

Conference Programme

# NORDAC 2012

Tenth Nordic Conference on

## Electricity Distribution System Management and Development

Espoo, Finland  
10-11 September 2012



**ELFORSK**

ELFORSK – SWEDISH ELECTRICAL  
UTILITIES' R&D COMPANY



In cooperation with



## **Aims and scope**

One of the main future challenges for the entire energy sector will be making substantial reductions in emissions of greenhouse gasses while ensuring a secure supply of energy at a reasonable cost. EU has launched its 2020 targets (20% cut in emissions, 20% improvement in energy efficiency and 20% increase in renewables) as a very important part of the solution.

The distribution system is expected to play a key role as further generation is implemented at the distribution level; changes in the consumption pattern due to electric vehicles, heat pumps, energy efficiency and Demand Response enabled by smart metering etc. will require large investments to facilitate future needs. Utilities as well as academia play a very important role in the development and implementation of intelligent solutions. The future electricity distribution system must be smarter !

The NORDAC 2012 conference will give participants the possibility to discuss these and other future challenges and solutions, as well as disseminate experiences regarding technical, economic and regulatory issues.

The conference covers the following areas:

- 1. Distribution system development and operation**
- 2. Asset management**  
Aging infrastructure management – Maintenance – Life time estimation – Risk management
- 3. Generation at the distribution level**  
Prospects and consequences of generation at the distribution level – Micro generation.
- 4. Regulation of DSOs**  
Regulatory issues – Trends – Challenges
- 5. Quality of supply and EMC**
- 6. Distribution automation**  
Distribution utility ICT - Applications – SCADA– Control – Protection
- 7. Active grids – Active loads – Active Customers - Prosumers**
- 8. Electric vehicles**  
Technology – Connection issues – Impact on load profiles
- 9. Smart metering**  
Automatic meter management – Demand Response – DSM
- 10. Distribution network components**  
Design and technology innovation – Components in future power systems
- 11. Energy Efficiency**  
Local energy planning – Environmental aspects – Sustainability
- 12. Multi utility**  
New business models – Management of parallel infrastructures

NORDAC provides a forum where the electricity distribution community and industry meets. The participants will meet colleagues from the other Nordic countries and the Baltics for discussions of existing practises and important future challenges.

The organisers need your valuable contribution to ensure that the forthcoming conference will be as successful as the nine previous events. All aspects of research and development in the electricity distribution sector will be welcomed, both papers with scientific as well as practical engineering considerations.

## **In cooperation with CIRE**

*Cired - International Conference on Electricity Distribution- is the leading forum where the international electricity distribution community meets. CIRE* works for the purpose of increasing the business relevant competencies, skills and knowledge of those participating in CIRE's activities. CIRE offers a biennial conference and exhibition where developments and best practices in technology and management of the technical side of electricity distribution are presented. Between conferences CIRE may organise specific Working Groups on current subjects of key interest to the electricity distribution community.

**Information available at [www.cired.net](http://www.cired.net)**

**The next event will be held in Stockholm, Sweden on 10-13 June 2013**

## **Primary target groups**

Focus will be on future challenges and possibilities for the Nordic distribution utilities. Therefore the primary target groups are:

- Distribution network operators
- Distribution network owners
- Distribution network service providers
- Research scientists
- Students
- PhDs
- Manufacturing industry, suppliers
- Consultants
- Software companies
- Authorities
- Regulators

## **Conference Fee**

The conference fee is 600 euros with the additional price 120 euros for the Conference dinner and evening party.

## **Working Language**

The official language for the conference is English.

## **Internet announcement and Registration**

News about the conference and registration link can be found on <http://www.nordac.net> and <http://nordac2012.aalto.fi/>

## **Venue**

The conference will be organised by Aalto University, School of Electrical Engineering. <http://electronics.tkk.fi/en/> The conference location is conference center Dipoli, Otakaari 24, Otaniemi, Espoo. <http://dipoli.aalto.fi/kokouspalvelut/english/index.html> Dipoli is at the campus of Aalto University and just a few hundred meters from Radisson Blu Hotel Espoo.

