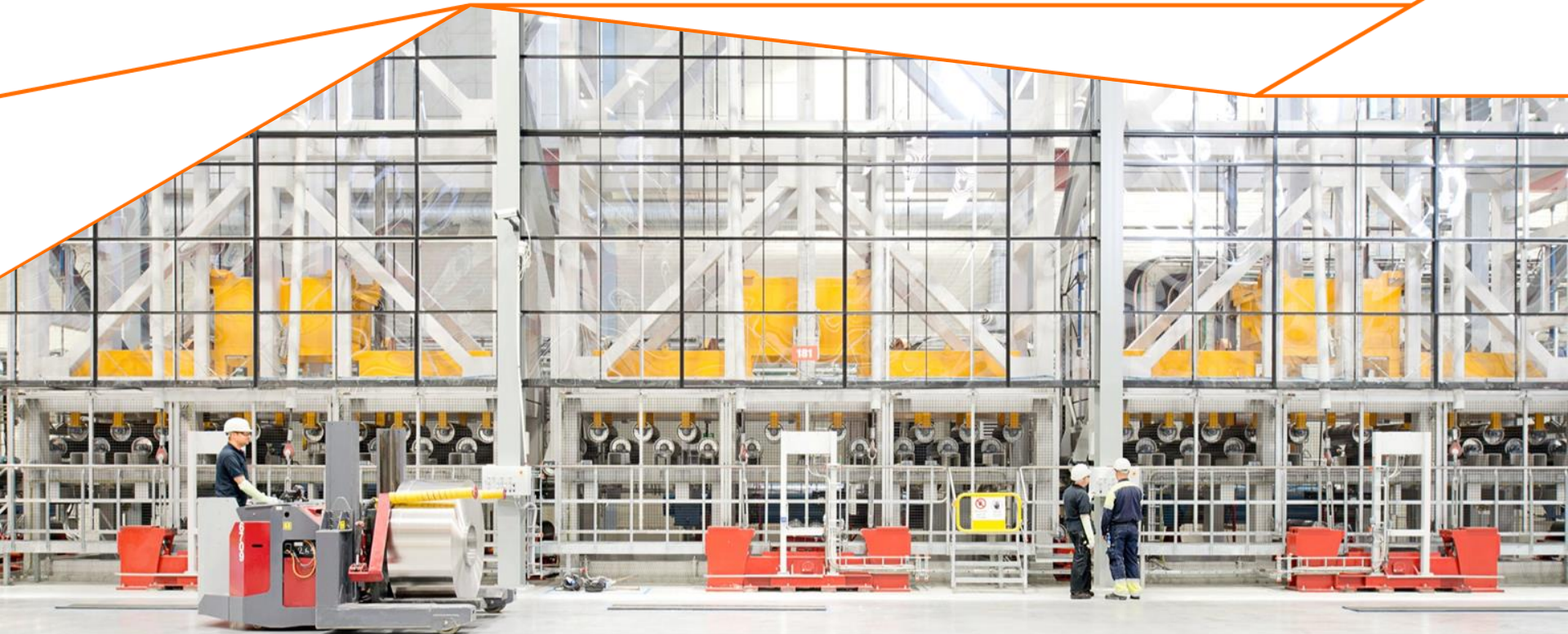


FUEL CELLS



ADDRESSING THE ENERGY CHALLENGE

JÖRGEN WESTLINDER, ENHETSCHEF BELAGDA BANDPRODUKTER FOU



SAFETY FIRST

Sandvik's objective is zero harm to our people, the environment we work in, our customers and our suppliers.



