SICS ICE –
DEVELOP AND TEST ENERGY EFFICIENT SOLUTIONS

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Research Institutes of Sweden
SICS North

FUTURE OUTLOOK

Industrialization – Innovation based on power

New-industrialization – Innovation based on data(power)

CREATING DIGITAL REPRESENTATIONS






temp
noise
air_quality
occupancy
energy
water

vibration
temperature
traffic_intensity
surface_condition
noise_level
route_to_work

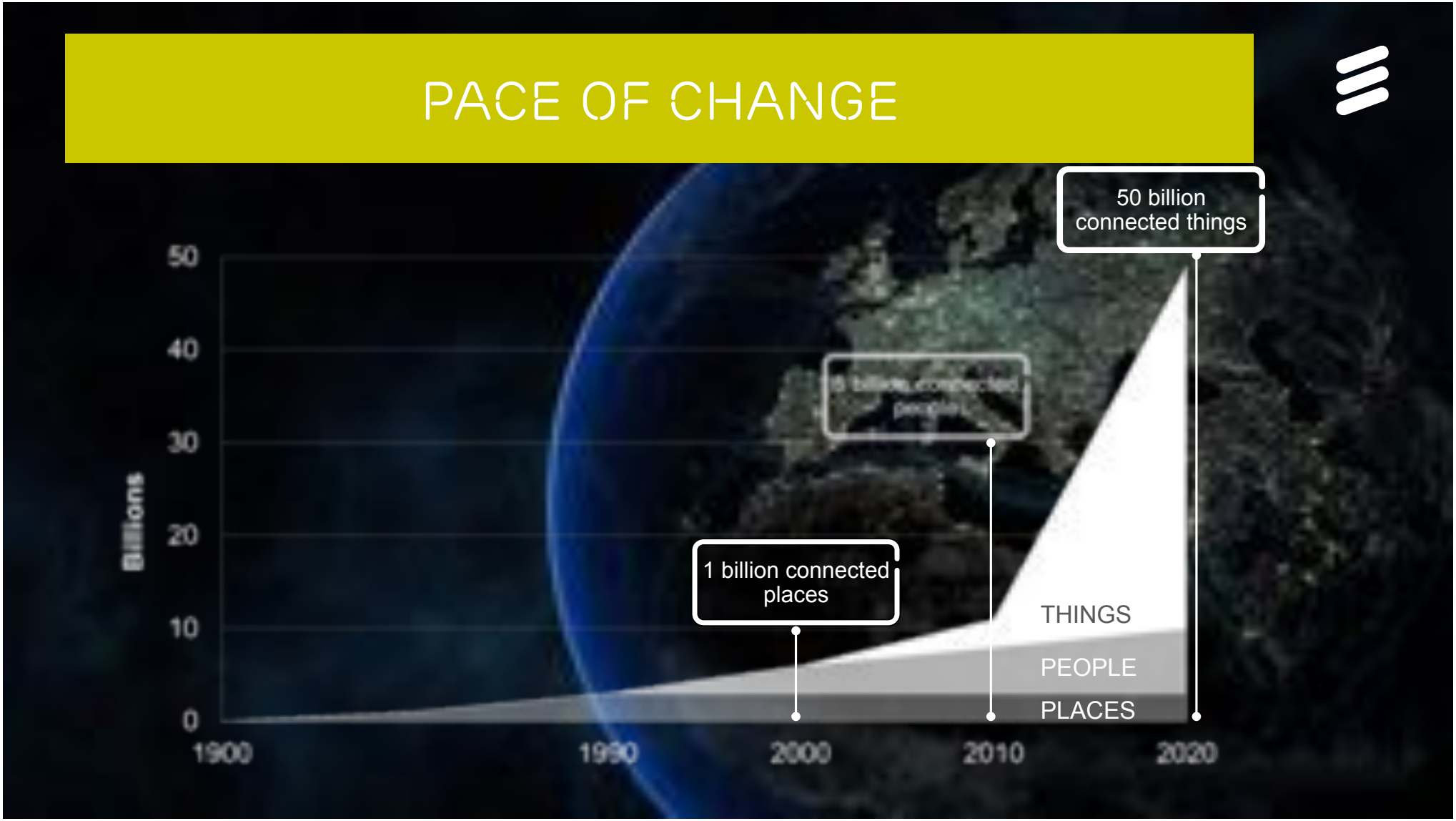
energy
water
waste
CO2_emission
machine_tear
production

heart_rate
skin_conductance
gesture
mood
position
movement

location
occupancy
fuel
emissions
speed

irrigation
luminosity
nutrition
moisture
pesticides

PACE OF CHANGE




WIRELESS ACCESS GENERATIONS
1G
2G
3G
4G
LTE
5G
~1980
~1990
~2000
~2010
~2020


Use cases
5G
USE CASES
BROADBAND AND MEDIA EVERYWHERE
SENSORS EVERYWHERE
SMART VEHICLES, TRANSPORT
INFRASTRUCTURE, MONITOR AND CONTROL
CRITICAL CONTROL OF REMOTE DEVICES
INTERACTION HUMAN-IOT

Diverse requirements

Application characteristics

Type	Response times	Data amount	Traffic amount	Cache	DC location
Cold storage	seconds	Gigabytes	Mb/s		remote
Off-line big data crunching	seconds	Gigabytes	Gb/s		remote
Chat/IoT type communication	100th milliseconds	kilobytes	kb/s		remote
Web/app rendering	100th milliseconds	Megabytes	Mb/s	Yes	remote
Streaming	10th milliseconds	Gigabytes	Mb/s	Yes	mix
Real-time conferencing	10th milliseconds	Megabytes	Mb/s	Yes	mix
Real-time analytics	milliseconds	Megabytes	Gb/s		proximity
Transaction based/Control loops	milliseconds	kilobytes	kb/s		proximity

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Green is becoming a requirement