## **Accommodation**

Rooms have been reserved at Radisson Blu Hotel Espoo under the code **NORDAC2012**. Price per night is 132 € for single and 152 € for double room. Hotel is in walking distance from the conference venue, for details, see: <http://www.radissonblu.com/hotel-espoo>

Reservations can be made by email: [reservations.finland@RadissonBlu.com](mailto:reservations.finland@RadissonBlu.com) or by phone +358 20 1234 700. The availability of rooms is guaranteed till 6.8.2012 at 6 p.m. Rooms are paid directly to the hotel either by cash or credit card. The guests have full responsibility for their contract with the hotel including possible damage to the hotel property.

## **Organisers**

The conference is being organised by the national research institutes or organisation responsible for research and development in the Nordic countries. Any inquiry should be communicated to the respective member of the organising committee, which consists of:

Sven Jansson  
Elforsk AB  
S-101 53 Stockholm  
Tel: + 46 8 677 27 32  
Fax: + 46 8 677 25 35  
Email: [sven.jansson@elforsk.se](mailto:sven.jansson@elforsk.se)

Kjell Sand  
SINTEF Energy Research  
N-7465 Trondheim  
Tel: + 47 73 59 71 84  
Fax: + 47 73 59 72 50  
Email: [kjell.sand@sintef.no](mailto:kjell.sand@sintef.no)

Matti Lehtonen  
Aalto University  
School of Electrical Engineering  
Department of Electrical Engineering  
P.O. Box 13000  
FI-00076 Aalto, Finland  
Tel: + 358 9 470 254 84  
Fax: + 358 9 470 250 12  
Email: [matti.lehtonen@tkk.fi](mailto:matti.lehtonen@tkk.fi)

Morten Møller Jensen  
c/o Danish Energy Association, DEFU  
Rosenørns Allé 9  
DK-1970 Frederiksberg C  
Tel: + 45 35 300 770  
Fax: + 45 35 300 771  
Email: [nordac@danskenergi.dk](mailto:nordac@danskenergi.dk)

Magni Thor Palsson  
c/o Samorka  
Sudurlandsbraut 48  
IS-108 Reykjavik  
Tel: +354 5639437  
Fax: +354 5639448  
Email: [magnip@landsnet.is](mailto:magnip@landsnet.is)

# NORDAC 2012 PROGRAMME

## **Monday the 10<sup>th</sup> September**

9:00 to 10:00 Registration

10:00 Opening of the conference

10:00 to 12:30 SESSION 1: SMART GRIDS – DISTRIBUTION SYSTEM DEVELOPMENT

--- lunch break ---

13:30 to 14:30 SESSION 2: ASSET MANAGEMENT

--- coffee ---

14:45 to 16:00 SESSION 3: GENERATION AT THE DISTRIBUTION LEVEL

16:00 to 16:45 SESSION 4: QUALITY OF SUPPLY AND EMC

---- break ---

17:00 to 18:00 POSTER SESSIONS

SESSION 5: DISTRIBUTION AUTOMATION

SESSION 6: DEMAND RESPONSE

19:00 to 22:00 EVENING PROGRAMME IN DIPOLI

## **Tuesday the 11<sup>th</sup> September**

9:00 to 11:00 SESSION 7: ELECTRIC VEHICLES

--- break ---

11:15-12:00 SESSION 8: SMART METERING

--- lunch break ---

13:00 to 15:00 SESSION 9: DISTRIBUTION NETWORKS AND COMPONENTS

--- coffee ---

15:30 to 16:00 SESSION 9 CONTINUES

16:00 TO 16:30 SESSION 10: ENERGY EFFICIENCY

16:30 WELCOME TO THE CIRED 2013 IN STOCKHOLM

17:00 CLOSING OF NORDAC 2012

## **SESSION 1: SMART GRIDS – DISTRIBUTION SYSTEM DEVELOPMENT**

**KEYNOTE:** SMART GRID PROJECTS IN FINLAND. Jani Valtari, CLEEN Oy, Santtu Vähäkuopus, LNI Verkko Oy, Osmo Huhtala, Fortum Distribution Oy, Markku Hyvärinen, Helen Sähköverkko Oy.

