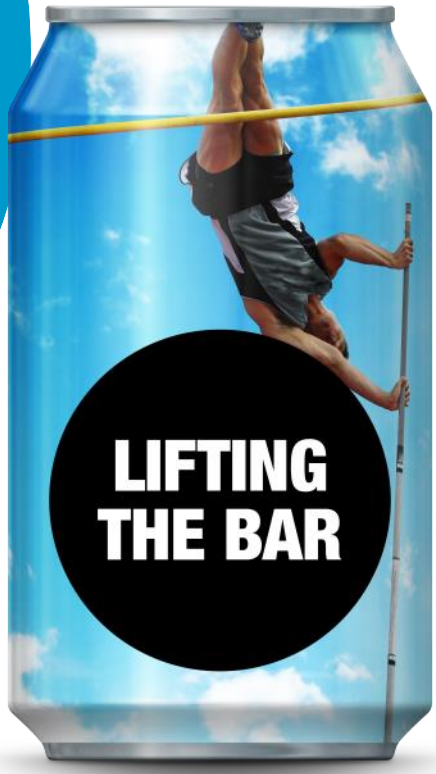
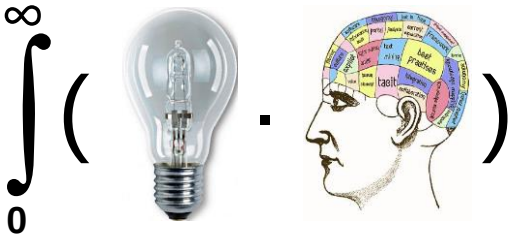
Hydros teknologiagenda

Hans Erik Vatne
Teknologidirektør
NTVA, 14.01.2015



Contents

- Hydro
- Aluminium: Product applications and state of the industry
- On Hydro's technology agenda
- Collaboration with academia
- Al production in a national and global perspective



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Hydro

01

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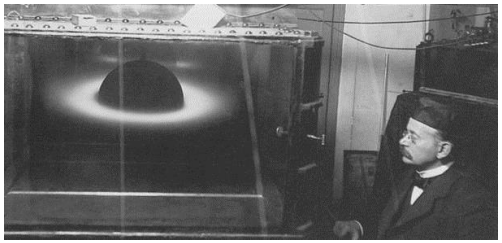
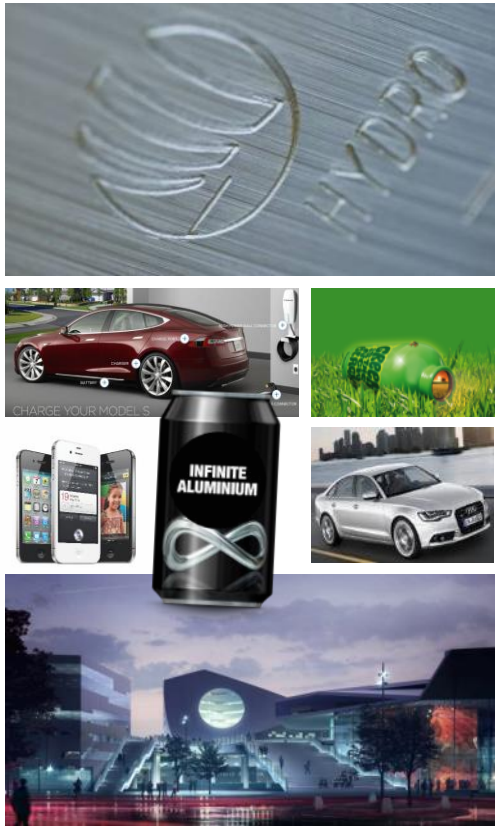
108 years of industrial and sustainable development

Hydro has led the industrialization of Norway for more than a century



Turning science and natural resources into products, contributing to viable societies

Fertilizer, aluminium, magnesium, oil & gas, polymers, fish farming, pharmacy, investments...



A world-leading aluminium company

HYDRO

A resource-rich, global aluminium company

With robust positions across the value chain

- Global provider of alumina, aluminium and aluminium products
- Leading businesses along the value chain; raw materials, energy, primary metal production, aluminium products and recycling
- 13 000 employees involved in activities in more than 50 countries
- Market capitalization ~NOK 75 billion
- Annual revenues ~NOK 65 billion
- Included in Dow Jones Sustainability Indices and FTSE4Good

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Hydro in Norway

Knowledge-based mainland industry with significant spin-off effects

- Operations
  - 5 primary aluminium plants in Sunndal, Karmøy, Årdal, Høyanger and Husnes (50% JV with RTA) [1)]
  - Rolling mill and recycling plant in Holmestrand
  - 20 hydropower plants in Telemark, Sogn, Røldal-Suldal and Agder
  - 50 % owner of SAPA, world's largest provider of aluminium solutions
- Employees in Norway
  - 3.400
- Investments
  - NOK 22 billion 2001-2012
- Research and development
  - Årdal, Sunndal, Karmøy, Porsgrunn, Oslo
  - NTNU, SINTEF, UiO, IFE
  - Annual R&D activity: NOK 350 millions

