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# Svenska kraftnät

Power System Communications – Essential Parts of a  
Future Smart Grid

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Chalmers 2019-10-07



# Power system

- > 15 000 km power lines
- > 160 substations
- > 16 international connections
- > National Control Centre:  
Sundbyberg
- > Nordic Monitoring center in  
Copenhagen, in operation 2017



# National – Regional and local networks

## National Grid

- 400 and 220 kV
- Svenska Kraftnät

## Regional networks

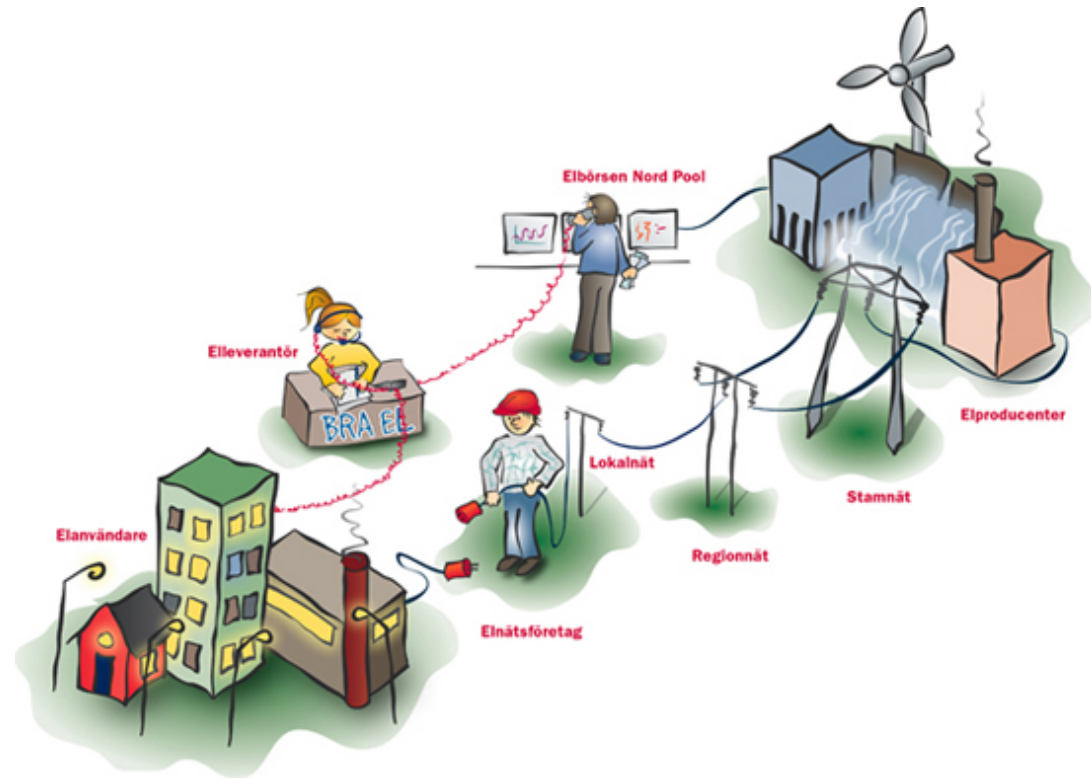
- 40 – 130 kV
- ~ 40 networks
- 10 companies

## Local networks

- < 40 kV
- ~ 310 networks
- ~200 companies

## Home

- 230 V



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# Transmission system operators (TSO)