PROTECTIVE
EQUIPMENT



FIRST AID
KIT



ALARM



EMERGENCY
NUMBER



EMERGENCY
EXIT



ASSEMBLY
POINT

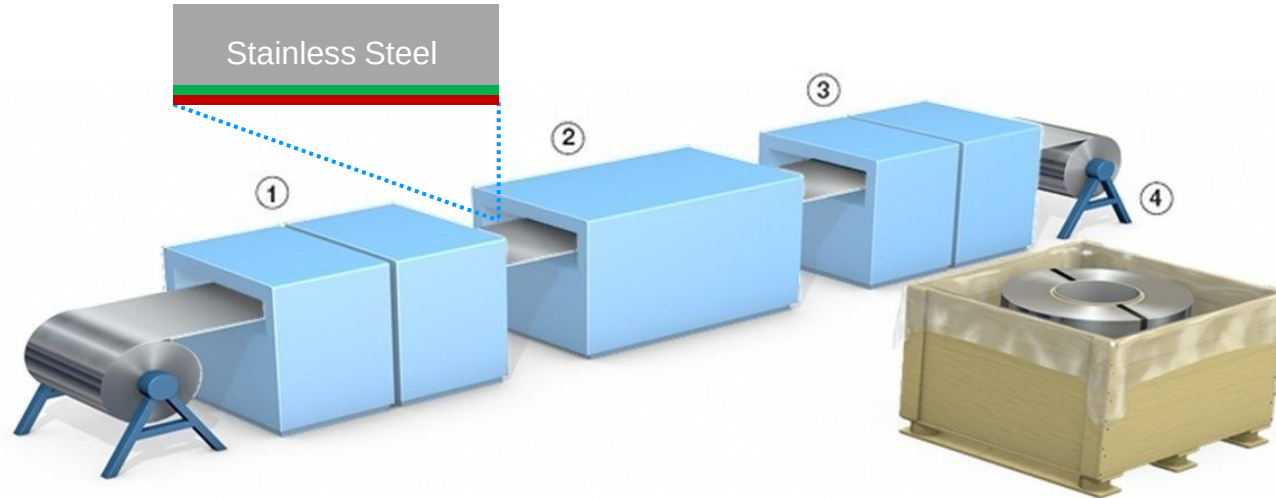


AGENDA

- **Sandviks koncept med coil-to-coil teknologin**
- **Uppbyggnad av kompetens**
 - tunnfilmsbeläggningar
 - materialanalys
 - oxidationstudier och elektrokemiska metoder
- **Framtida energisamhället**
 - Energilagring, Power-to-gas
 - Elektrolys – HYBRIT
 - Tankstation i Sandviken

SANDVIKS PRE-COATED SOLUTION

NANOTECHNOLOGY READY FOR MASSPRODUCTION



1. Cleaning/inspection

2. Coating

Coating of metal layers by Sandvik's continuous evaporation coating process.

3. Inspection

Automatic X-ray inspection devices measure the thickness and quality of the coating.

4. Testing, slitting and packaging

SANDVIK PROPERTY • PRESENTATION ENERGIMYNDIGHETEN

2016-10-14



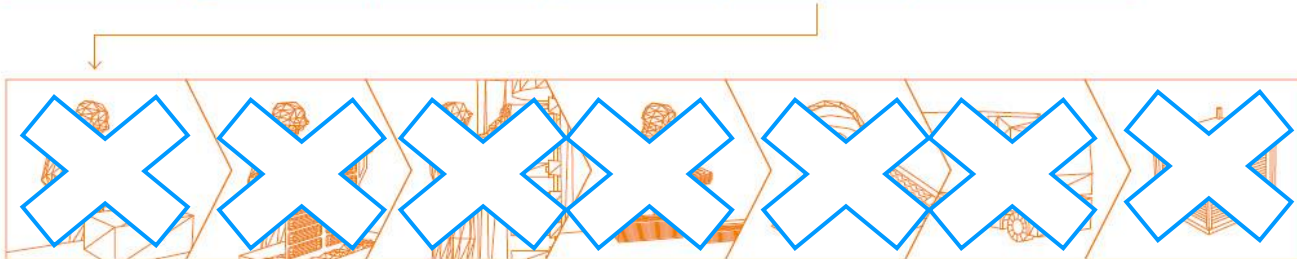
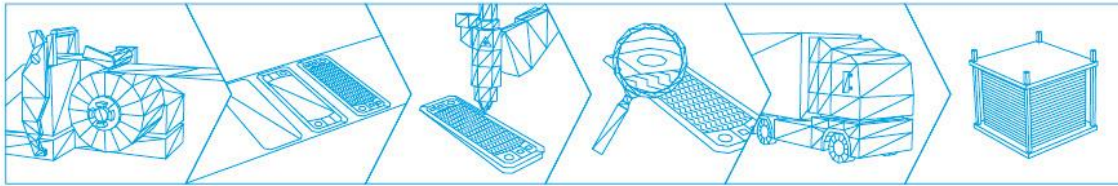
- High capacity PVD coating line
- Coil
 - width: < 800 mm
 - thickness: 0,07-0,8 mm
- Coating
 - Homogeneous or heterogeneous
 - Multiple layers in one coating run
 - In-line thickness control