Source: Greenpeace 2014

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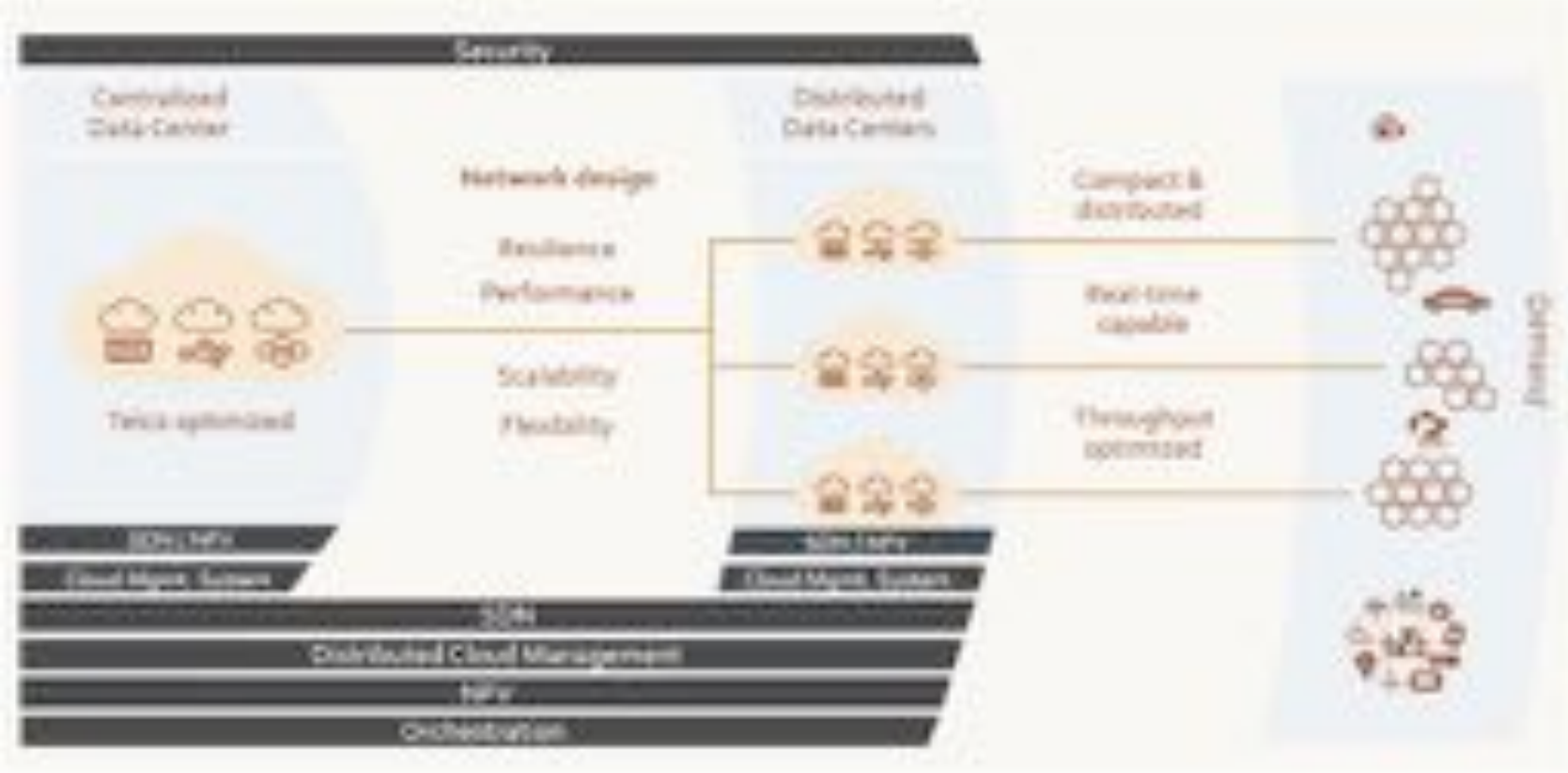
Greenpeace Clicking Clean 2015

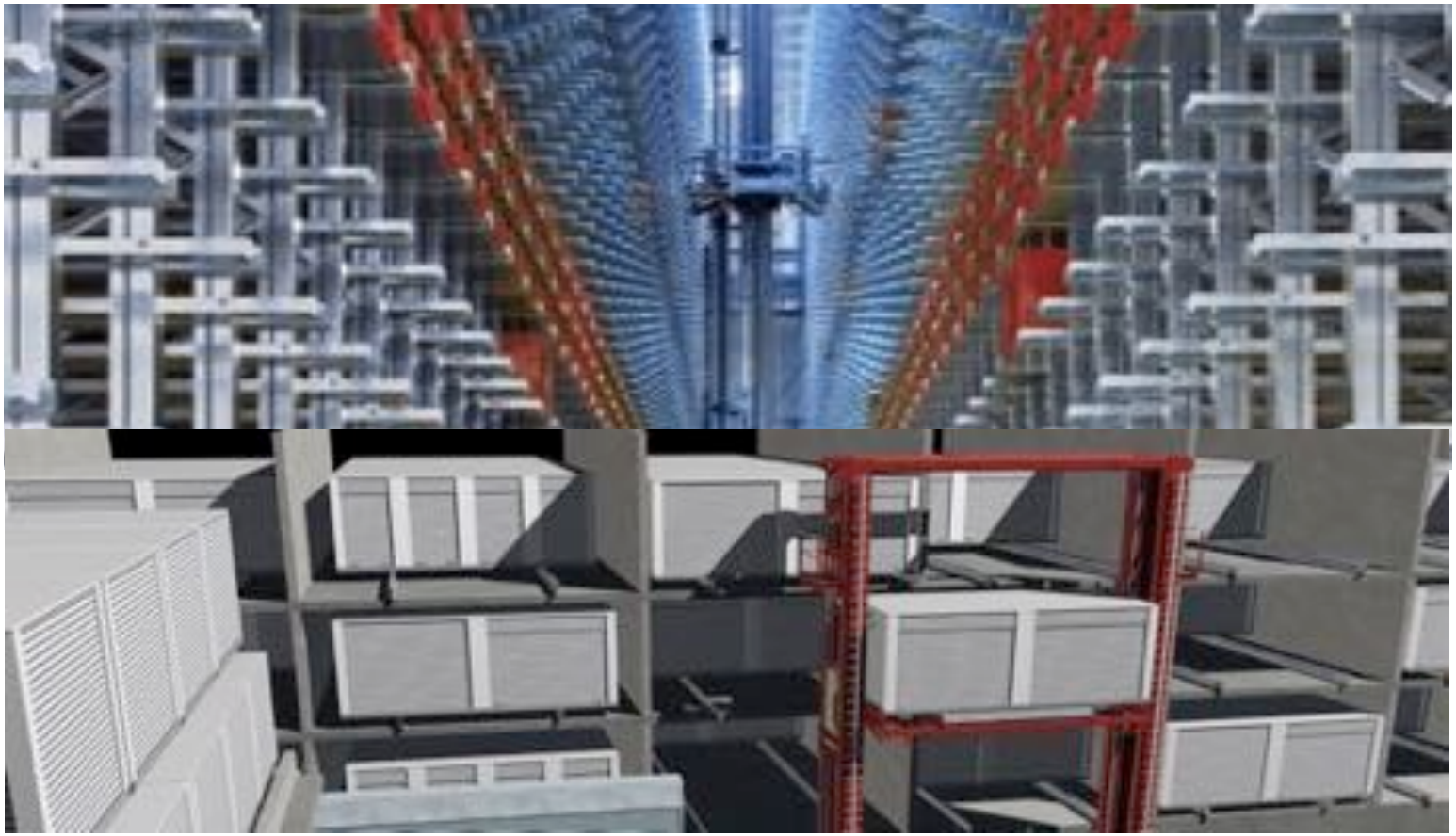
FUTURE DATACENTER AREAS OF HIGH INTEREST