**KEYNOTE:** SMART GRID PROJECTS IN NORWAY. Kjell Sand, SINTEF Energy Research.

VARIOUS SMART GRID CONCEPTS AND TECHNOLOGICAL DEMONSTRATIONS DEVELOPED WORLDWIDE. Murtaza Hashmi, VTT Technical Research Centre of Finland. [murtaza.hashmi@vtt.fi](mailto:murtaza.hashmi@vtt.fi)

SMART ENERGY HVALER. Kjell Sand, Vidar Kristoffersen, Eilert Henriksen. SINTEF Energy Research/NTNU, FEAS. [kjell.sand@sintef.no](mailto:kjell.sand@sintef.no)

STEINKJER SMART GRID PILOT PROJECT. Tarjei Solvang, Eilert Bjerkan, Jan A. Foosnæs, Erling Tønne. SINTEF Energy Research, NTE, NTNU. [tarjei.solvang@sintef.no](mailto:tarjei.solvang@sintef.no)

DEMONSTRATION OF ICT INFRASTRUCTURES FOR SMART GRIDS WITH SMART HOUSES. Dag Eirik Nordgård, Eirik Gundegjerde, Dagfinn Waage. SINTEF Energy Research, Lyse. [Dag.E.Nordgard@sintef.no](mailto:Dag.E.Nordgard@sintef.no)

DISTRIBUTION AUTOMATION AND SELF HEALING CITY NETWORKS. O. Siirto<sup>1</sup>, S. Hakala<sup>1</sup>, M. Hyvärinen<sup>1</sup>, M. Loukkalahti<sup>1</sup> and M. Lehtonen<sup>2</sup>, <sup>1</sup>Helen Electricity Network Ltd, Finland, <sup>2</sup>Aalto University School of Science and Technology, Finland. [Osmo.siiro@helen.fi](mailto:Osmo.siiro@helen.fi)

SMART GRID GOTLAND (ACTIVE GRIDS). Erik Segergren, Pöyry AB. [Erik.segergren@poyry.com](mailto:Erik.segergren@poyry.com)

GREEN CAMPUS – SMART GRID. Henri Makkonen, Ville Tikka, Tero Kaipia, Jukka Lassila, Jarmo Partanen and Pertti Silventoinen. Lappeenranta University of Technology. [henri.makkonen@lut.fi](mailto:henri.makkonen@lut.fi)

## **SESSION 2: ASSET MANAGEMENT**

DEALING WITH MAJOR STORMS IN ASSET MANAGEMENT. Gerd H. Kjølle, Ruth H. Kyte. SINTEF Energy Research. [gerd.kjolle@sintef.no](mailto:gerd.kjolle@sintef.no)

POWER TRANSFORMER DIAGNOSTICS. Fredrik Carlsson and Stefan Melin, Vattenfall Research and Development. [j.fredrik.carlsson@vattenfall.com](mailto:j.fredrik.carlsson@vattenfall.com)

THE NEW SWEDISH REGULATION OF POWER DISTRIBUTION SYSTEM TARIFFS – A DESCRIPTION AND A SUPERFICIALLY INITIAL EVALUATION ON ITS RISK AND ASSET MANAGEMENT INCENTIVES. Sabina Stenberg (UU/SvK), Carl Johan Wallnerström (KTH), Patrik Hilber (KTH), Olle Hansson (Fortum Distribution). [Patrik.hilber@ee.kth.se](mailto:Patrik.hilber@ee.kth.se)

CHANGES IN PARTIAL DISCHARGE PATTERNS IN A CAVITY EMBEDDED IN PAPER INSULATION DUE TO AC VOLTAGES WITH HIGH VOLTAGE IMPULSES SUPERIMPOSED. R. Clemence Kiiza\*, R. Nikjoo and H. Edin, KTH Electrical Engineering. [respic@kth.se](mailto:respic@kth.se)

### **SESSION 3: GENERATION AT THE DISTRIBUTION LEVEL**

INTEGRATION OF SMALL SCALE HYDRO UNITS IN DISTRIBUTION NETWORKS. Dag Eirik Nordgård, Tarjei Solvang and Luis Aleixo, SINTEF Energy Research. [Dag.E.Nordgard@sintef.no](mailto:Dag.E.Nordgard@sintef.no)

PHOTOVOLTAIC POWER GENERATION MODELING. Hannu-Pekka Hellman, Matti Koivisto and Matti Lehtonen. Aalto University School of Electrical Engineering. [hannu-pekka.hellman@aalto.fi](mailto:hannu-pekka.hellman@aalto.fi)