COIL COATING CONCEPT

SHORTENING THE VALUE CHAIN

SANDVIK COIL-COATING CONCEPT FOR INDUSTRIAL BIPOLAR PLATE PRODUCTION



~~ADDITIONAL PROCESS STEPS FOR BATCH COATING OF BIPOLAR PLATES~~

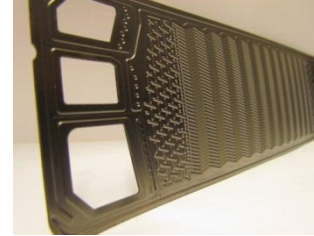
COATING REQUIREMENTS PEMFC

- **PEMFC Coating**

- Graphite-like carbon (GLC) coating
- Metallic interlayer layer

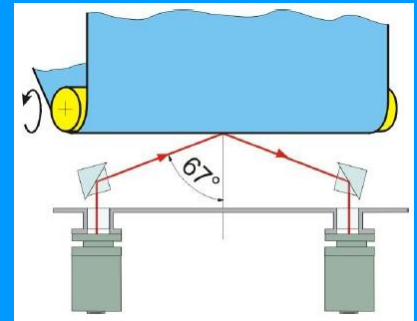
- **Properties**

- Good corrosion resistance
- Prevent formation of oxide scale on SS
- Low contact resistance (ICR)
- Good formability / coating adhesion



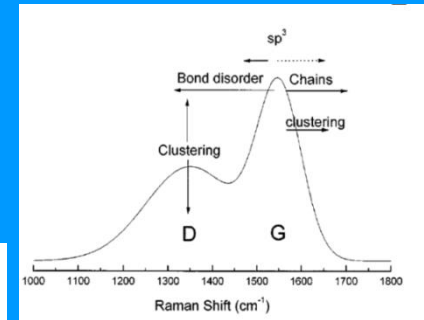
UTMANINGAR SANERGY LT

- Mäta skiktegenskaper
 - in-line mätningar med ellipsometri och XRF
 - mäta restspänningar (tunnfilms XRD)
 - mäta kolskiktets egenskaper med Raman spektroskopi
- Studier av gränsskikten före/efter stacktestning – TEM analysis, ESCA, AES
- Tillgång till elektrokemiska mätningar, dvs single cell / stacktestning