A distributed cloud

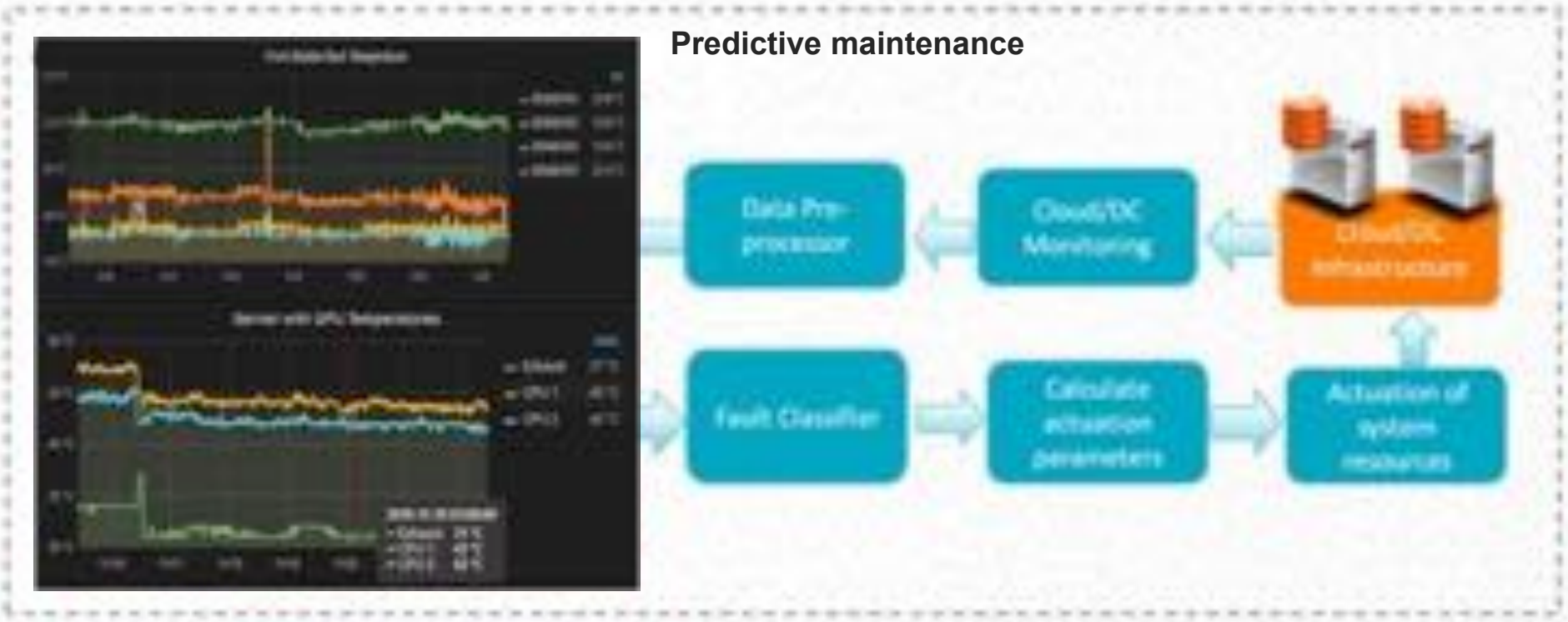


Central Macro Micro Pico

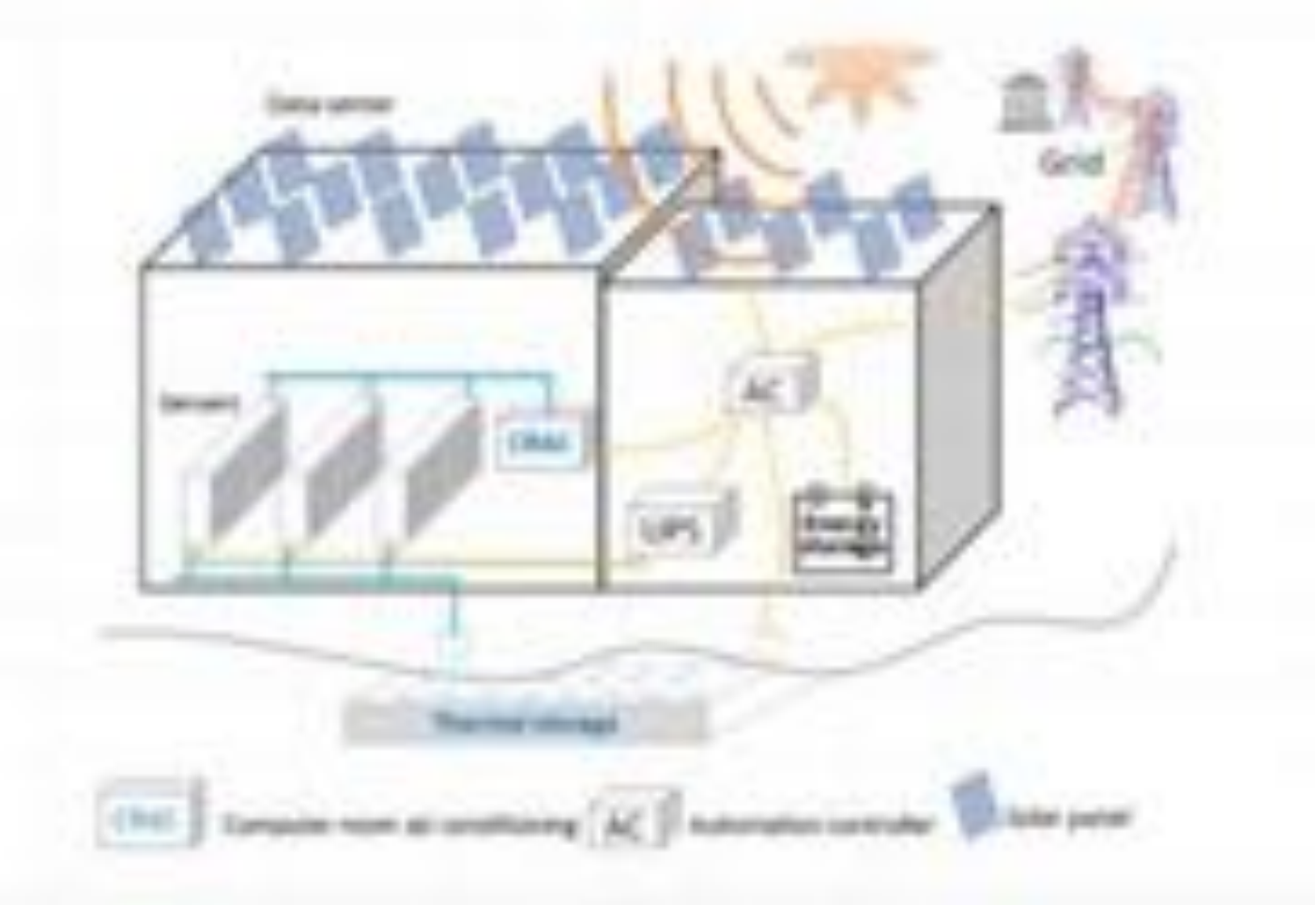
Autonomous operations



Machine learning in datacenter operations

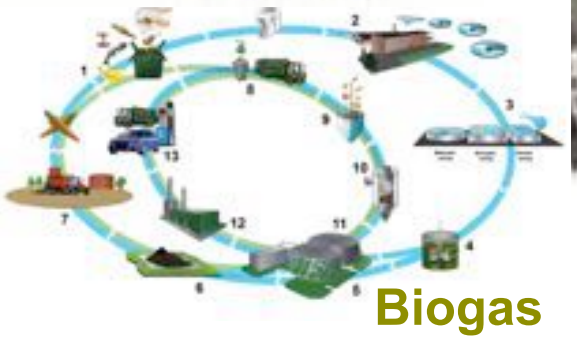


Smart utility grid interaction



Beyond the heat pump

Wood

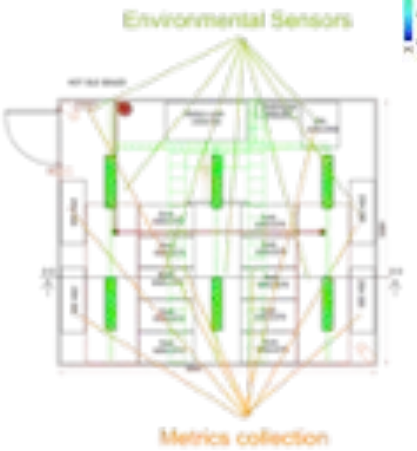


Biogas

Water & soil

Waste

Holistic climate & thermal control

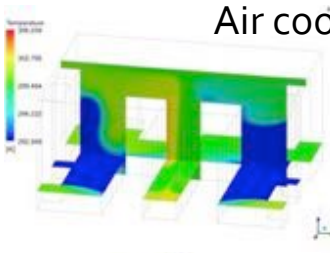


Raw data

ZABBIX

kafka

Data flow



Air cooling

Liquid cooling

Operation, Maintenance & Automation

Analytics on real-time data

FLINK

Analytics on Historical data

APACHE Spark

HIVE

OPENTSDB

elasticsearch

APACHE HBASE

hadoop HDFS

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Datacenter generations

Generation	Power distribution	Cooling infrastructure	IT system	Energy use
Generation 1 Old School DC	Stand-alone, N+1, many transformation steps. diesel backup	Compressor cooling, no containment, raised floor	Monolithic applications, low grade of automation	PUE > 1.8 High energy use