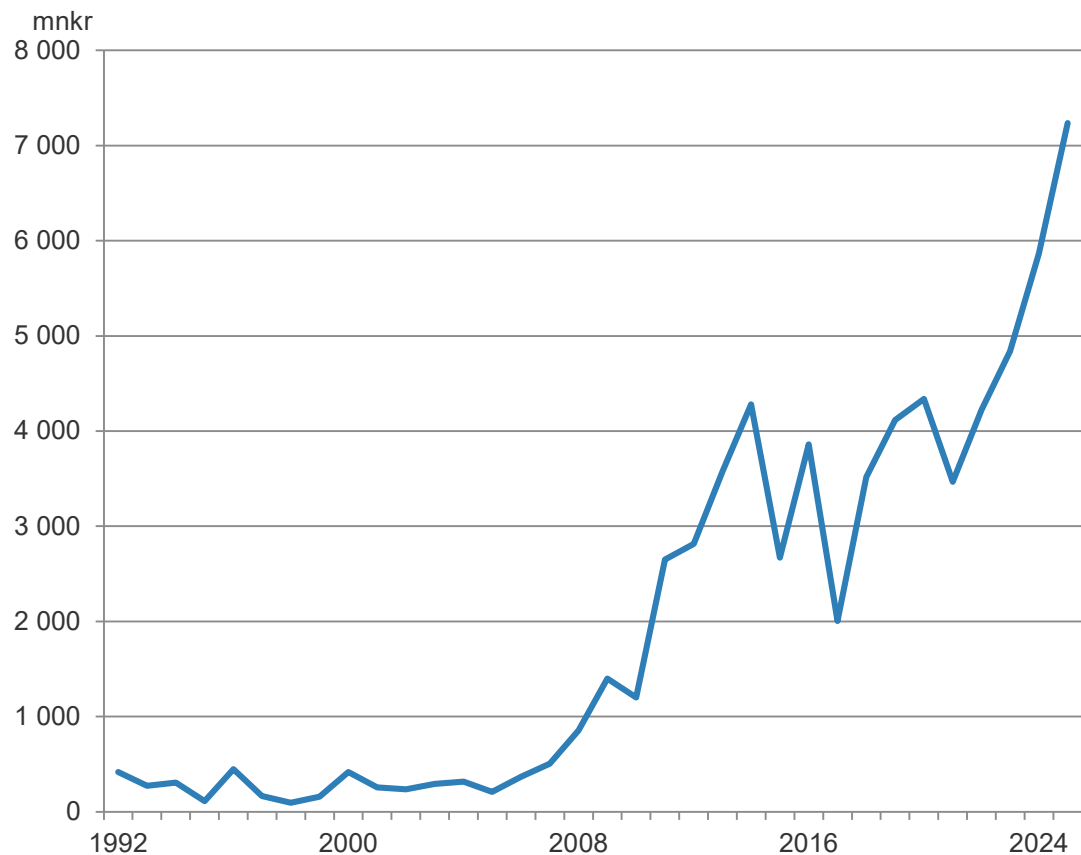


National grid =  
Highway for electricity

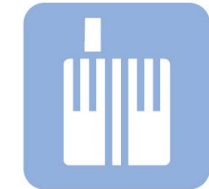
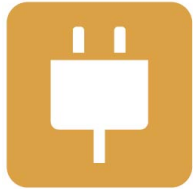
Highest voltage  
(400 kV and 220 kV)