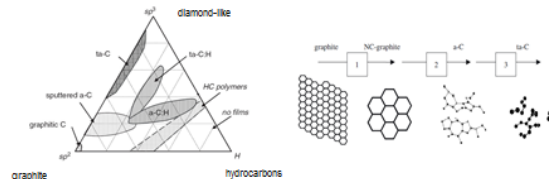


Source

Detector



KOLETS MIKROSTRUKTUR



Modell av Andres C Ferrari, John Robertson, University of Cambridge

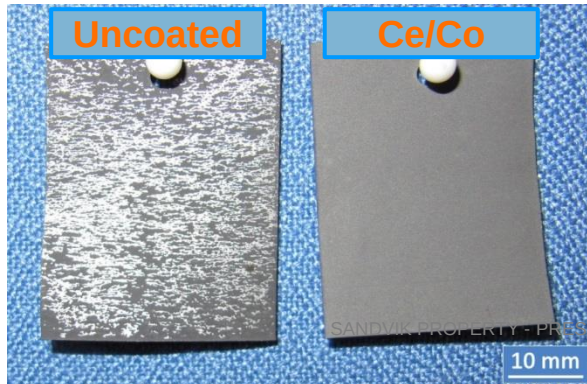


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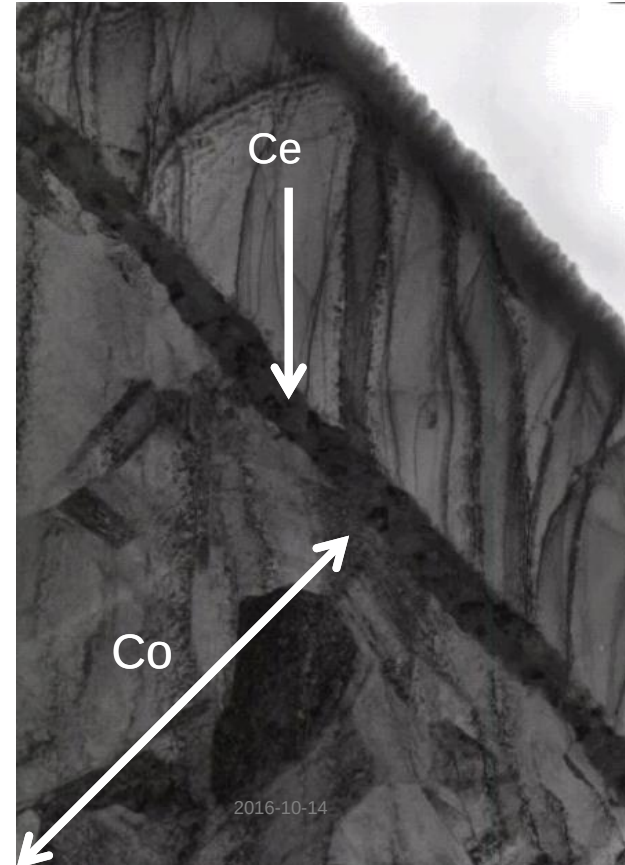
DEVELOPMENT OF SOFC INTERCONNECTS

Improve SOFC life time by keeping Cr in the steel:

- Reduce Cr evaporation
- Improve corrosion resistance
- Cobalt coating to create $(\text{Co}, \text{Mn})_3\text{O}_4$ to reduce outward diffusion of chromium
- Utilize cerium coating to reduce oxidation rate

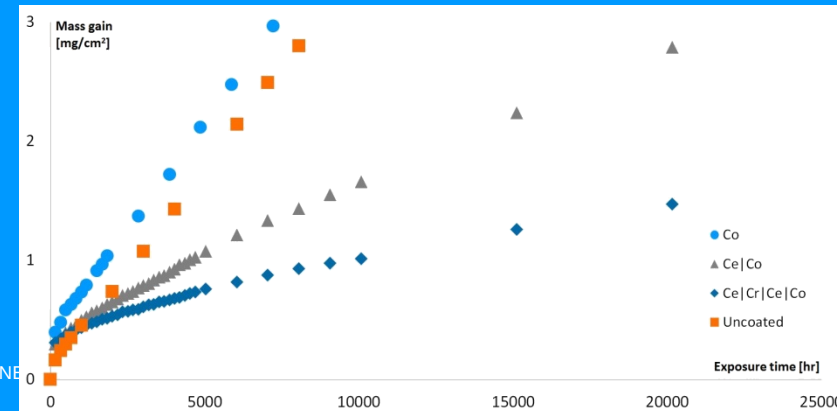
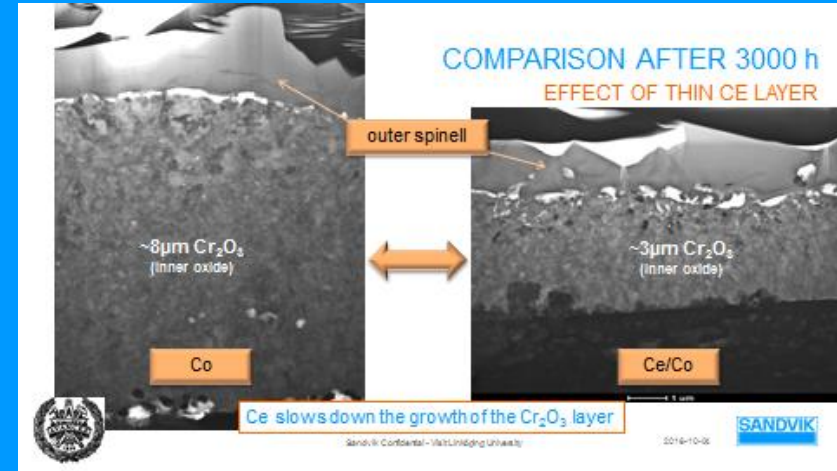