1) Agreement for Hydro to take over Rio Tinto Alcan's 50% in Søral, Husnes

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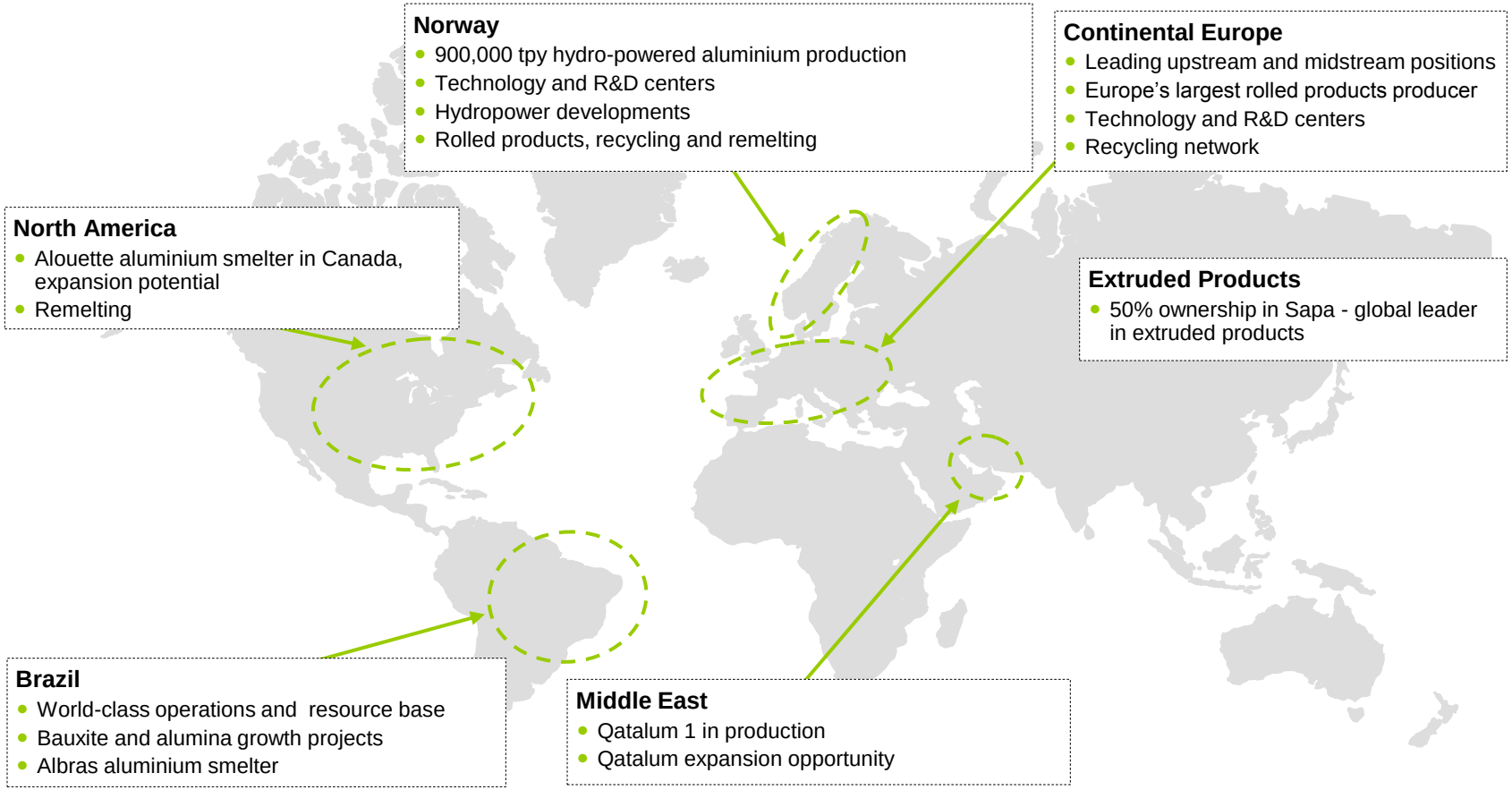
Attractively positioned, global reach



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Aluminium: Product applications and state of the industry

02

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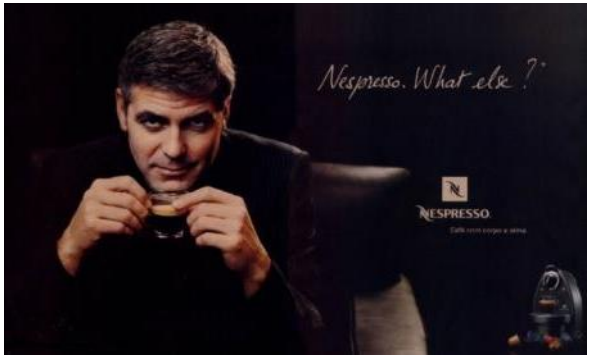
Aluminium is everywhere

An important building block of modern society



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Megatrends drive aluminium demand and our technology agenda

Millions climb out of poverty

Population growth, urbanization
Increasing mobility
Democratization, digitalization

Infrastructure, transport, cables, construction, machinery, consumer durables, packaging, industrialization

Increasing energy demand

Resource scarcity
Energy efficiency

Energy efficiency
Marine/offshore applications
Transport segment

Climate change

Global warming awareness,
CO_2/GHG legislation
Renewable energy

Smelter efficiency
ZEB/Powerhouse solutions
Transport segment

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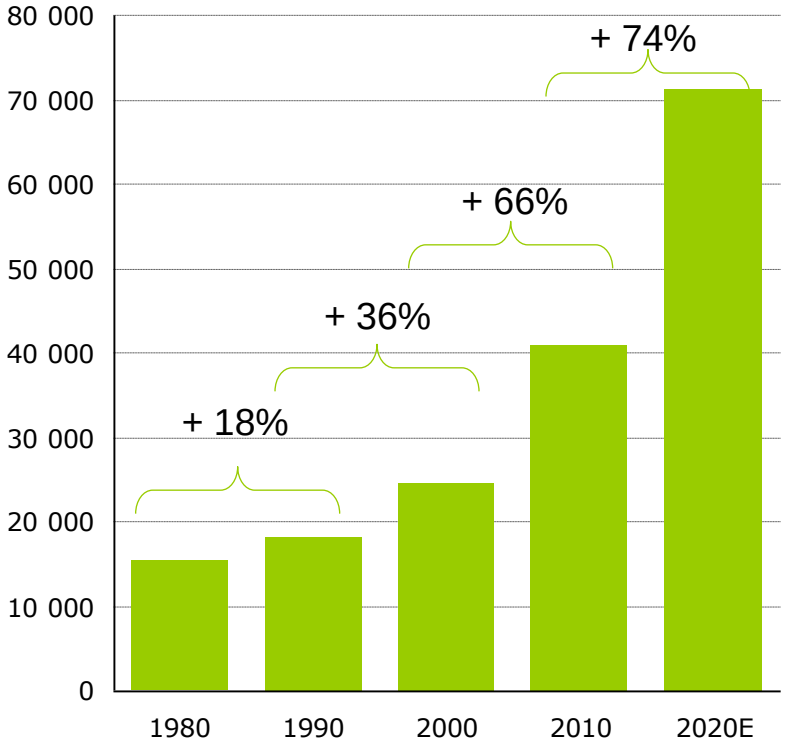
The world needs more and more aluminium

Should be produced with the lowest carbon footprint

Rising aluminium demand



Properties give wide range of applications



Lightweight – 1/3 density of steel

Recyclable – 5% of original energy consumption

Corrosion resistant – Natural oxide layer

Formable – Extrusion, rolling, casting, low melting point

Excellent conductivity – Thermal, electrical

Alloying technology – Wide range of properties

- Aluminium intensive urbanization and infrastructure
- Climate challenge – aluminium part of the solution
- Recyclability more important with high energy prices