COMPARISON OF NORDIC AND GERMAN PRACTICES IN CONNECTING SMALL-SCALE DISTRIBUTED GENERATION TO LOW-VOLTAGE NETWORK. Janne Karppanen, Tero Kaipia and Jarmo Partanen. Lappeenranta University of Technology (LUT). [janne.karppanen@lut.fi](mailto:janne.karppanen@lut.fi)

IMPLEMENTATION OF ISLANDING CONTROL ARCHETECTURE FOR INTENTIONAL ISLAND OPERATION IN FUTURE DISTRIBUTION SYSTEM. Yu Chen, STRI AB. [yu.chen@stri.se](mailto:yu.chen@stri.se)

MAPPING OF ACTORS RELEVANT FOR INTEGRATION OF DISTRIBUTED GENERATION IN DISTRIBUTION NETWORKS. Gerd B. Jacobsen, Helene Egeland, Dag Eirik Nordgård and Tarjei Solvang, SINTEF Energy Research. [Dag.E.Nordgard@sintef.no](mailto:Dag.E.Nordgard@sintef.no)

### **SESSION 4: QUALITY OF SUPPLY AND EMC**

MEASUREMENTS OF FOUR-WINDPARK HARMONIC EMISSIONS IN NORTHERN SWEDEN. Kai Yang, Math Bollen, Luleå University of Technology, Math Wahlberg, Skellefteå Kraft. [kai.yang@ltu.se](mailto:kai.yang@ltu.se)

EMISSION FROM DIFFERENT TYPES OF ENERGY EFFICIENT LAMPS AT FREQUENCIES UP TO 150 kHz. Sarah Rönnerberg, Math Bollen, Anders Larsson and Mats Wahlberg, Luleå Tekniska Universitet. [sarah.ronnerberg@ltu.se](mailto:sarah.ronnerberg@ltu.se)

DISTRIBUTION SYSTEM CHALLENGES DUE TO NEW ELECTRICAL APPLIANCES. Helge Seljeseth, Kjell Sand and Tarjei Solvang, SINTEF Energy Research. [tarjei.solvang@sintef.no](mailto:tarjei.solvang@sintef.no)

## **SESSION 5: DISTRIBUTION AUTOMATION – POSTER SESSION**

EXAMPLES OF INTER-APPLICATION COMMUNICATIONS IN DSO. Shengye Lu and Sami Repo. Department of Electrical Energy Engineering, Tampere University of Technology  
[sami.repo@tut.fi](mailto:sami.repo@tut.fi)

PREPARING FOR DEPLOYMENT OF SMART SUBSTATION STANDARD IEC 61850. Anders Johnsson and Berkan Kapkac. Vattenfall Research and Development AB and Vattenfall Eldistribution AB. [anders.johnsson@vattenfall.com](mailto:anders.johnsson@vattenfall.com)  
DISTANCE PROTECTION IN MEDIUM VOLTAGE SYSTEMS. Tore Lefstad and Hans Kristian Høidalen. NTNU, Norway. [Hans.Hoidalen@elkraft.ntnu.no](mailto:Hans.Hoidalen@elkraft.ntnu.no)

VERIFYING THE METHOD FOR INDICATION OF HIGH-RESISTANCE EARTH FAULTS IN DEVELOPED RTDS TEST ENVIRONMENT. Ari Nikander, Jani Valtari, and Ontrei Raipala and Erkka Kettunen, Tampere University of Technology, Erkka Kettunen, ABB Oy.  
[ari.nikander@tut.fi](mailto:ari.nikander@tut.fi)

CURRENT SENSOR FOR 3-PHASE MV-CABLES. Peter Johansen, Jomitek.  
[peter.johansen@jomitek.dk](mailto:peter.johansen@jomitek.dk)

EU FP7 PROJECT GRID4EU, DEMO # 2 - LV NETWORK MONITORING AND CONTROL. Henrik Alm, Ulf Ysberg and Stefan Melin. Vattenfall Distribution Nordic.  
[henrik.alm@vattenfall.com](mailto:henrik.alm@vattenfall.com)

## **SESSION 6: DEMAND RESPONSE – POSTER SESSION**

BUSINESS MODELS FOR AN AGGREGATOR. Is an Aggregator economically Sustainable on Gotland? Quentin Lambert, Vattenfall R&D/KTH-ICS [quentinl@kth.se](mailto:quentinl@kth.se)