Generation 2 Internet DC	Some local green power production, reduced diesel backup	Free-cooling and compressor, hot and cold isle, heat pumps	Some monolithic and virtualized applications, monolithic automation	PUE < 1.5 Modest energy use, some energy re-use
Generation 3 Green DC	380 VDC, only green power production, no diesel backup	Air-based free-cooling combined with heat re-use, air flow tech	SDN, Fully virtualized IT, software redundancy, integrated automation	PUE < 1.2 High energy efficiency, energy re-use
Generation 4 Integrated society DC	Grid integration, micro grids, load balancing, wood building	Liquid cooling, closed loop energy system, predictive operation	SD-DC, holistic automation, robot maintenance, distributed compute	PUE < 1.1 Fully integrated in electrical & thermal grid

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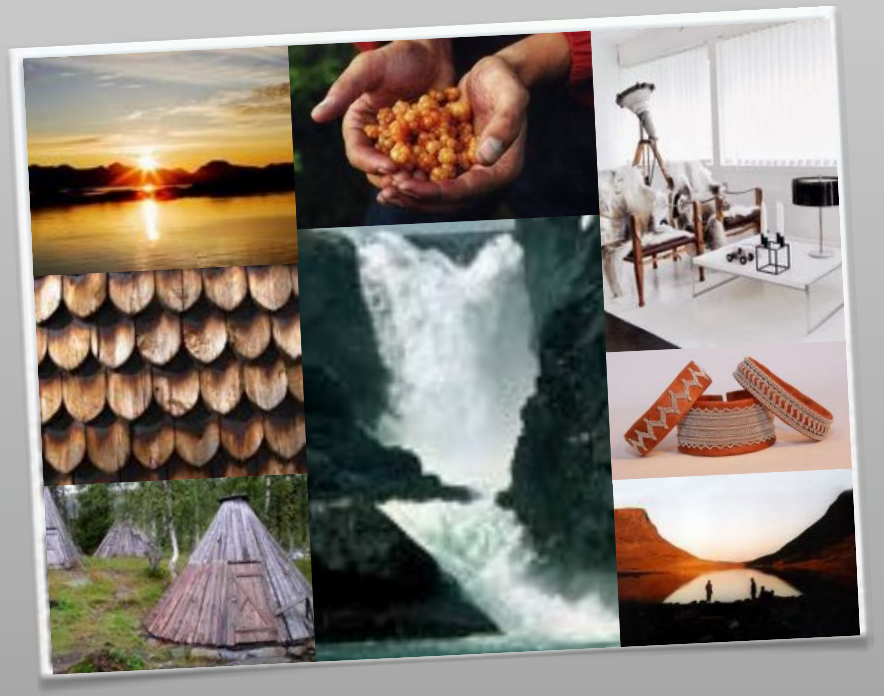
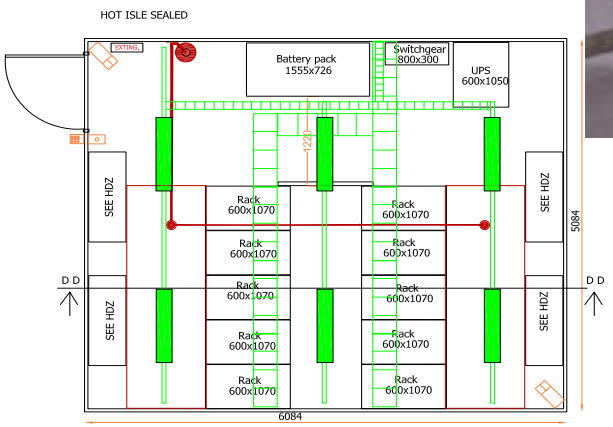
SICS - ICE
A LARGE SCALE DATACENTER RESEARCH & TEST ENVIRONMENT