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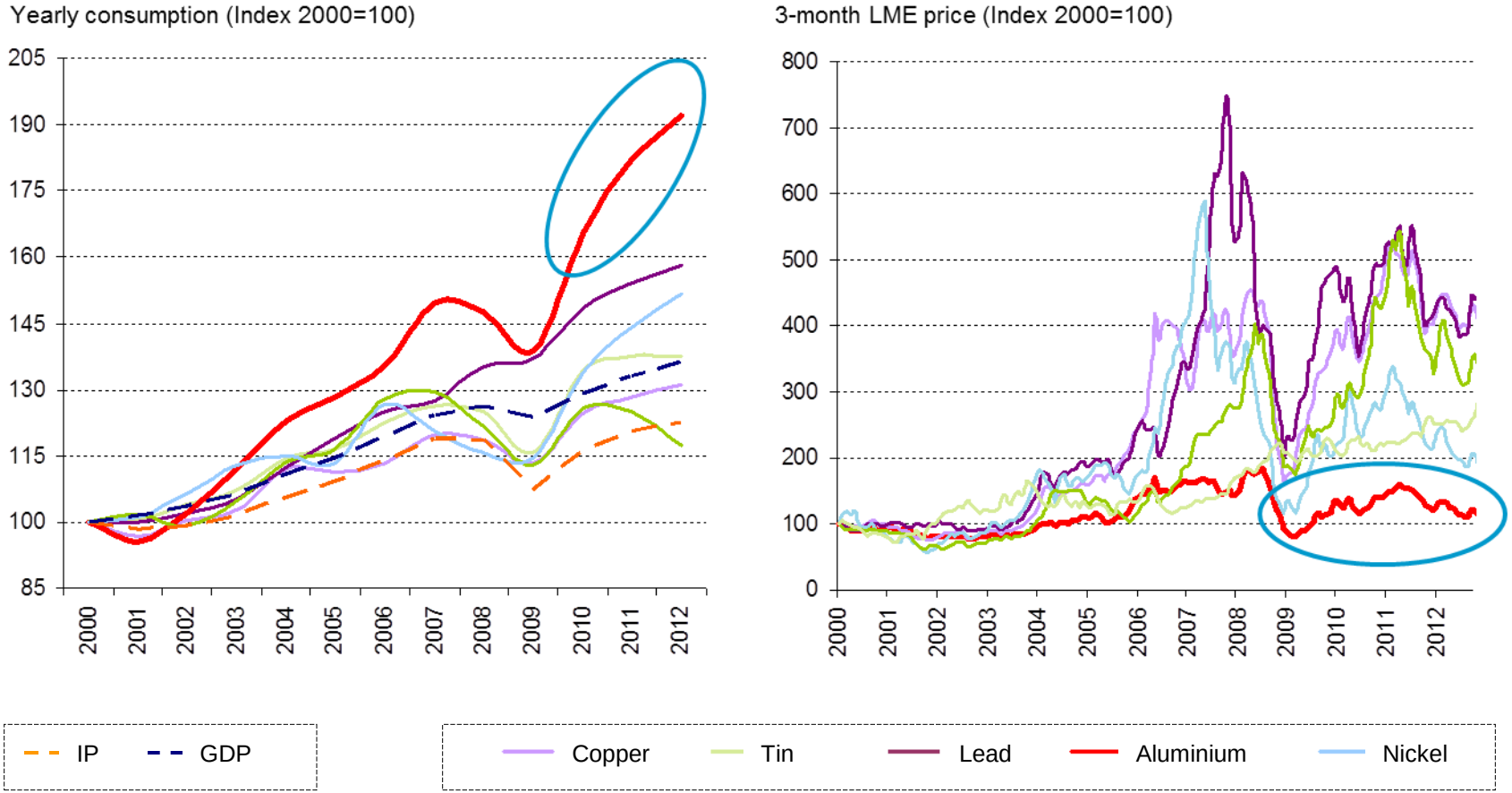
The paradox of the aluminium industry

Demand winner – yet price laggard



Source: CRU/Global Insight

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Strong interest in our metal

Driving forces towards reduced emissions, energy efficiency and sustainability

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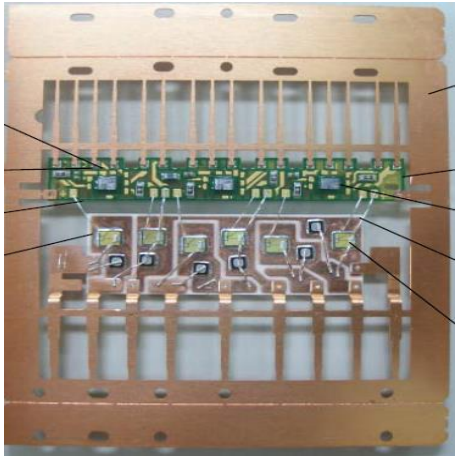
Aluminium in electrical/energy solutions

Potential growth products – challenge to convince conservative customers

Driver:
- **Cu prices**
- **Image**
- **Weight**



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On our technology agenda

03

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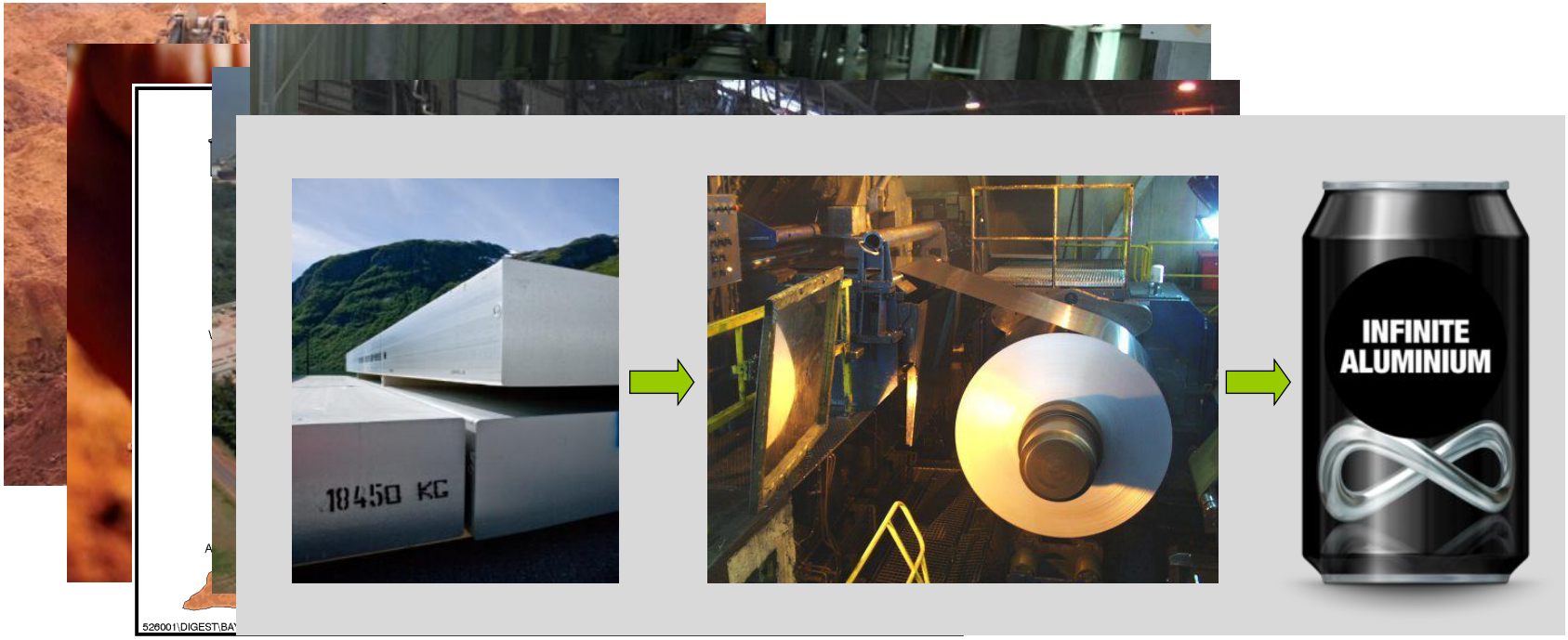
From bauxite to aluminium products