# Investments



# Balance between generation and demand



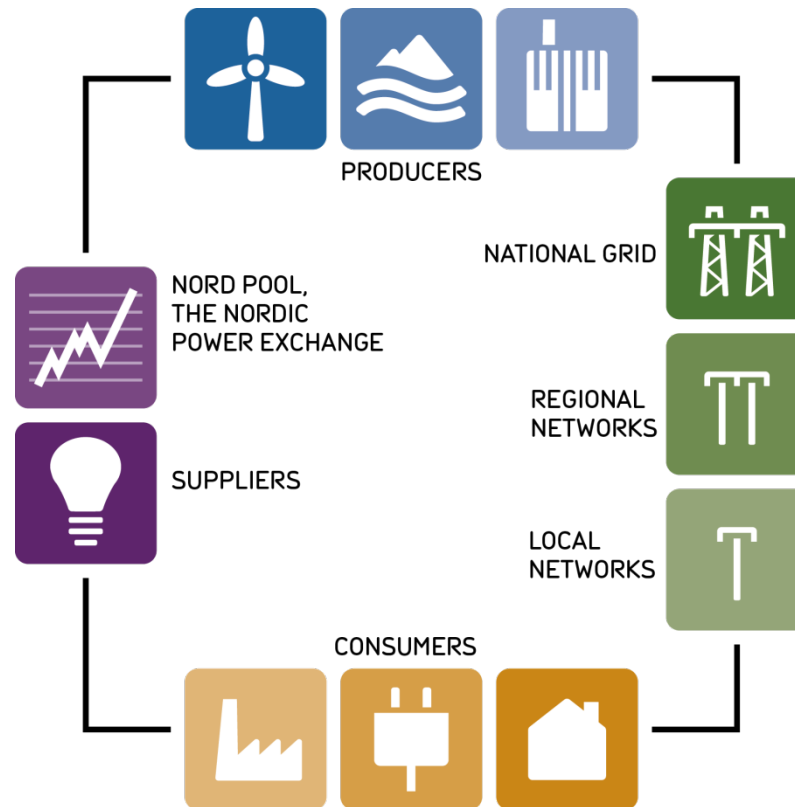
ELECTRICITY  
CONSUMERS



ELECTRICITY  
PRODUCERS

# The route of electricity

## – actors in the electricity market



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# Electricity – Basis for a modern society

- Internet
- Mobile networks
- Payment systems
- ...





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# Broad scope

- > Energy supply
- > Infrastructure – critical for society
- > Environment
- > Technology
- > Market issues
- > National – Nordic – International



# Deeper...

- > Power flow – equations
- > Technical solutions
- > Price settings for the electricity market

Power Flow Equations Part 2

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POWER FLOW EQUATIONS PART 2

$Z = R + jX$

$Z = \frac{V_{12} - V_{21}}{I} = \frac{V_{12}}{I} = Y_{12} V_{12}$

$I_1 = \sum_{j=1}^N Y_{1j} V_j = \bar{I}_{11} - \bar{I}_{12}$

$Z = R + jX$  (Impedance)

$Z = R + jX$  (Reactance)

$Y = \frac{1}{Z} = G - jB$  (Admittance)

$Y = \frac{1}{Z} = G - jB$  (Susceptance)

$Y = \frac{1}{Z} = G - jB$  (Conductance)

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# Challenges

- > "Nybygggaranda" – Building new power grid infrastructure
- > Decision process – can be extensive and long in time
- > Renewables: Windpower, intermittent.
- > Nuclear power reduced to 2020?