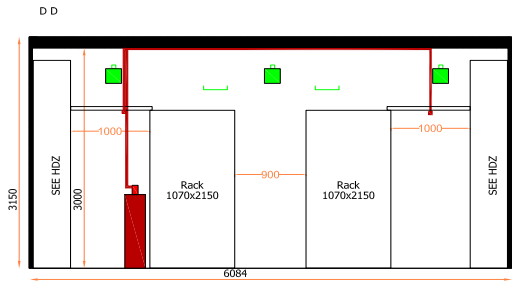


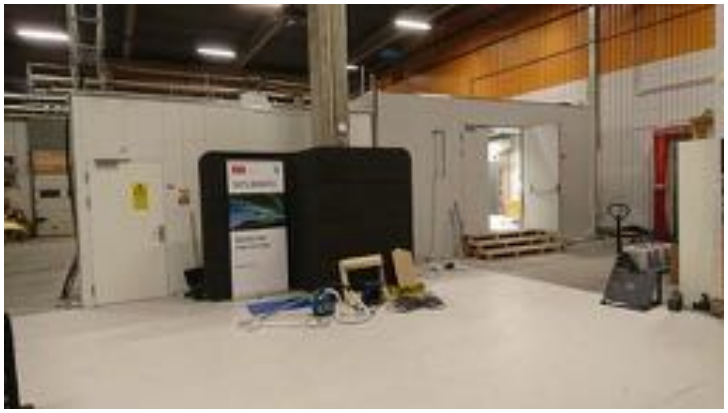
SICS ICE research facility

A large-scale datacenter research and test environment

Purpose: Increase knowledge, strengthen universities & companies, attract researchers







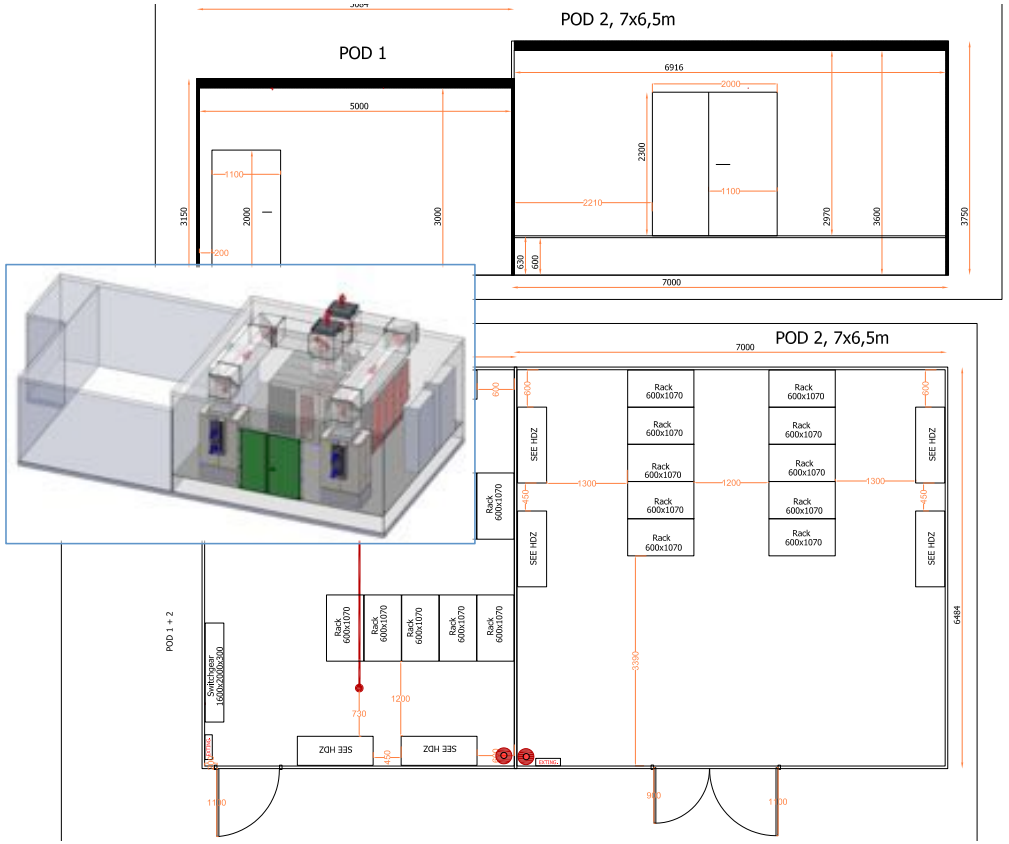
R&D institute, 3 lab modules, 1000 servers, 240 kW

A web-scale compute cluster

160 Dell servers in module 1

- 3600 cores
- 40 TB RAM
- Up to 7 petabyte harddisk
- 10/40 Gb/s network
- Separate management network

Module 2 – A flexible lab



- Servers: OCP and Dell
- Prepared for free-air cooling
- Fast connectors for water, power and fiber
- Raised floor for tiles or hard-top air-flow handling
- Double door for easy equipment exchange

Business model

Experiment-as-a-Service

1. Compute capacity and tools for big data and cloud
   - Based on a Hadoop platform for Apache Flink/Spark
   - OpenStack and container platforms next step
2. Demonstration space for new products & solutions
   - Datacenter facility for solution integration
   - Show room for projects and products
3. Datacenter infrastructure for experiments and facility data
   - Flexible lab modules and re-configuration
   - Measurement equipment for energy, cooling, capacity etc
   - Measurement data access on-site or on-line
4. Competence for verticals and datacenter infrastructure
   - Support network of analytics and cloud researchers
   - Researchers & engineers for datacenter infrastructure support