A huge span in technologies and competences



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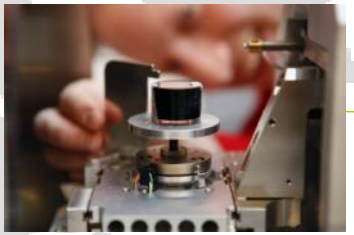
R&D locations in decentralised structure

R&D locations fit with decentralised organisation



RTD Reference Center,
Sunndalsøra in Norway

Sunndal
Årdal
Karmøy
Oslo
Porsgrunn
Neuss
Bonn
Michigan
Doha

HAL4e Reference Center,
Årdal in Norway

Hydro Research and
Development Center,
Bonn in Germany

- Bauxite and Alumina
- Primary Metal Technology hubs
- Mid- and Downstream R&D units

- Årlig FoU-aktivitet:
  Ca 350 mill. NOK
- Totalt mer enn 250 ansatte i FoU
- 120 ansatte ved våre norske forsknings- og teknologisentre:
  - Sunndal
  - Årdal
  - Karmøy
  - Porsgrunn
  - Oslo

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3.1 Bauxite and alumina

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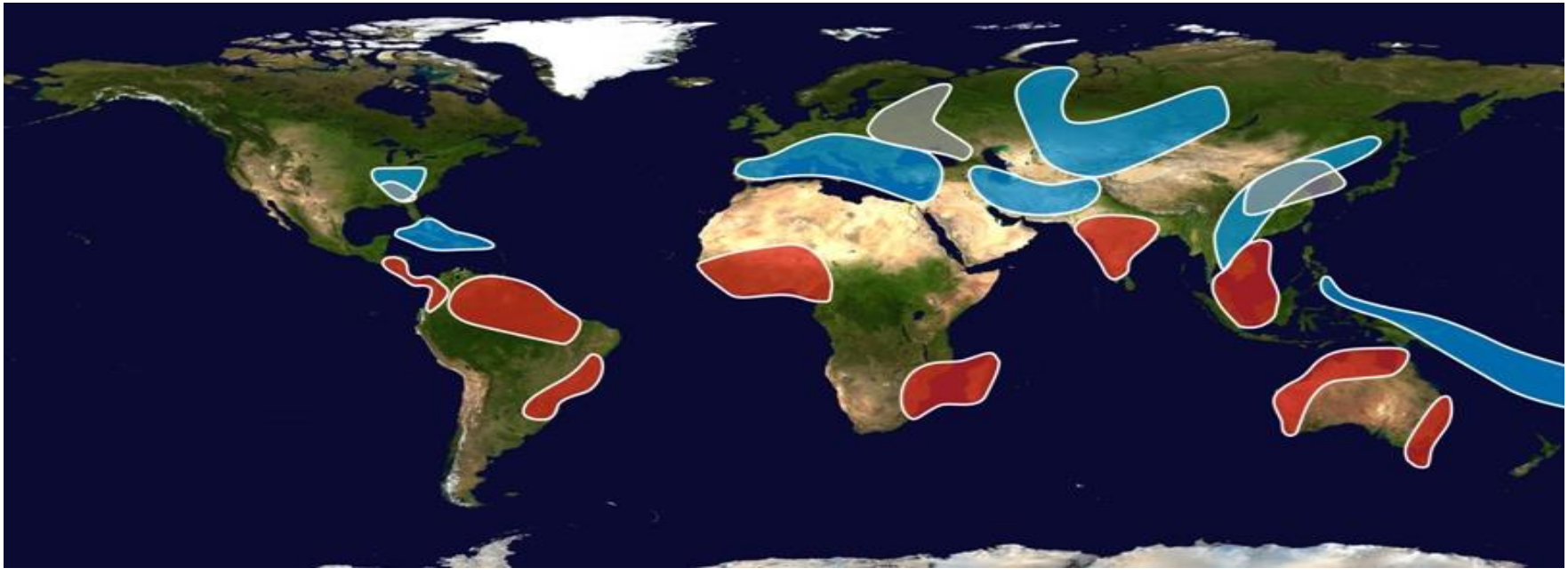
Technology challenges

Bauxite/alumina

- Mining technology: from excavators to surface miners
- Reactive silica and caustic consumption
  - Beneficiation methods
- Energy and CO2 footprints (alumina refinery)
- Reduce and utilise bauxite residues
- CSR: Reforestation, sensitive areas, political stability



3.2 Primary metal production (electrolysis)

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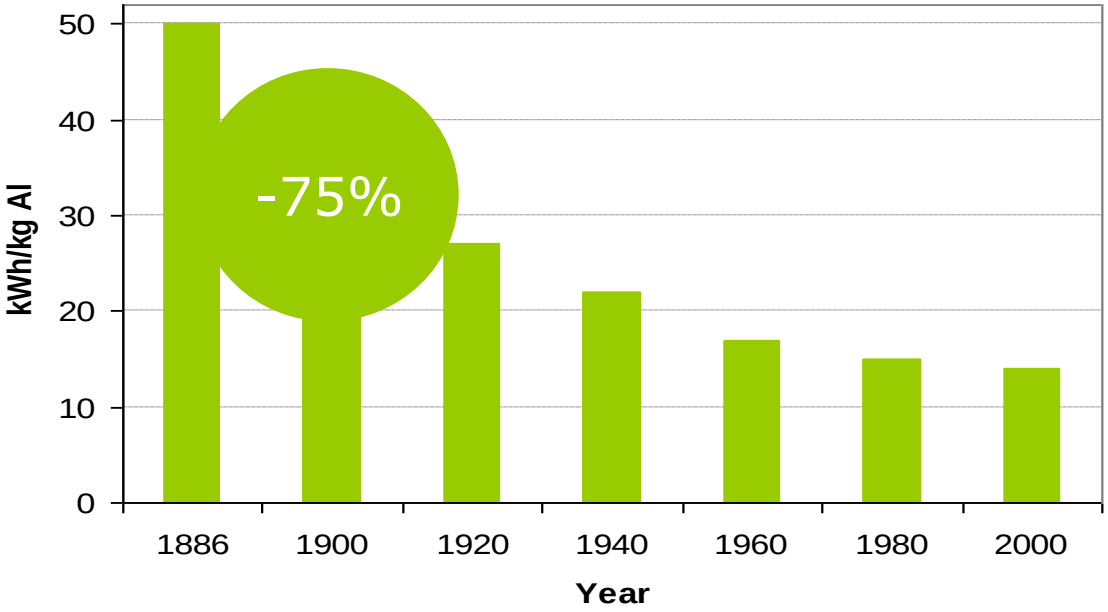
Electrolysis technology