MANAGING IMPACTS OF DISTRIBUTED ENERGY RESOURCES AND DEMAND RESPONSE BY TARIFF PLANNING. Jussi Tuunanen, Samuli Honkapuro, Salla Annala & Jarmo Partanen, Lappeenranta University of Technology. [jussi.tuunanen@lut.fi](mailto:jussi.tuunanen@lut.fi)

COST – BENEFIT ANALYSIS OF LOAD CONTROL AGGREGATION SERVICE USING HOME AUTOMATION Petri Trygg, Sami Repo and Pertti Järventausta, Tampere University of Technology, Department of Electrical Energy Engineering. [petri.trygg@tut.fi](mailto:petri.trygg@tut.fi)

A GENERAL MARKET FOR FLEXIBILITY SERVICES FOR BOTH DSO, TSO AND OTHERS. Niels Christian Nordentoft, Danish energy Association. [ncn@danskenergi.dk](mailto:ncn@danskenergi.dk)

MARKET-BASED LOAD CONTROL OF RESIDENTIAL ELECTRIC HEATING: EFFECT ON BUSINESS OF RETAILER AND DSO. Nadezda Belonogova, Petri Valtonen and Jarmo Partanen. Lappeenranta University of Technology (LUT). [Nadezda.Belonogova@lut.fi](mailto:Nadezda.Belonogova@lut.fi)

COMPARISON OF DIFFERENT TECHNIQUES TO REDUCE PEAK POWER IN AN ELECTRICAL DISTRIBUTION SYSTEM – WITH EXAMPLES FROM GOTHENBURG AREA. David Steen, Tuan Le Anh, Lina Bertling and Ola Carlson. Division of Electric Power Engineering, Chalmers University of Technology. [David.Steen@chalmers.se](mailto:David.Steen@chalmers.se)



DEMAND RESPONSE INFORMATION EXCHANGE REQUIREMENTS. Jan Segerstam, Empower IM Oy, Finland. [jan.segerstam@empower.fi](mailto:jan.segerstam@empower.fi)

THE ROLE AND BUSINESS POTENTIAL OF CUSTOMER LOAD CONTROLS IN ELECTRICITY RETAILER'S SHORT-TERM PROFIT OPTIMIZATION. Petri Valtonen, Jarmo Partanen, Nadezda Belonogova and Jussi Tuunanen. Lappeenranta University of Technology (LUT). [petri.valtonen@lut.fi](mailto:petri.valtonen@lut.fi)

CUSTOMERS AND NON-ECONOMIC INCENTIVES. Poul Brath [ [POBRA@dongenergy.dk](mailto:POBRA@dongenergy.dk) ]

## **SESSION 7: ELECTRIC VEHICLES**

**KEYNOTE:** EV PROJECTS IN SWEDEN. Sten Bergman, Elforsk.

**KEYNOTE:** EV PROJECTS IN DENMARK. Ole Alm, ChoosE.

ELECTRIC VEHICLES' IMPACT ON THE POWER QUALITY IN LOW-VOLTAGE NETWORKS – TWO CASE STUDIES. Morten Møller Jensen. [morten@mollerjensen.eu](mailto:morten@mollerjensen.eu)

GRID IMPACT OF EV CHARGING IN GREEN CAMPUS ENVIRONMENT. Ville Tikka, Jukka Lassila, Henri Makkonen and Jarmo Partanen. Lappeenranta University of Technology (LUT). [ville.tikka@lut.fi](mailto:ville.tikka@lut.fi)

NETWORK IMPACT FROM DIFFERENT ELECTRIC VEHICLES DURING SLOW CHARGING. Tarjei Solvang and Helge Seljeseth, SINTEF Energy Research. [tarjei.solvang@sintef.no](mailto:tarjei.solvang@sintef.no)

## **SESSION 8: SMART METERING**

SMARTREGIONS - PROMOTING BEST PRACTICES OF INNOVATIVE SMART METERING SERVICES TO EUROPEAN REGIONS. Hanne Sæle and Dag Eirik Nordgård, SINTEF Energy Research. [Hanne.Saele@sintef.no](mailto:Hanne.Saele@sintef.no)

BENEFITS FROM AMR INVESTMENTS. Per-Olof Nylén, Vattenfall Research and Development AB. [per-olof.nylen@vattenfall.com](mailto:per-olof.nylen@vattenfall.com)

