|___> SCADA software
<___|___> Control Software
<___|___> Visualization & HMI
<___|___> Interfacing & Protocols
<___|___> Data Analysis & Modeling tools
<___|___> OTHER: ________________________.

Q19.2. Do you plan to recruit / develop further competences within the next 3 years?

__ *Yes* __ *No* (if yes, please use 2nd column in above list)

Q20. Procedures & Policies

Q20.1. With respect to lab use, to what extent do you have formal procedures to cover the following issues?

Range: ***0*** N/A; ***1*** *No Formal Procedure;* ***2*** *Informal knowledge w/go-to persons;* ***3*** *Dedicated Staff Roles;* ***4*** *Forms with semi-formal process;* ***5*** *Strictly formalized procedure*

<___> Safety
<___> Booking & Reservation
<___> Experiment Setup & Conclusion

Q20.2. With respect to intellectual property of the lab (data, software and models), what is your general policy regulating exchange with external parties?

Range: ***0*** *N/A;* ***1*** *Only internal use;* ***2*** *against fees;* ***3*** *under NDA;* ***4*** *Sharing with Collaborators (barter-basis);* ***5*** Open to anyone (available online)

<___> Data
<___> Models

<___> Software

Q20.3. For the IP aspects marked between 1-3, please indicate if there are established/formal procedures to initiate the exchange.

Q21. Documentation

Q21.1. Functional Descriptions & Operation Manuals (official documentation):

Is it generally easy to find out what (Software/Hardware) is available in your lab the Specs? Is there some systematic organization of the information?

Range: 0 N/A (it's easy, there's only a few documents, everyone knows, all in one place);
1 It's hard, it could be anywhere; 2 just ask the right person; 3 "Once you get a feel for it, there is a kind of system"; 4 Strictly organized, Structured folders; 5 Search engine enabled

<___> for Software
<___> for Hardware

Q21.2. How-to-Know-How (internal knowledge-sharing about how to perform lab-activities):

For common lab tasks, do you have written checklists, how-to manuals or other kinds of instructions to guide new users: (I've read the manual, but still don't know what to do…)

Range: ***0*** *N/A (*Come on, you're an engineer!)*;* ***1*** just ask the right person*;* ***2*** for some things someone once wrote a how-to manual (it's outdated)*;* ***3*** It's common practice to contribute to written documentation (e.g. no code without comments)*;* ***5*** 'software wizards' / 'assistance robots'

<___> Software
<___> Hardware (Data sheet)

PART II: Core Software Functions

This part of the survey is aimed at understanding the existing lab software infrastructure. Lab software is not easily thought of as an infrastructure, but, possibly more appropriate, as a zoo – or a djungle. A taxonomy of lab software has been provided in the “Domain Study” *(RTLabOS Deliverable 1.1; Section 3: Software tools). The following questions aim to collect and index the most relevant software species and identify their contribution to the laboratory software ecosystem.*

Questions include both multiple choice and open fields.

A) Analysis and Development Tools

Q1. Simulation Software

Q1.1. Which (modeling, simulation & calculation) software are used in your lab? (multiple ticks possible)

	Power Factory		Eurostag		LabView
	RSCAD		ETAP		Matlab
	PSS/E		Mathematica		R (statistics)
	PSpice		Maple		
	PSCAD		SAS		Other tools, please list below.

Q1.2. Are licenses usually available to all employees? How are licensed managed? Is there a central license server for software licenses?

Q1.3. Open source software: Is there a local preference regarding open source tools? Does your lab contribute to OS developments? Please provide examples.

Q2. Model Types

Q2.1. What types of Models are in use in your lab?
(e.g. thermal models, power system models (transient, dynamic, power flow), forecast, …)

Q2.2. Are there conventions on the model data types to be used? Which?
(i.e. CIM would be a common standard, but can hardly be used for all simulation programs)

Q2.3. Model Management: Is sharing of models across the lab common? How is it organized?
(i.e. is there central repository of folder structure, even a database? How are NDA aspects addressed?)

Q2.4. Model development: Are models developed systematically in the lab context? What type of models? Is model development driven by lab-related measurements?

Q2.5. Is there a policy or practice regarding sharing of models externally?

Q3. Data Storage, Extraction and Handling

Q3.1. Which are the common data types in use? Please list more specific types where possible

<____> time series from measurements:
<____> GIS data:
<____> market price data:
<____> forecast & meteorological data:
<____> other data:

Q3.2. Is there a central storage facility for time series data? What type?

Q3.3. What other types of data are common that have been missed here?

Q4. Objects of Development

Q4.1. What types of Controls and Algorithms are developed in you lab?
(consider control applications and layer)

Q4.2. Is simulation software developed in your lab? What kind?