Energy reduction has been a continuous process



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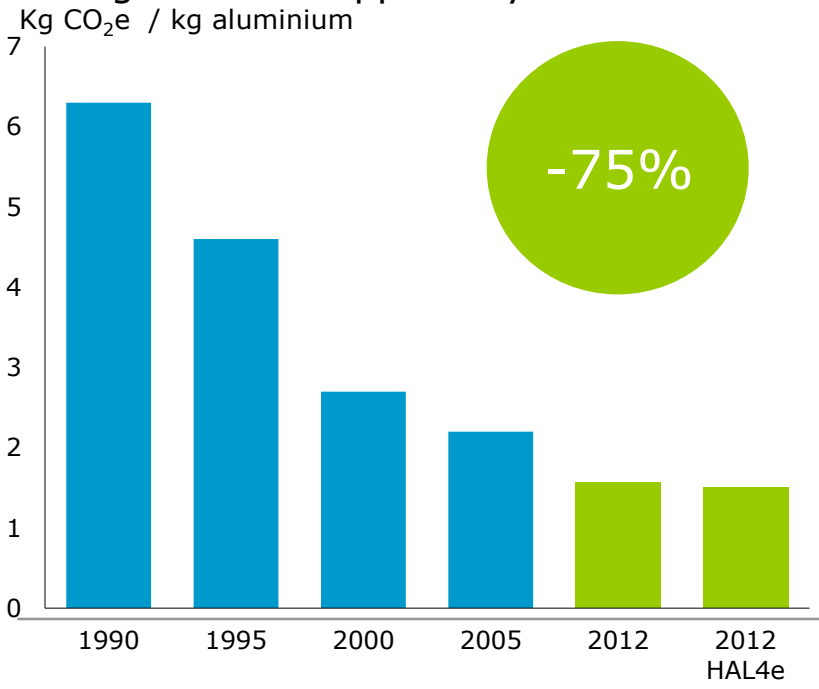
Electrolysis technology

Energy reduction has been a continuous process

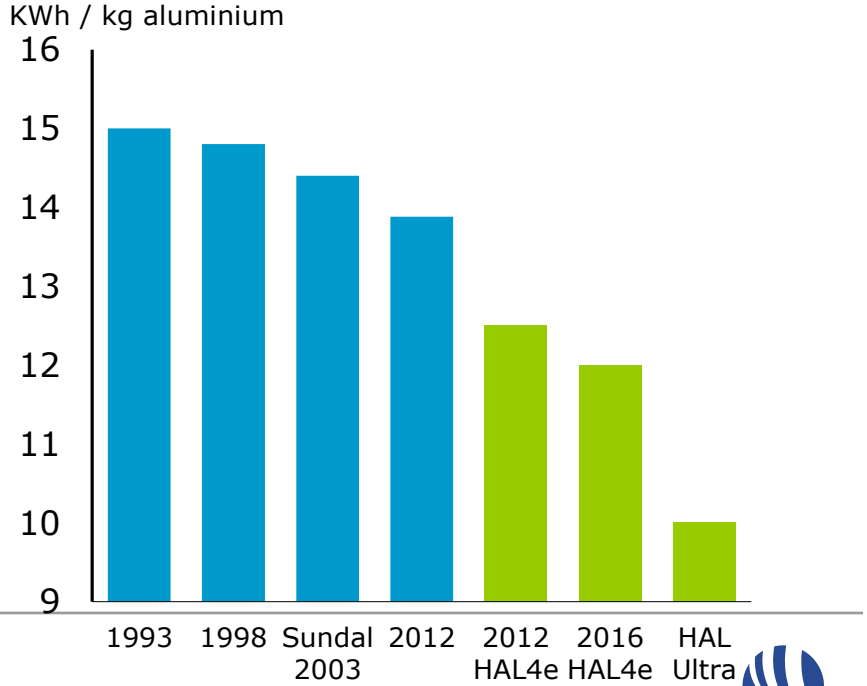
A reduction of 1 kWh/kilo aluminium will give an annual energy reduction of 1 TWh for Hydro's aluminium production in Norway.

To produce 1 mill. tonn/year aluminium in Norway reduces global emissions of CO_2 by 15 mill. Tonnes compared to alternative production in China

Stadig lavere utslipp fra Hydros verk



Lavere energiforbruk ved Hydros verk



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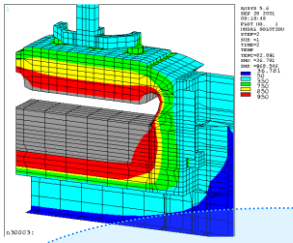
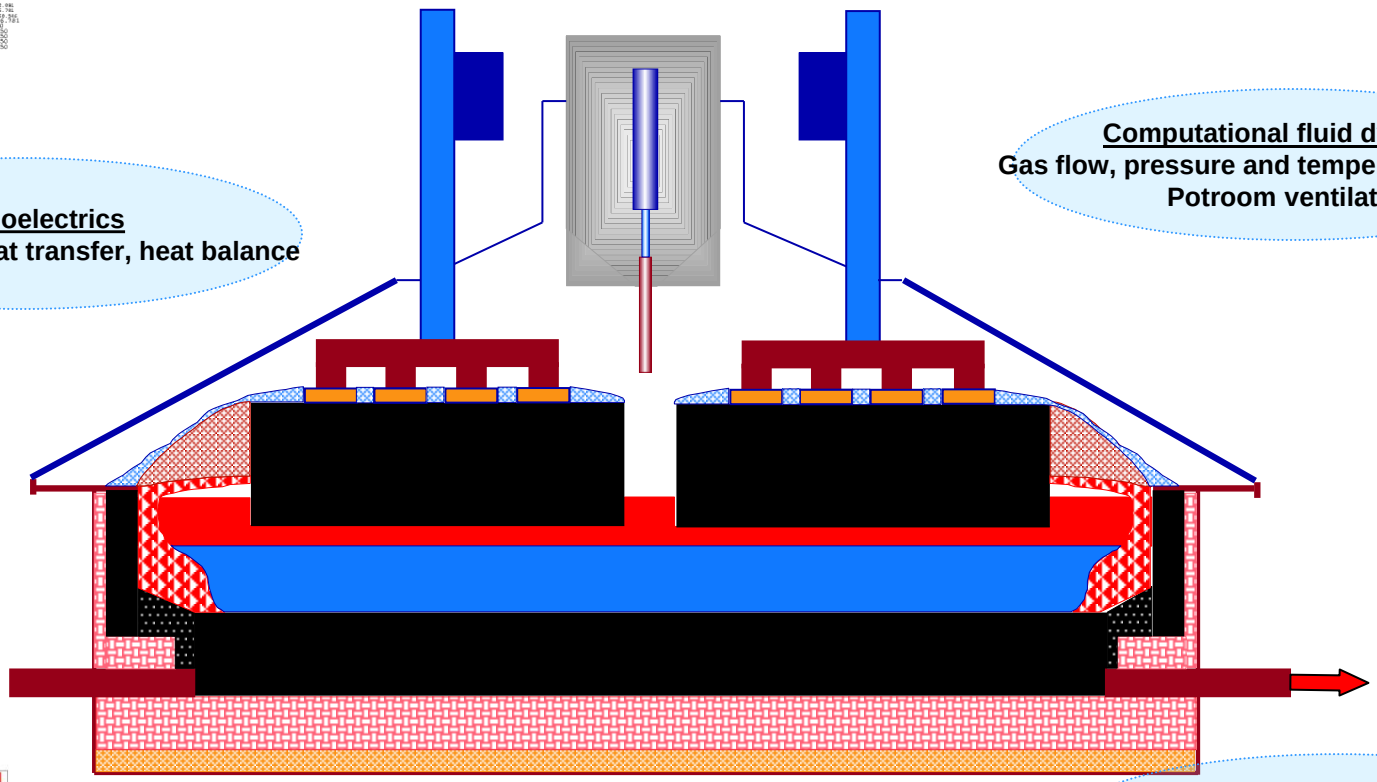
Electrolysis: High-tech technology and cross-disciplinary skills