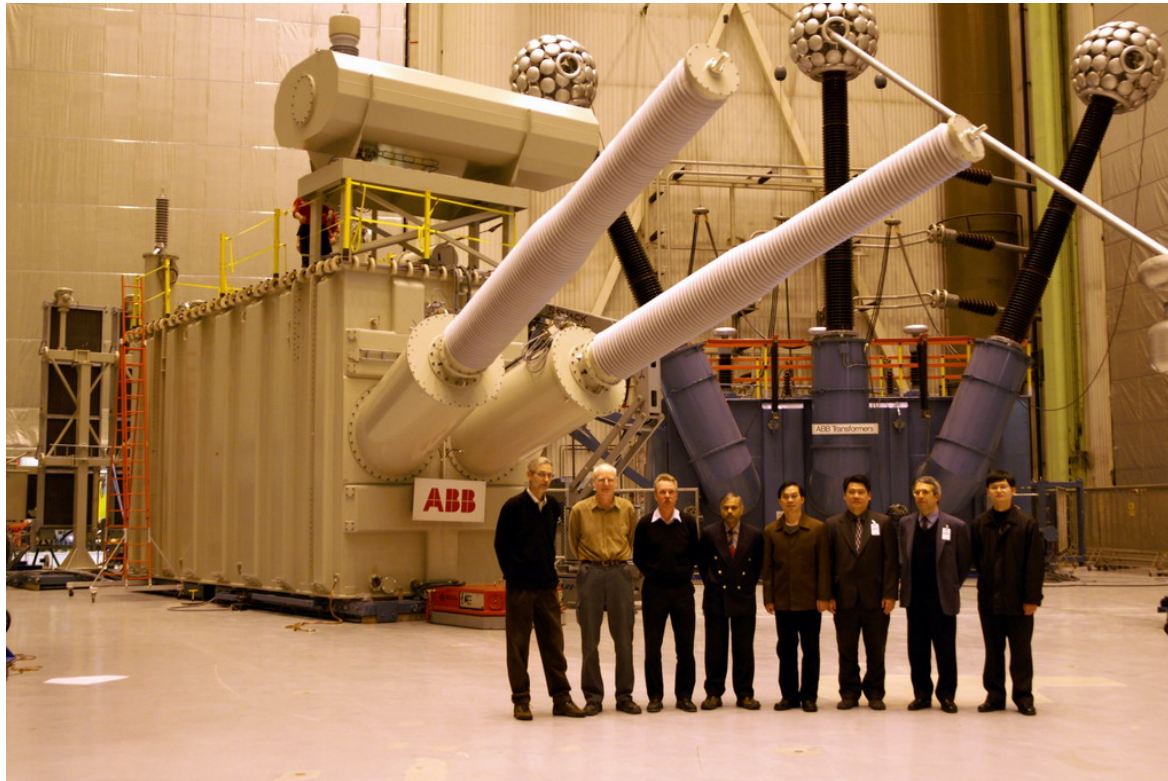
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# Dam – Three Gorges China



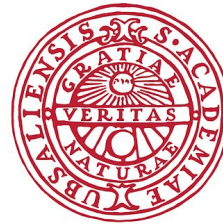
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# Transformer for Three Gorges-Shanghai



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# Research



UPPSALA  
UNIVERSITET



**CHALMERS**  
UNIVERSITY OF TECHNOLOGY



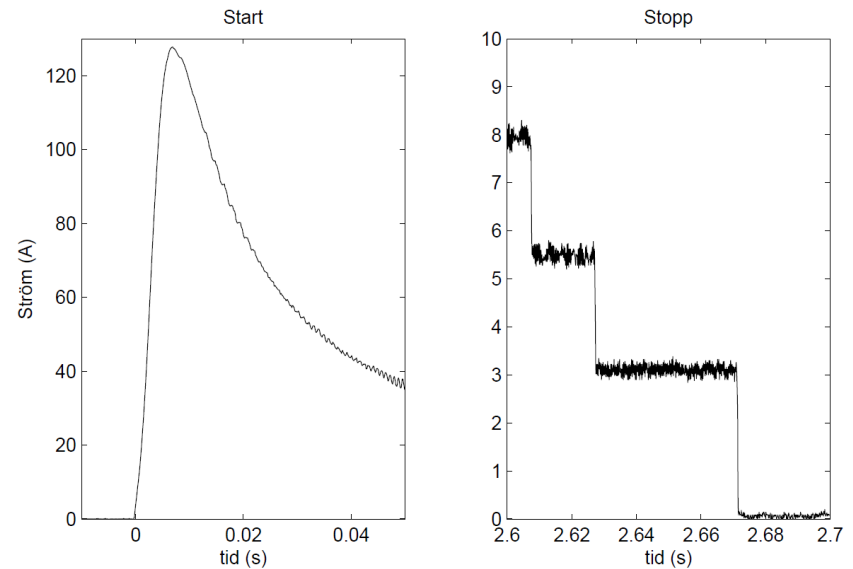
**LUNDS UNIVERSITET**  
Lunds Tekniska Högskola