Q4.3. Decision Support and Visualization: Is there dedicated research and development into decision support and visualization that integrates with the lab? Please indicate scope.

Q5. Development Environment

Q5.1. Programming Languages: Which languages are commonly used in your lab?

Q5.2. Development Environments: Which Development environments are most used?
(If there is a split, please estimate the proportions)

<____> Visual Studio & .Net
<____> Eclipse
<____> other:

Q5.3. Code Management: What forms of internal code sharing are common in your lab? Is there a general policy / preferred method?
e.g. from simple file based sharing (or Dropbox) to various forms of versioning systems (CVS / SVN / Mercurial / Git, etc.)

Q6. Knowledge Sharing

Q6.1. How is information access and sharing enabled in your lab?
Please qualify how information sharing is organized.

Range: ***0*** *N/A;* ***1*** some people use external file sharing tools (e.g. dropbox); **2** a central drive network exists; **3** shared folders are strictly organizated and typed; **4** common file types are in use and deviations are documented; ***5*** standard *i*nformation models are employed / usually a conversion tool is provided for application formats

<__> Models
<__> Other data
<__> Code / development files
<__> Experiment configuration data

Q6.2. Are tools in use for Document Management? For which documents are they used? How are NDA (non-disclosure agreement) aspects handled?

Q6.3. Which collaboration & coordination tools are in use?
(e.g. Outlook Exchange /shared calendar, Online project Management tools (Kanban, Podio, ..), Issue-tracking tools, …)

B) Lab-Related Software

Q7. Is there a dedicated SCADA system for the Lab? What features does it have?
Please cover aspects such as: commercial (incl. brand) / open source; degree of tailoring & in-house development; granularity of user access; features for locking configurations for experiments; flexibility to integrate new devices; how is data access secured/structured

Q8. GUIs for monitoring and lab management
Please describe the types of GUIs that are in use for Lab management; are there dedicated GUIs for supervising experiments? How are new GUIs set up?

Q9. Data aquisition and storage infrastructure

Q9.1. Please describe the features of your Data Acquisition infrastructure.
Aspects: time resolutions; time stamping; types of measurements; life data vs. historians (e.g. in case of Power Quality recording); data access

Q9.2. Data Hosting & Storage: How is historical data stored in your lab?
Is there a central database for all data or are there several systems? Can data be 'tagged' for specific experiments? (e.g. as "restricted access")

Q10. Equipment and components control
What infrastructure do you have to deploy controllers onto your lab equipment?

C) Additional Tools and Advanced System Integration

The questions in this category are all open questions. If availability of related capabilities is available the respondent is requested to provide a free-text reply. Please refer to the “Domain Study” document for clarifications on the question topics.

Q11. Co-simulation and HIL coupling and interconnection

Q11.1. Does your Lab provide Hardware-in-the loop facilities? Of which type?

Q11.2. What types of co-simulation can be performed in you lab?

Q12. Remote access to equipment and simulation

Q12.1. Can data and time series of equipment in the lab be accessed remotely? Are visualizations supported? What platform is used for this purpose?

Q12.2. Is remote control possible? How?

Q12.3. Is there an API for remote closed-loop control? Based on what technology / standards?

Q13. Data merging tools

Q13.1. Are dedicated services available in your lab that simplify merging of data from different sources?

Q14. Experiment booking and permissions

Q14.1. What tools are available and actually used in your lab to reserve experiment space and equipment, lock access to breakers?

Q14.2. Is it possible to unify these permissions under a single experiment access 'tag'?

Q15. Platform for deploying and testing controls

Q15.1. Does your lab offer standardized functionality to deploy controllers onto devices?

Q15.2. Is this mechanism based on a particular standard?

Q15.3. Is the mechanism in use? What percentage of possible users actually empoy the mechanism?

Q15.4. Is there an infrastructure that integrates development and testing of controls in simulations that can be (seamlessly) integrated with a deployment on laboratory equimpment? How does it work? What are the elements of this toolchain?

Q16. Advanced configuration management

Configuration, Controls & Configuration Data Management

Q17. Software Interoperability and Interface Standards

Q17.1. Does your lab encourage use of standardized data exchange protocols?
Indicate for different layers.

Level 1: Process & Components

Level 2: (Distributed) Process Control

Level 3: SCADA (DA, Supervision and Visualization)

Level 4: Service Layer

(Level 5: System Engineering / Planning)

Q17.2. *System Integration:* With respect to integration of new software / components, do you have shared principles for alignment?

Range:

1 everything ad-hoc **3** shared principles & patterns **5** following strict architecture