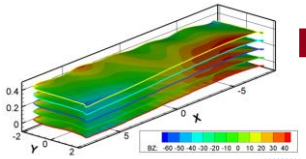
$$Al_2O_3 + {}^3/_2\,C + \text{Energy} = 2Al + {}^3/_2\,CO_2$$



Thermoelectrics
Heat production, heat transfer, heat balance



Computational fluid dynamics
Gas flow, pressure and temperature within cell
Potroom ventilation



Magnetohydrodynamics
Stability of metal pad
Metal & electrolyte flow
Metal heaving

Thermomechanics
Deformation of pot shell and brick lining under varying thermal load

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Preparing for the next technology leap

Parallel development of technology platforms

HAL 300

13.5 kWh/kilo
1.6 tonne CO_2/tonne aluminium

HAL4*e*

12.5 kWh/kilo
1.5 tonne CO_2/tonne aluminium

Future technology

10 kWh/kilo
CO_2 capture ready

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Karmøy teknologipilot – HAL4e

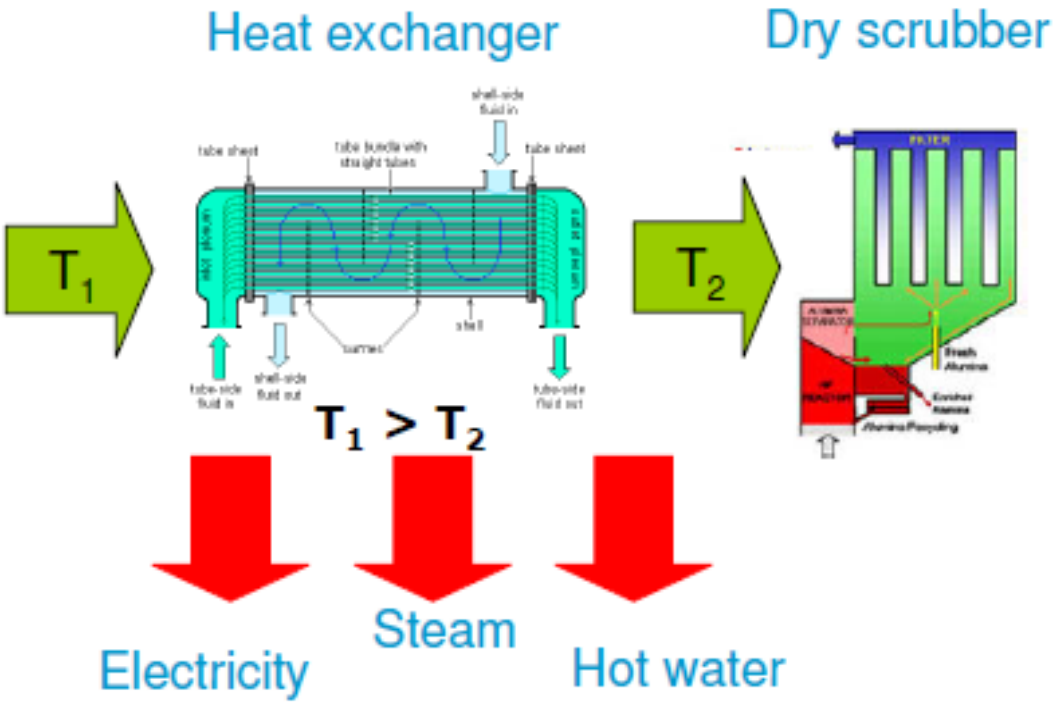
Viktig steg for å utvikle verdens beste elektrolyseteknologi

Forutsetninger

- Krafttilgang
- Enova-støtte
- Nettforsterkninger
- Gode markedsforhold

Technology challenges

Primary production, $Al_2O_3 + {}^3/_2\ C + \text{Energy} = 2Al + {}^3/_2\ CO_2$



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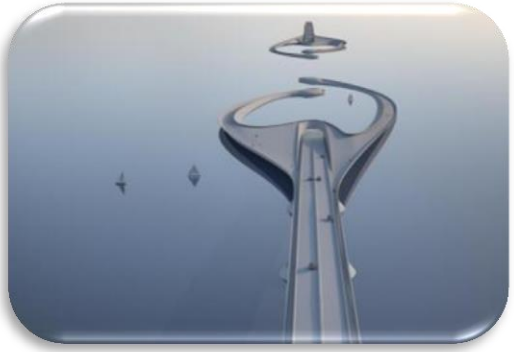
3.3 Product applications

Infinite ideas in aluminium

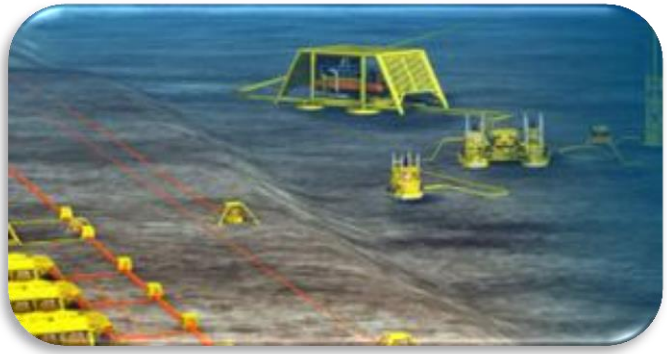
More and more sectors “discover” new areas for aluminium applications

Lightweight, non-corrosive offshore applications

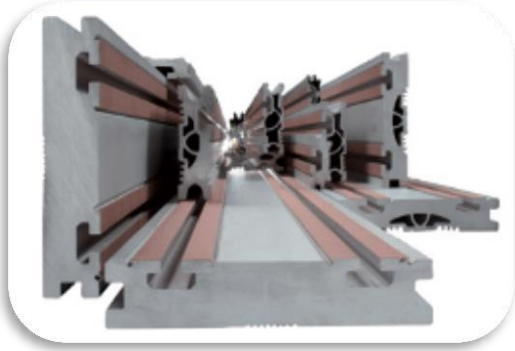
Zero emission electrical car ferry in 100% aluminium for lightweighting. In operation from 2015



Floating aluminium bridge with a submerged floating tunnel at mid span. Under planning