## **SESSION 9: DISTRIBUTION NETWORKS AND COMPONENTS**

DYNAMIC CAPACITY RATING FOR WIND COOLED OVERHEAD LINES. Elisabeth Lindberg\*, Arne Bergström\*\*, Urban Axelsson\*, \*Vattenfall Research and Development, \*\*Vattenfall Distribution. [Elisabeth.lindberg@vattenfall.com](mailto:Elisabeth.lindberg@vattenfall.com), [urban.axelsson@vattenfall.com](mailto:urban.axelsson@vattenfall.com)

COMMISSIONING INSPECTION OF LVDC DISTRIBUTION NETWORK. Pasi Nuutinen, Pasi Peltoniemi, Tero Kaipia, Pertti Silventoinen, Lappeenranta University of Technology (LUT). [pasi.nuutinen@lut.fi](mailto:pasi.nuutinen@lut.fi)

EXPERIENCES FROM a TESTPROJECT in Norway Using composite POLES IN 132 kV OVERHEAD LINES. Erling Tønne, Jan A Foosnæs and Vidar Dale, NTE Nett AS / NTNU. [erling.toenne@nte.no](mailto:erling.toenne@nte.no)

GROUNDING SYSTEM –KNOWLEDGE OF SOIL RESISTIVITY. Mats Wahlberg, Sarah Rönnerberg and Martin Lundmark, Luleå Tekniska Universitet. [mats.wahlberg@ltu.se](mailto:mats.wahlberg@ltu.se)

FAILURES IN MV JOINTS (XLPE CABLE) IN HEAVY LOADED CABLE SYSTEMS CONNECTING LARGE WINDMILLS TO THE DISTRIBUTION SYSTEM. Jens Zoëga Hansen, Danish Energy Association. [jzh@danskenergi.dk](mailto:jzh@danskenergi.dk)

30 YEARS OF EXPERIENCES WITH DRY CURED XLPE CABLES IN DANMARK. Jens Zoëga Hansen, Danish Energy Association. [jzh@danskenergi.dk](mailto:jzh@danskenergi.dk)

On the screening failure of transmission lines caused by non-vertical stepped leader channels. Vernon Cooray. Uppsala University, Uppsala, Sweden  
[Vernon.Cooray@angstrom.uu.se](mailto:Vernon.Cooray@angstrom.uu.se)

ON CONSIDERING TOPOLOGY CHANGES IN NETWORK RENOVATION. Juha Haakana, Tero Kaipia, Jukka Lassila and Jarmo Partanen. Lappeenranta University of Technology (LUT). [juha.haakana@lut.fi](mailto:juha.haakana@lut.fi)

INTER-ORGANIZATIONAL CHALLENGES OF UNDERGROUND CABLING IN THE RURAL AREAS. J. Sorri<sup>1</sup>, O. Bergius<sup>2</sup>, O.Teriö<sup>1</sup>, P. Pakonen<sup>2</sup>, P. Verho<sup>2</sup>. <sup>1</sup>Department of Civil Engineering, <sup>2</sup>Department of Electrical Energy Engineering, Tampere University of Technology, Tampere, Finland. [jaakko.sorri@tut.fi](mailto:jaakko.sorri@tut.fi)

FEASIBILITY OF NON-BACK-UPPED RADIAL CABLE LINE SECTIONS IN POWER DISTRIBUTION NETWORKS. Eero Saarijärvi, John Millar and Matti Lehtonen, Aalto University. [eero.saarijarvi@aalto.fi](mailto:eero.saarijarvi@aalto.fi)

## **SESSION 10: ENERGY EFFICIENCY**

SPECIFICATION AND DESIGN OF DISTRIBUTION TRANSFORMERS FOR ENERGY EFFICIENCY. Thomas Fogelberg, ABB AB Sweden, John-Bjarne Sund ABB A/S Norway, Manoj Pradhan, ABB Corp Research, Sweden. [Thomas.fogelberg@se.abb.com](mailto:Thomas.fogelberg@se.abb.com)

EFFECT OF LARGE SCALE ENERGY STORAGE ON CO<sub>2</sub> EMISSIONS IN SCANDINAVIAN PENINSULA. Nicholas Etherden, Math Bollen STRI AB/Luleå University of Technology. [Nicholas.etherden@stri.se](mailto:Nicholas.etherden@stri.se)