# Maintenance

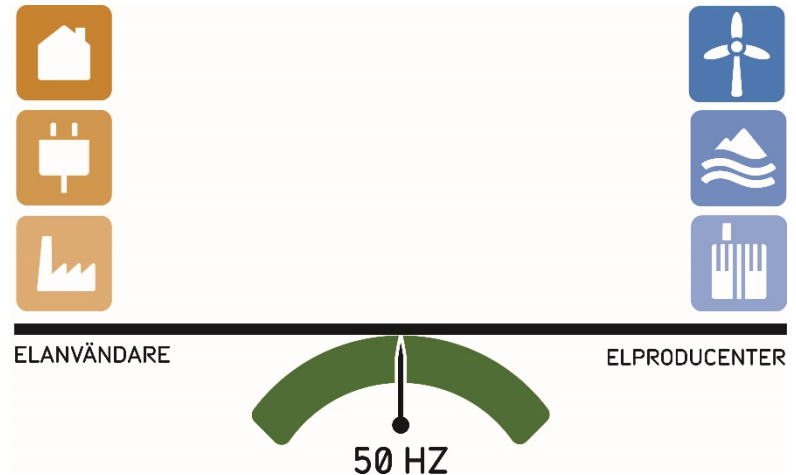


# R&D project: Automated data collection for management purposes





- > Balance between production and consumption of electricity



## OPTONÄTET I SVERIGE

- SVK OPTOFIBER
- PLANERAD OPTOFIBER
- INHYRD OPTOFIBER



# Optical fibre network – to supervise and control the power network

- Approx 9500 km own optical fiber
- Dark fiber – surplus capacity is leased out
- Main customers: big telecom operators or energy companies (operation communication)'
- OPGW – Optical Ground Wire: Most of the fibers are installed in the ground wire.
- Wrapping – not North of Dalälven (due to climate)



# Svenska kraftnät's optical fiber network

- From North (Ritsem) to South (Sege)
- Telecom operators and city networks connect to technical sheds in the network
- High availability



# The fiber network is constantly being developed

During 2016 increase of 900km

Southwest link (approx 500km) for more secure power delivery in Southren Sweden

- Hallsberg – Motala - Nässjö- Värnamo – Hässleholm – Hörby
  - Technical sheds in Östansjö – Barkeryd – Lindstad - Hurva
  - Partly placed in the ground
  - 48 fibers



# Connection points



- Splicing box mounted on pylon
- Technical sheds - Customers can access the equipment themselves



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# Smart Grids ("intelligenta elnät")

## Definitions

- > **"The application of digital technology to the electric power infrastructure"**
  
- > ....and many more

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# 'Smart Grids' may be good – but who pays?

- > The end-user always pays
- > Smart Grids must be the smartest and most economical way of solving the problems
- > Smart Grids must be driven by sound business based incentives
- > Smart Grids shall support reduction – not raise – of the energy price



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# What can be smart?

- > Not the power lines themselves

But:

- > The applications in the nodes (connection points)
- > Protection, Control and Automation Equipments (Kontrollanläggningar)
- > SCADA/EMS systems for supervisory control
- > The customers!

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# More digitalized

- > Substations
- > Advanced supervisory control systems

*and*

- > Meter/equipment at customer premises

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# Development of communication capabilities

- > From
- > Small, narrowband paths in the woods ("kostigar")

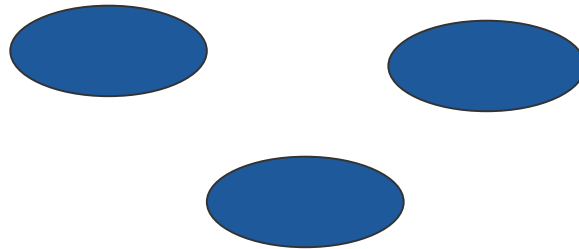
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- > To
- > Broad, 7-lane highways