AISI441
1000h/800°C

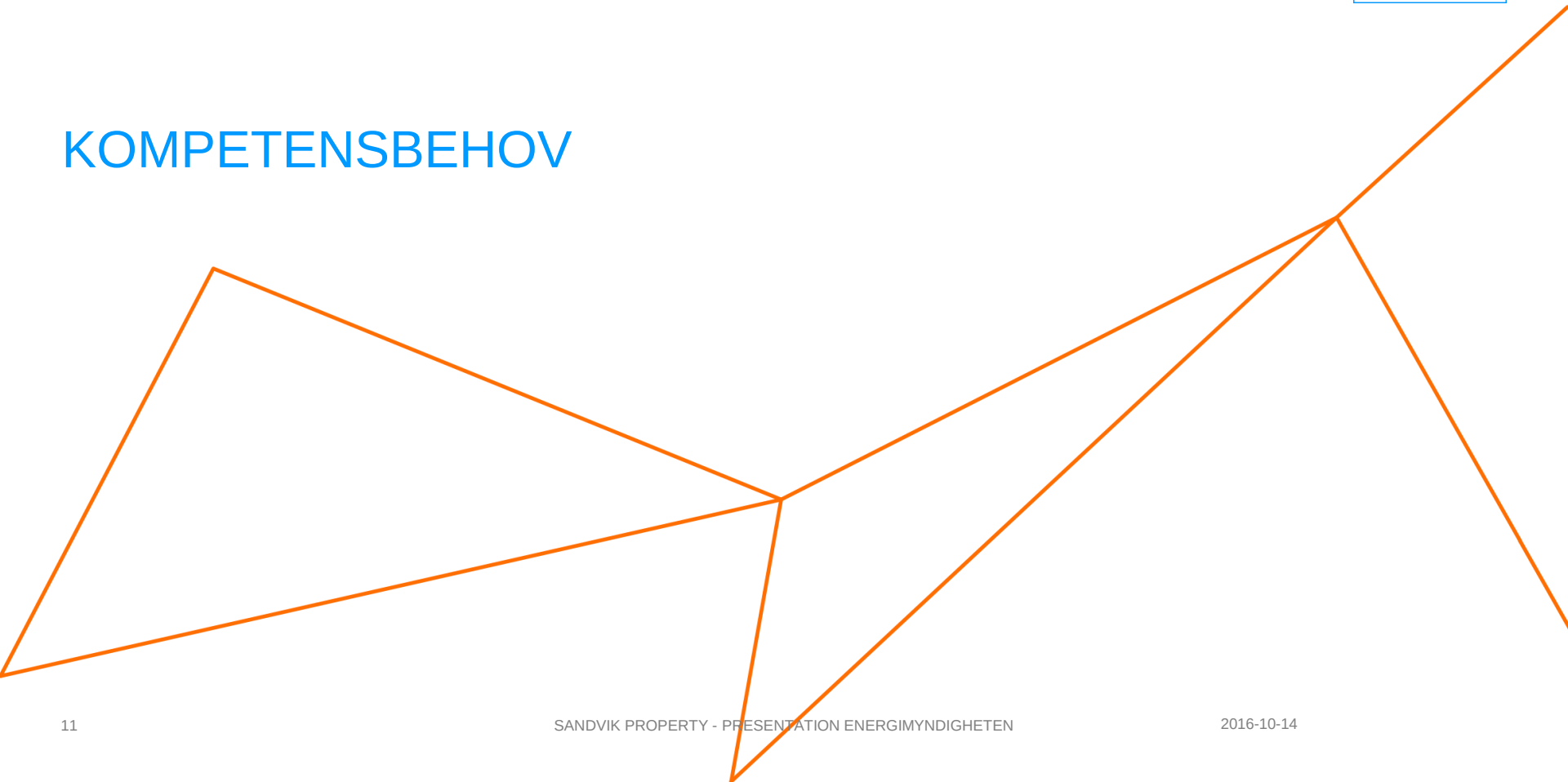


UTMANINGAR SANERGY HT

- Fortsätta med högupplösta TEM studier på Sanergy HT produkten
- Vad händer i stackmiljö?
 - Interconnect i kontakt med katodmaterial
 - Oxidbildning vid närvaro av elektrisk ström
 - Oxidbildning vid olika (lägre) temperaturer
- Nya skikt som ger längre livslängd



KOMPETENSBEHOV



BEHOV

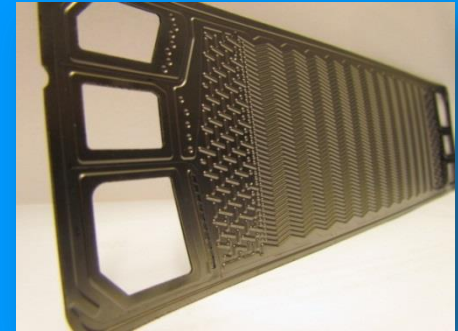
GRUNDLÄGGANDE KUNSKAPSUPPBYGGNAD

- Tunnfilmsbeläggningar
 - Kärnbildning, tillväxt, analys av beläggningar på stål
 - SMT deltar i ansökan till VINNOVA, FunMat – Linköpings univ. koordinator
- Högtemperaturundersökningar
 - Oxidationsstudier, stacktester och materialanalys
 - Internationella projekt (EU: METSOFC, METSAPP, NELLHI, qSOFC; Nordiskt: NaCoSOFC)
 - Nationella projekt (HTC samt FFI)
 - Samarbetet med Chalmers grupp nödvändigt för fortsatt produktutveckling

BEHOV (FORTS.)

GRUNDLÄGGANDE KUNSKAPSUPPBYGGNAD

- Elektrokemiska metoder
 - Elektrokemiska metoder för BPP, stacktestning, frisättning av metalljoner, elektrolys m.m.
 - Nationellt projekt: FFI
 - SMT-finansierat projekt: ZSW och Borit för stacktestning av BPP
- Materialanalys med ytkänsliga metoder (ESCA, AES)
- Applikationskunskap om bränsleceller och elektrolysceller