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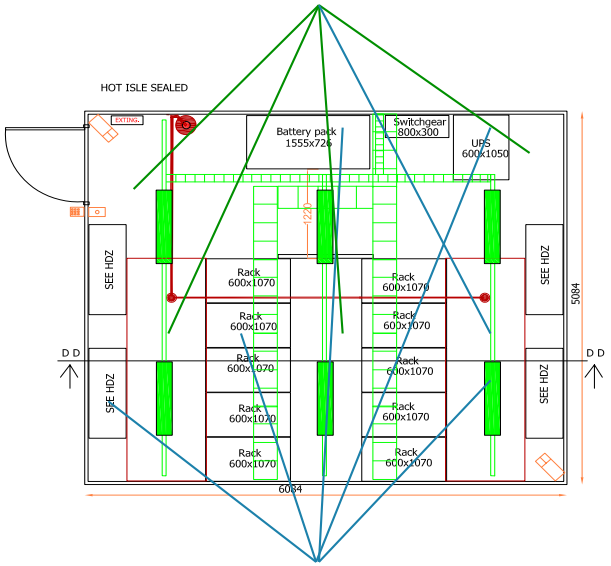
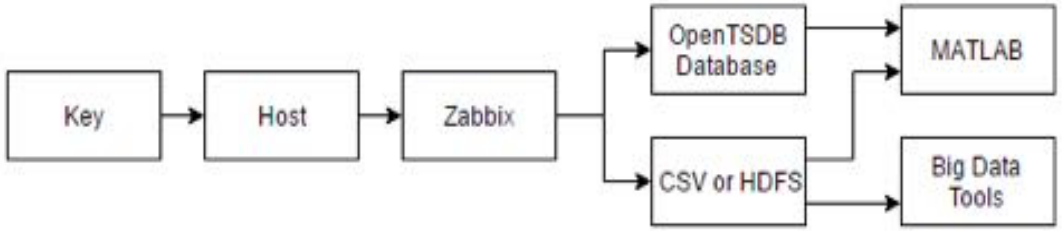
Data collection

Environmental sensors



Equipment metrics



Metrics collected in one module

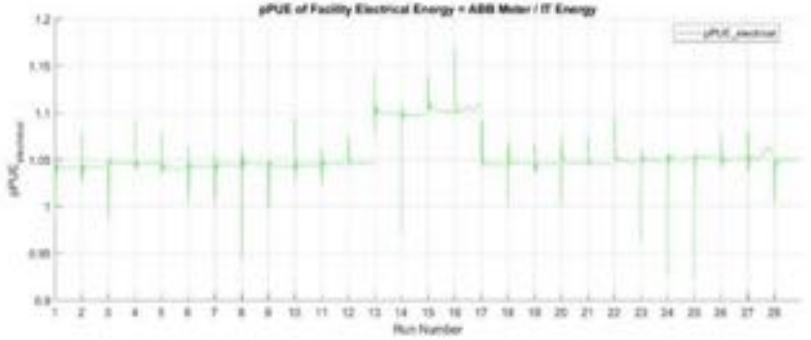
Measuring groups	Items	Note
Cooling measuring points	1418	Cooling, Servers, Weather Station, Environment
Power measuring points	5056	PDU, UPS, Servers, Switches
IT HW	22968	Servers, Switches, ping on all hosts
Other	101	Zabbix, EMC, Ext, Leak, PUE
	29622	