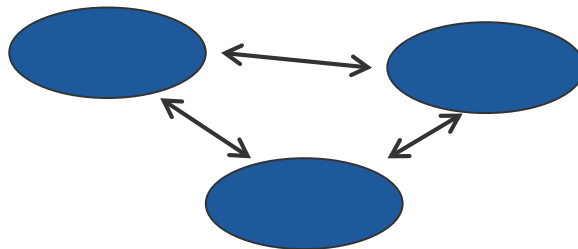
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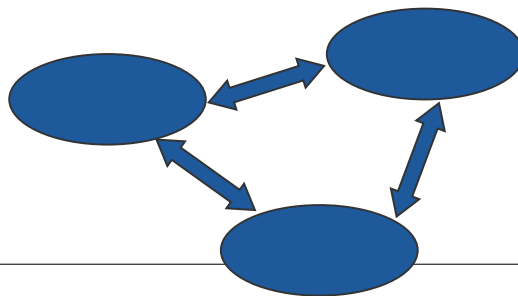
# Development of Industrial Control Systems 1(2)



1. Islands of operation



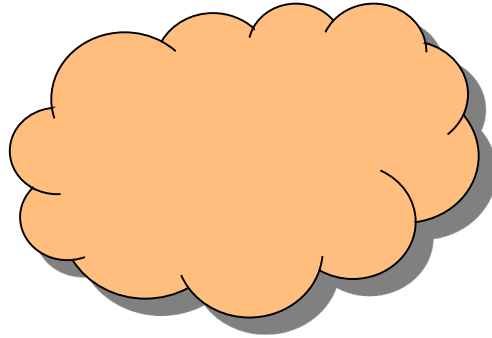
2. Interconnected



3. Partially Integrated

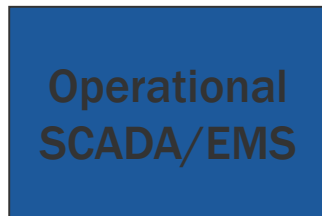
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# Development of Industrial Control Systems 1(2)