Sandvik / ZSW / Borit

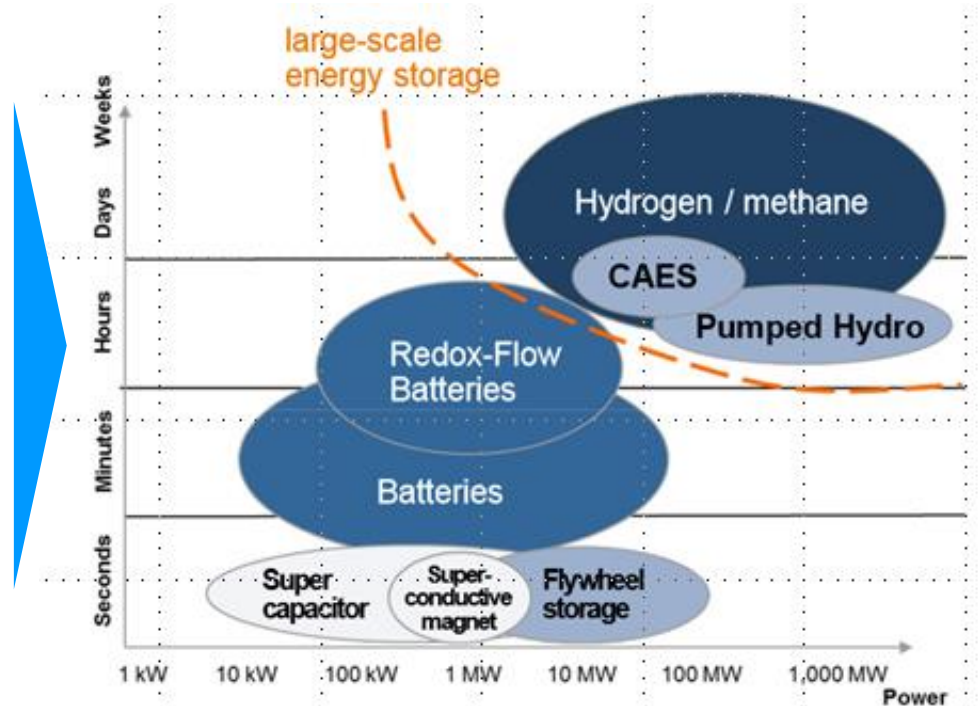
FRAMTIDA ENERGISAMHÄLLE – ENERGILAGRING

RENEWABLE ENERGY AND STORAGE - A MUST TO REACH CLIMATE GOALS

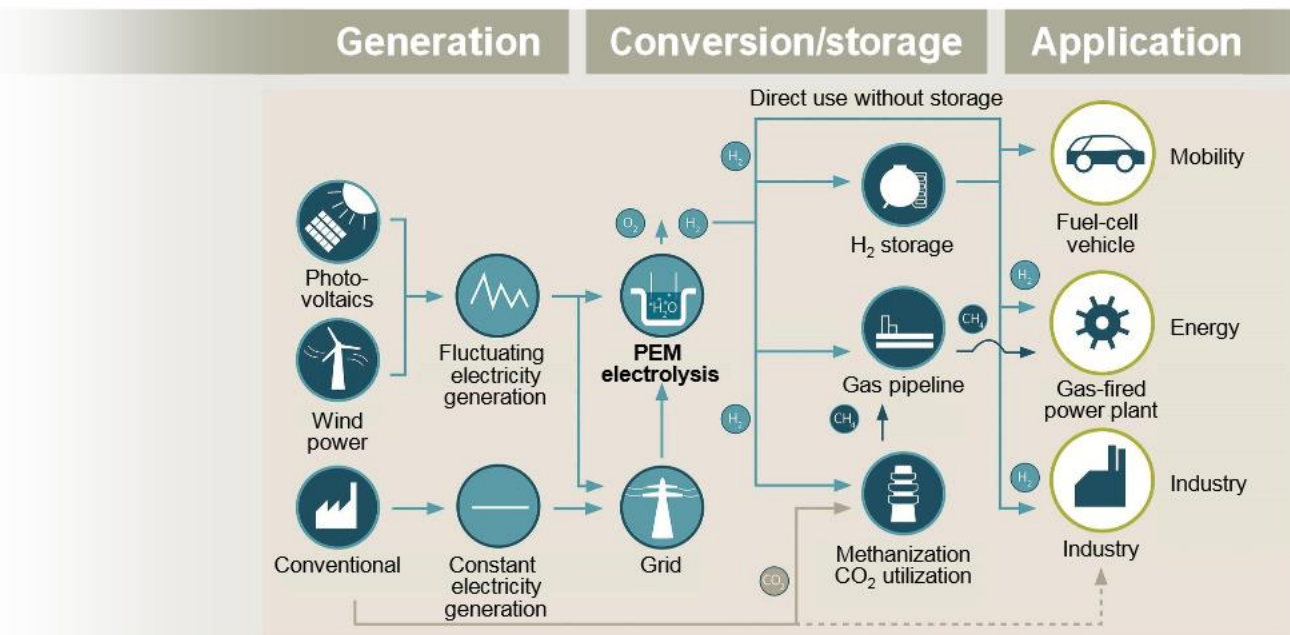
ENERGY

- Energy consumption will increase
 - More people (+2 billion 2050)
 - Larger middle class
 - Increased mobility (prognosis +45%)
- Fossil free energy a must to reach climate goals
 - For heating and electricity for buildings
 - As fuel for vehicles
- Fossil free energy requires storage
 - Fluctuating production

HYDROGEN – OPTIMAL ENERGY CARRIER



PEM electrolysis enables conversion of electrical into chemical energy



H₂ drives the convergence between energy & industrial markets

Next projects Energie Park Mainz