Total amount collected from one module 9 GB per day

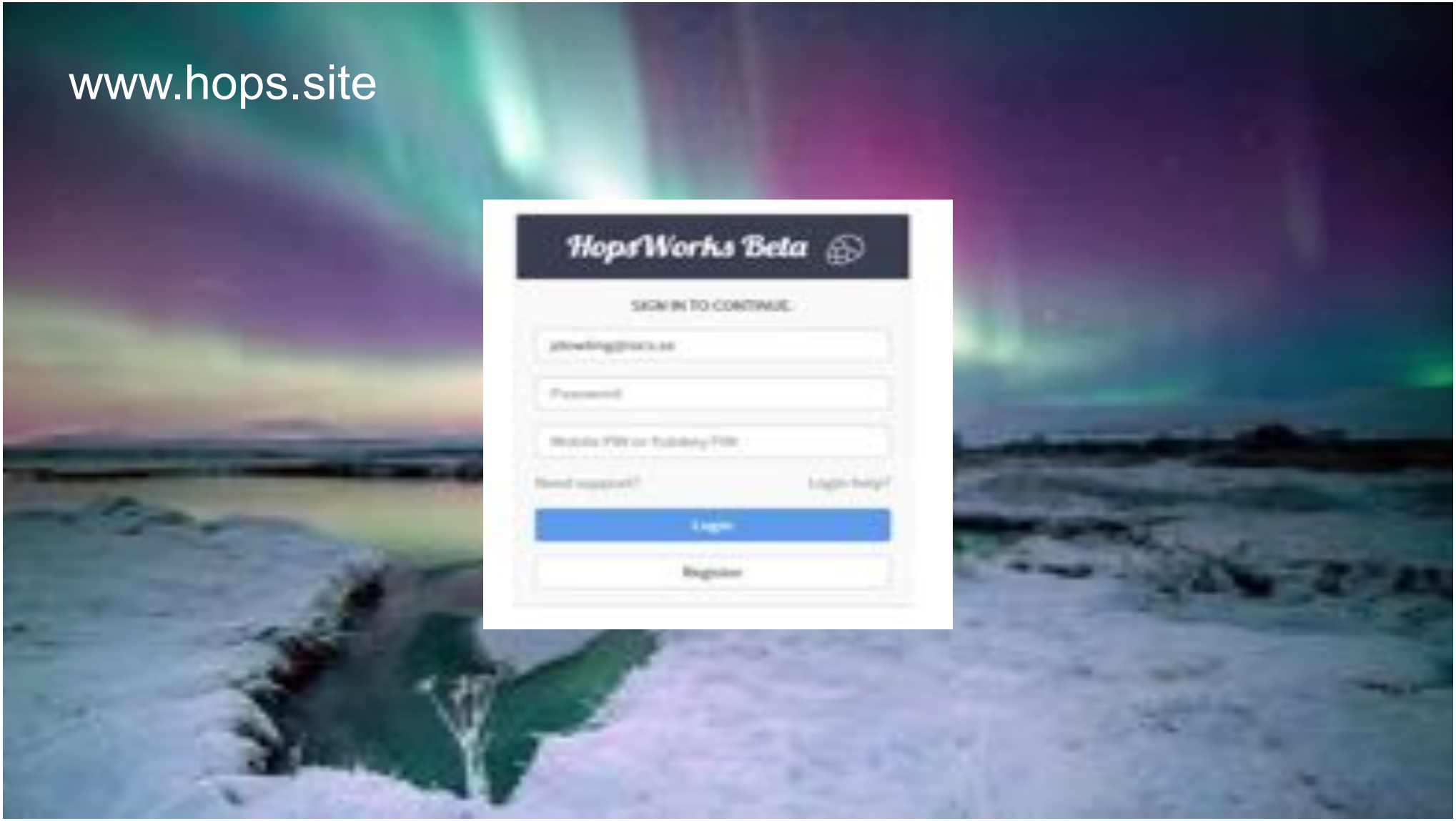
Example of a data collection run

Experiments performed during test week							
	Inlet temp	20 °C		23 °C		26 °C	
Liquid Temp	CPULoad / Door	50%	100%	50%	100%	50%	100%
15.5 °C	Closed	✓	✓	✓	✓	✓	✓
	Open	✓	✓	✓	✓	✓	✓
19.5 °C	Closed	✓	✓	✓	✓	✓	✓
	Open	✓	✓	✓	✓	✓	✓
23.5 °C	Closed					✓	✓
	Open					✓	✓
Standard Run: 0% load, 19.5°C liquid, 23°C air, Closed door							✓

pPUE (Electrical) Averaged							
	Air Temp	20 °C		23 °C		26 °C	
Liquid Temp	CPULoad / Door	50%	100%	50%	100%	50%	100%
15.5 °C	Closed	1.0410	1.0421	1.0410	1.0420	1.0409	1.0446
	Open	1.0455	1.0452	1.0437	1.0450	1.0441	1.0461
19.5 °C	Closed	1.0977	1.0980	1.0433	1.0453	1.0453	1.0469
	Open	1.1000	1.1086	1.0448	1.0455	1.0484	1.0494
23.5 °C	Closed					1.0517	1.0528
	Open					1.0551	1.0500



www.hops.site



Traditional Hadoop Model

Applications

Files

Users

Separate Clusters for Multi-tenancy: sharing is copying

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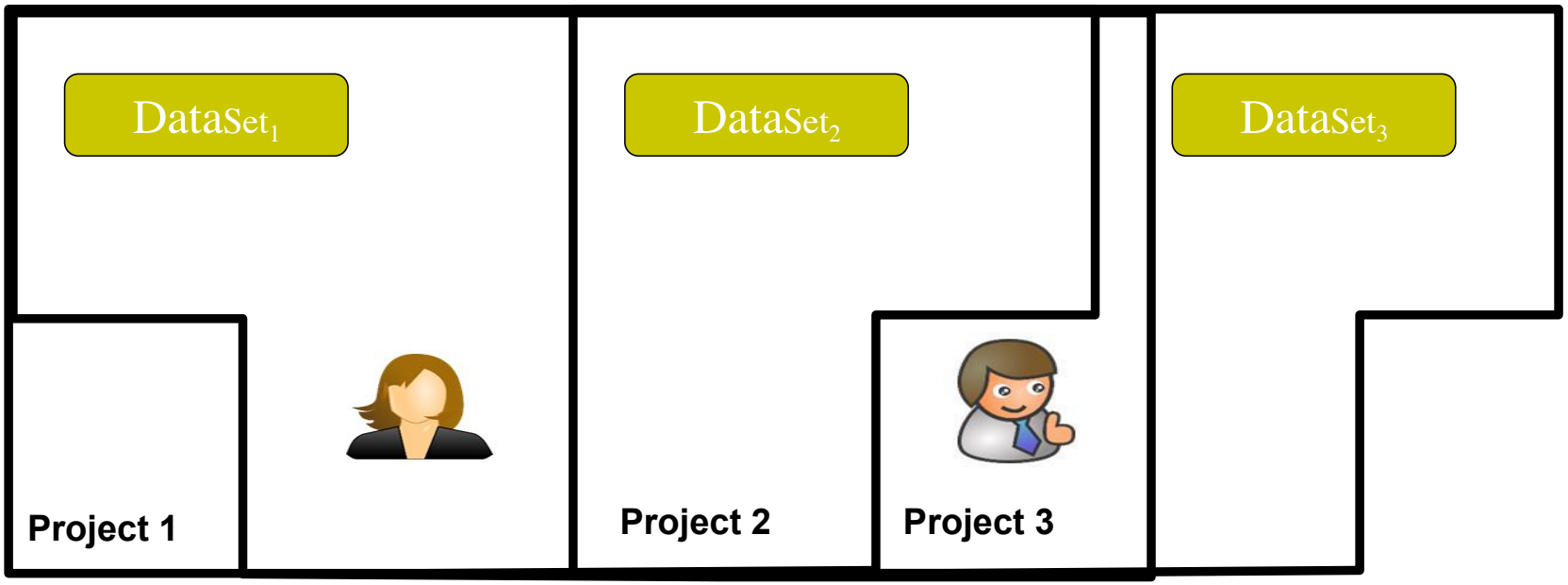
HopsWorks: Users, DataSets, and Projects



In-Place Data Sharing - no Copying!

No Cross-Linking DataSets across Projects!

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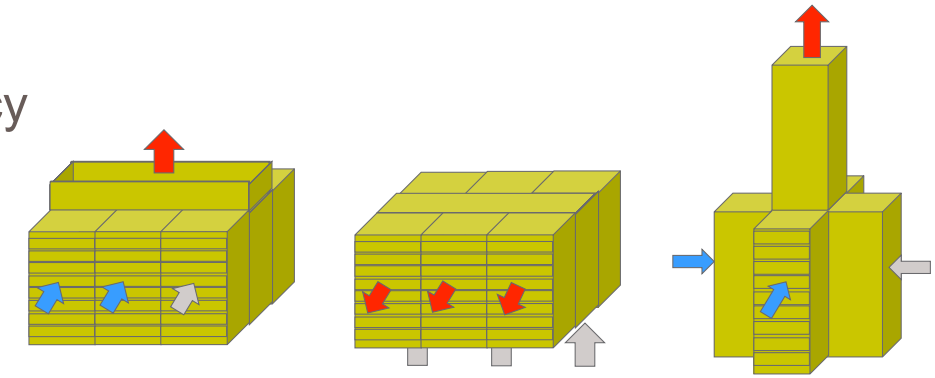
CURRENT PROJECTS AT RISE SICS NORTH

SENDATE EXTEND – Datacenter automation

- Project in the Celtic plus program of EUREKA.
- To improve the datacenter automation by doing holistic optimization.
- Target is to reduce overall overhead energy consumption by 50%.
- The total project cost amounts to 5,5 MEuro over three years.
- The main partners are SICS, Ericsson, ABB, KTH and LTU.