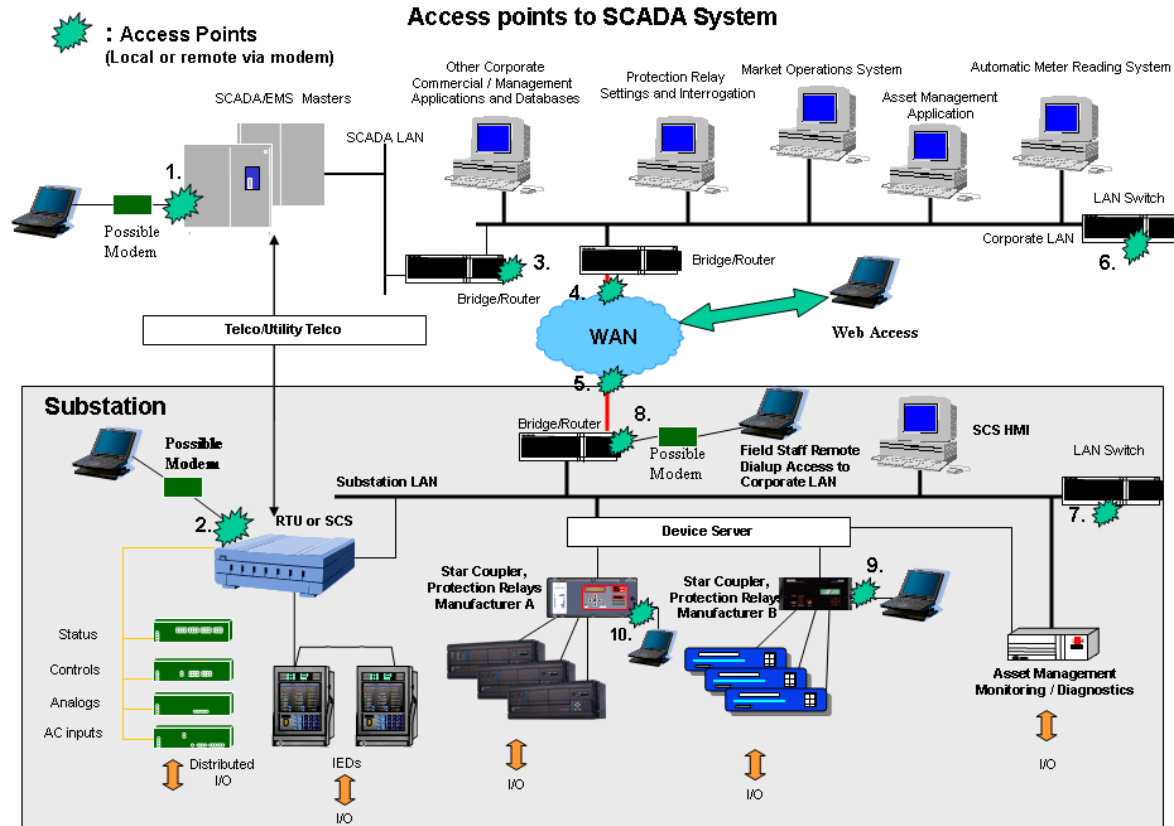


4. Today. Full integration system structure

5. De-coupling between Operational SCADA/EMS and Admin IT environments



# Access points to SCADA-system Threat and possibilities



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# SCADA-system

## Supervisory Control And Data Acquisition

- > Increasingly accessible via Internet
- > Same technical solution as common administrative IT-systems
- > Integrated with administrative IT-systems
- > ***Same vulnerabilities for SCADA-systems as for administrative IT-systems! What to do?***
- > Disturbances have impact on critical infrastructures
  - > *Power, water, oil/gas, transport*
- > CIP = Critical Infrastructure Protection
- > CIIP = Critical **Information** Infrastructure Protection

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# "AIC" rather than "CIA" in electric arena – Delicate issues!

> Confidentiality ("Sekretess")

> Integrity ("Riktighet")

> Availability ("Tillgänglighet")

=> Low priority for Confidentiality – Risk for Intrusion?

> SCADA Security

> Enormous need for education – awareness!



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# Smart meters – How to deal with the cybersecurity issues?

- > Technical possibilities. Broadband => faster, bulky
  - > From the households:
    - > collect kWh-data, basis for billing
  - > To the households
    - > Price information
    - > **Controls** – opens up new cyber security issues
  - > ***“Which party will be responsible when, by mistake or by intentional digital tampering, a household is disconnected for two weeks, and that the owner of the house gets damages by destroyed food or water leakage, when he is away on two weeks of vacation?”***
    - > The owner? The utility? ...Who?
  - > These issues are clearly related to cyber security and they must be raised within the electric power arena.
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# Concluding remarks – Questions?

- > Climate goals => Introduction of renewables => change in power transmission
- > From islands-of-automation to fully integrated
- > Openness. Communication capabilities – fiber networks
- > Digital/Cyber security
  - > New issue for the utility
  - > Essential issue in a smart grid critical infrastructure
- > Smart Grid → Smart System

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# Svenska kraftnät Trainee program

- > Startad 1998. One year program.  
80% still here!
- > Every even year. 2016, 2018, 2020,  
...
- > One "home unit" & 10 weeks practice
- > Personal and professional developm
- > Internship @ other TSO possible



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# Studie visit



International exchange of 3-6 months

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# Why trainees like working at Svenska kraftnät

- > Helpful colleagues
- > Keen that we develop and our health
- > 53 % female leaders
- > Learn new things every day!

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# General

- > Svenska kraftnät – authority/myndighet
- > Security clearance – prerequisite for employment
- > Fluent Swedish – documentations
- > Swedish citizenship – at least Nordic

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# Svenska kraftnät

- > 2019: 650 employees  
( 320 employees (2010) -> 420 employees (end 2011) )
- > Exjobb: [student@svk.se](mailto:student@svk.se)  
All presented at [www.svk.se](http://www.svk.se)

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# Thanks for your attention!