Key statements

- Location: Mainz-Hechtsheim (GER)
- Three high performance electrolysis systems with peak power of 2,1 MW_{el.} Each
- Connection to 10 MW wind-farm
- 1000 kg storage (33 MWh)
- 200 tons target annual output (Trailer-filling station and injection into local gas grid)
- Highly dynamic operation over broad load range (ramp speed 10% per sec.)

Study SILYZER 200



CARBON-DIOXIDE-FREE STEEL INDUSTRY

HYBRIT – HYdrogen BReaktrough Ironmaking Technology



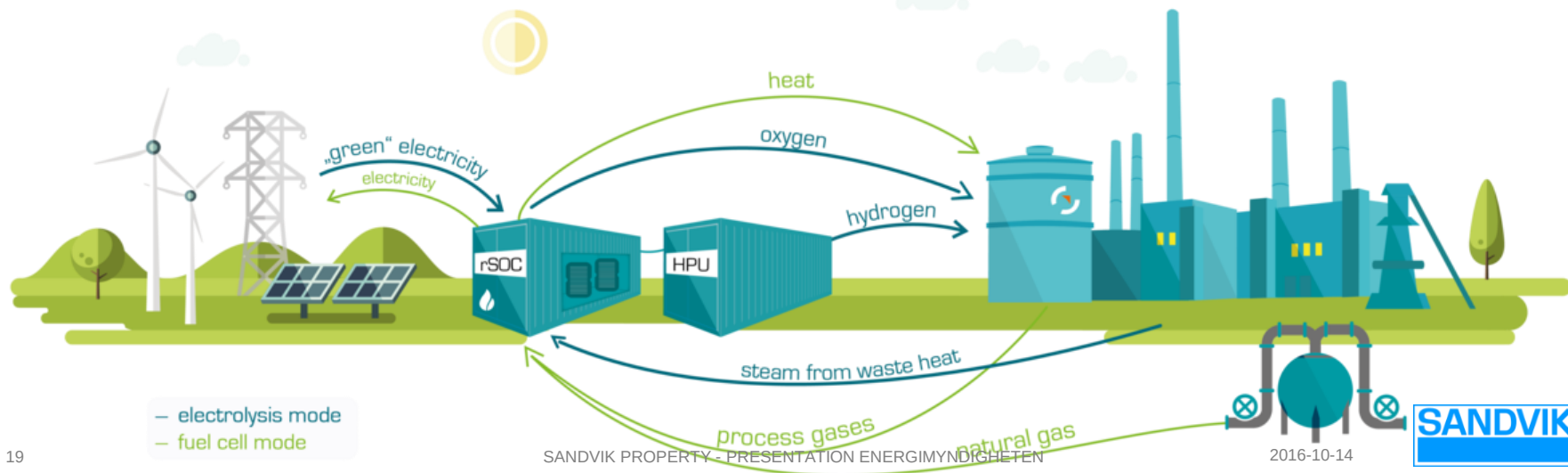
SSAB

LKAB

VATTENFALL



SANDVIK



SAVE THE PLANET
USE MORE FUEL (CELLS)



THANK YOU!

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Sandvik Materials Technology

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