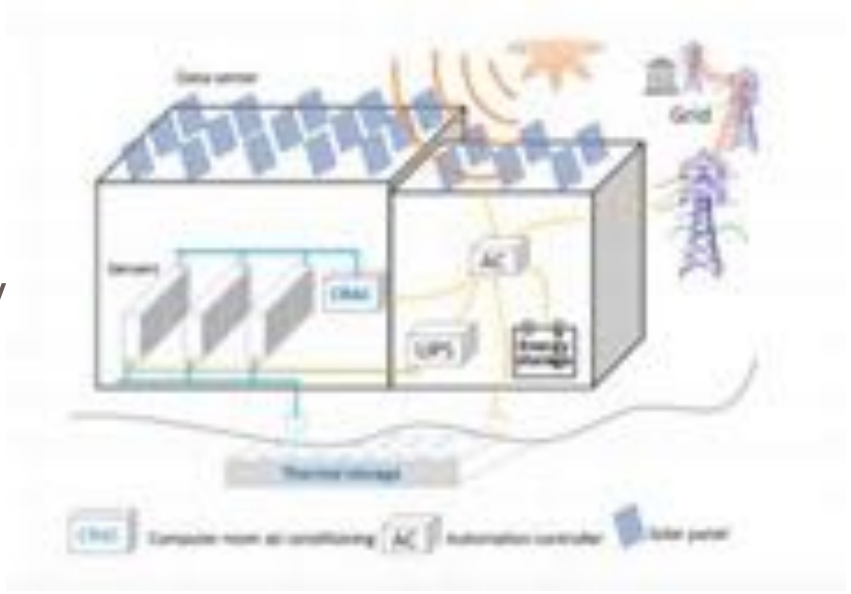
DRAFT - Datacenter Research on Air-Flow Technologies

- Project funded by Swedish Energy Agency
- To improve the air flow in datacenters to reduce the energy consumption in fans.
- Target is to reduce overall fan energy consumption by 50%.
- The total project cost amounts to 1 MEuro over two years.
- The main partners are SICS and LTU. Swegon, SEECooling, DCT & Siemon are stakeholders



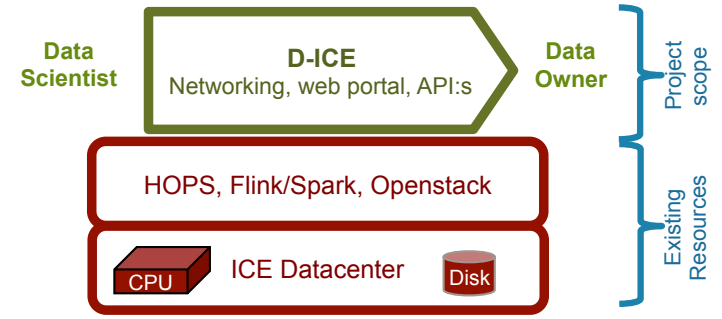
DMI – Datacenter Micro-grid Integration

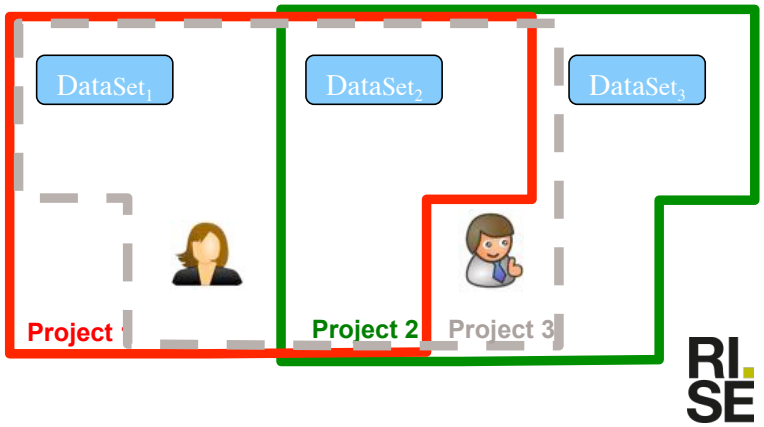
- Project funded by Swedish Energy Agency
- To integrate a datacenter micro-grid with the local smart grid for load balancing
- Target is to improve overall renewable energy use by load balancing reducing use of dirty top-up diesel/oil power
- The total project cost amounts to 0,6 MEuro over two years.
- The main partners are LTU, SICS, Vattenfall, EON, ABB, Acon



D-ICE – Data driven lab on ICE

- Project funded by Swedish Innovation Agency
- To enable multi-tenant use of Hadoop (Big Data) clusters in industry
- Target is to be able to share servers and data between Hadoop projects in the same server cluster instead of multi-copies reducing the overall energy used.
- The total project cost amounts to 0,3 MEuro over two years.
- The partners are KTH, Ericsson, Logical Clocks





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HopsFS world record set in a test on ICE

- Test with real-world Hadoop workload from Spotify AB on the SICS ICE cluster.
- 16X performance gains for Hadoop, delivering over 1.2 million operations per second

"*With the help of SICS ICE data center we were able to test and benchmark our platform at the scale needed*", says Jim Dowling, Assoc. Prof in Distributed Systems at KTH and CEO Logical Clocks AB

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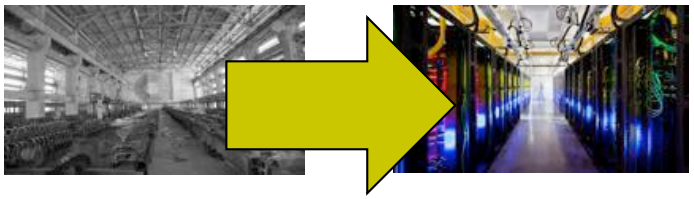
Conclusions

- Digital transformation and 5G enables a wide range of use cases in all fields that will require new datacenter technologies
- A 50-fold growth of digital data production in the zeta-byte industry era will be handled by an increase in datacenters capacity and need innovations in software, hardware & facility
- SICS ICE is supporting the national academia and industry with a large-scale research & test facility for development of new technologies needed to enable the transformation



THANK YOU!

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