Lightweight, non-corrosive subsea applications



Electrical busbars – in aluminium

Middle and high voltage cables, wire and cables for electrical applications

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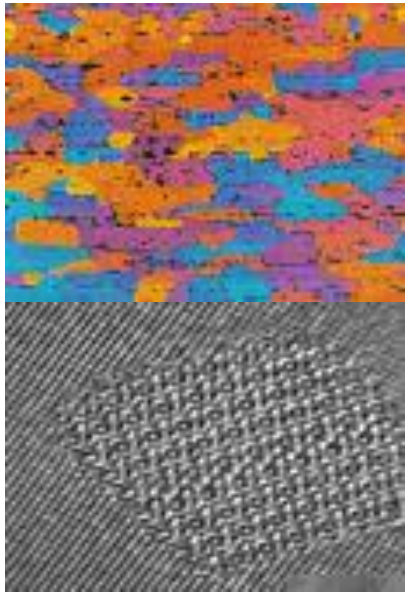
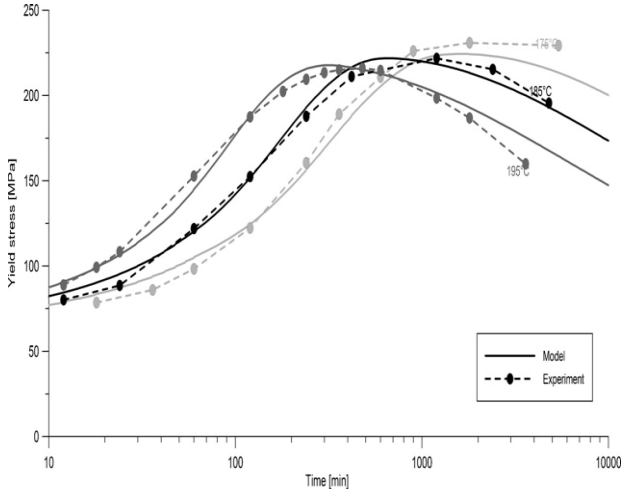
Alloy development: tailor-made properties

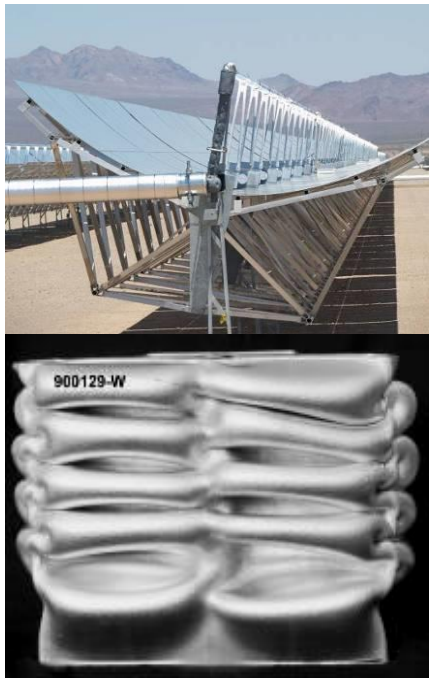
Understanding micro/ macro structure

Predicting & modelling properties

Alloys with tailormade properties optimized for specific applications







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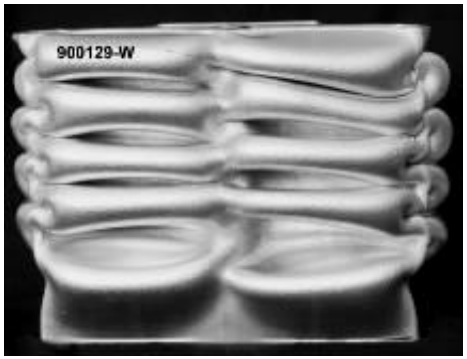
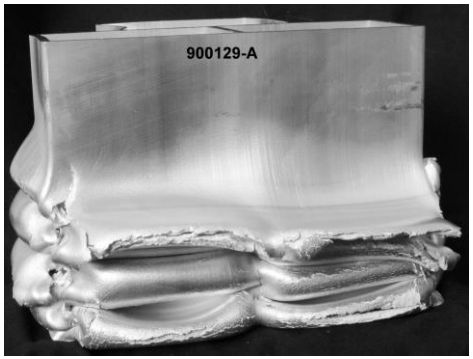
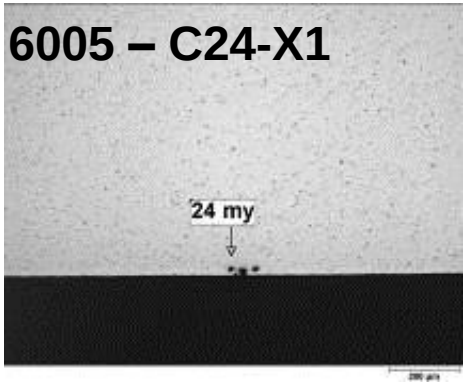
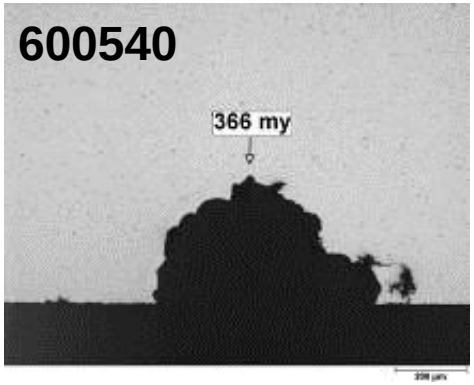
Extruded profiles for crash boxes

Extrusion Alloy Development; Meeting the C28 crash standard









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«Stronger, tougher and more fuel efficient”

… but also stronger and tougher demands on suppliers

“ALUMINUM BODY STRUCTURE:
STRONG, RIGID, AND LIGHT

The Model S body is a **state-of-the-art, aluminum-intensive design**. **Weight-saving benefits make**

Automotive embraces Al but has tough demands:

- Alloy development and modelling
- Simulation to replace prototypes

JAGUAR

LAND ROVER

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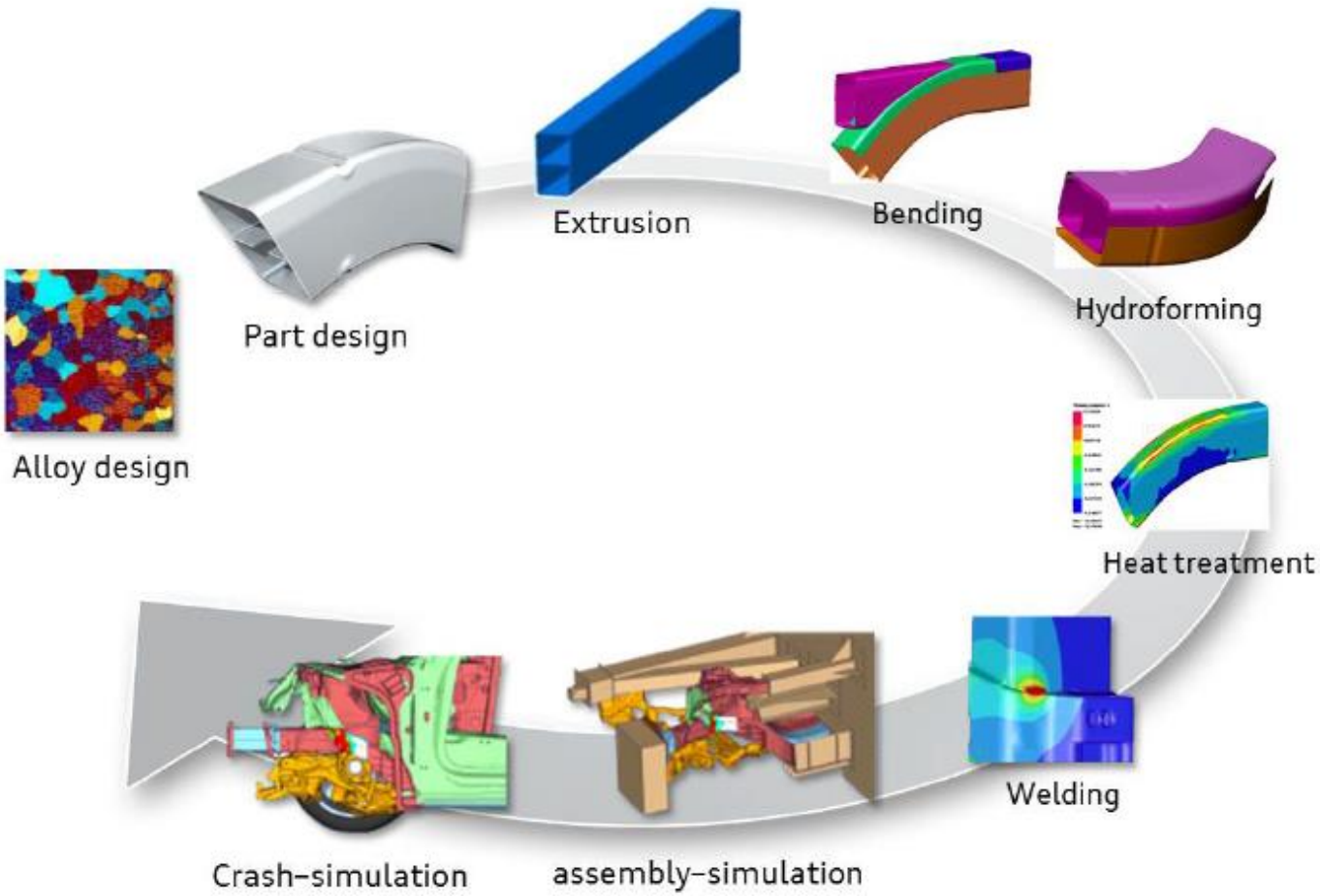
Meeting the modelling challenge from automotive

From material models to forming and crash simulations



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Meeting the modelling challenge from automotive

From material models to forming and crash simulations

Penetration into new, advanced product segments requires:

- **Modelling tools, linking micro and macro scales**
- **Fundamental metallurgical competence**
- **Design/construction competence**
- **Cross-disciplinary skills**
- **Good process control**

Important trend: Multi-material hybrid solutions

- **Joining and bonding technologies**

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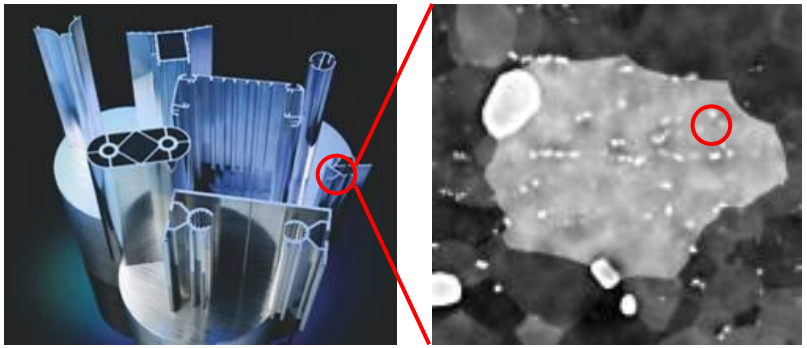
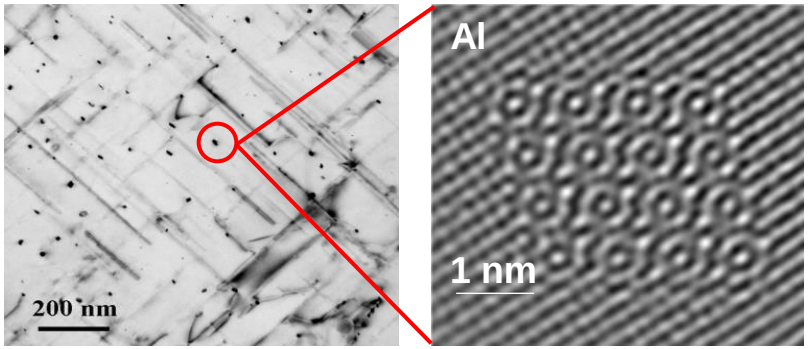
New experimental and modelling techniques

New insight might improve properties even further

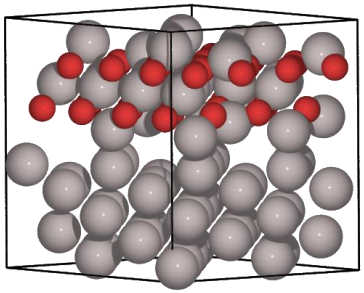
Experimental techniques

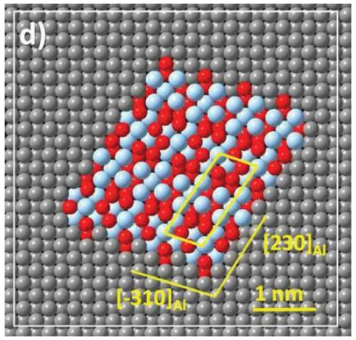


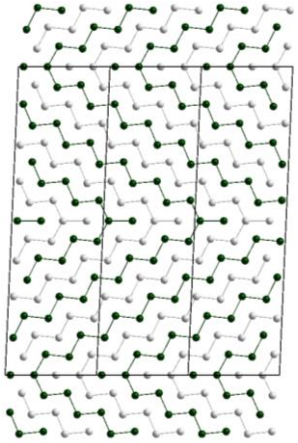


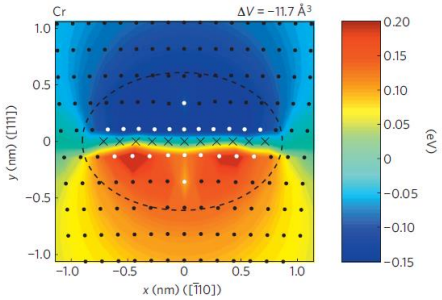
- Interfaces
- Diffusivities
- Precipitates
- Dislocations
- Grain boundaries
- Thermodynamics

Atomistic modelling









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3.4 Recycling and carbon footprints

More for less

Through technology and innovation we are able to make aluminium part of the solution

Reducing energy consumption and emissions in our own processes

Developing products and solutions that help our customers reduce energy consumption and emissions

Reducing waste in a world of limited resources and recovering energy and value from used products through recycling

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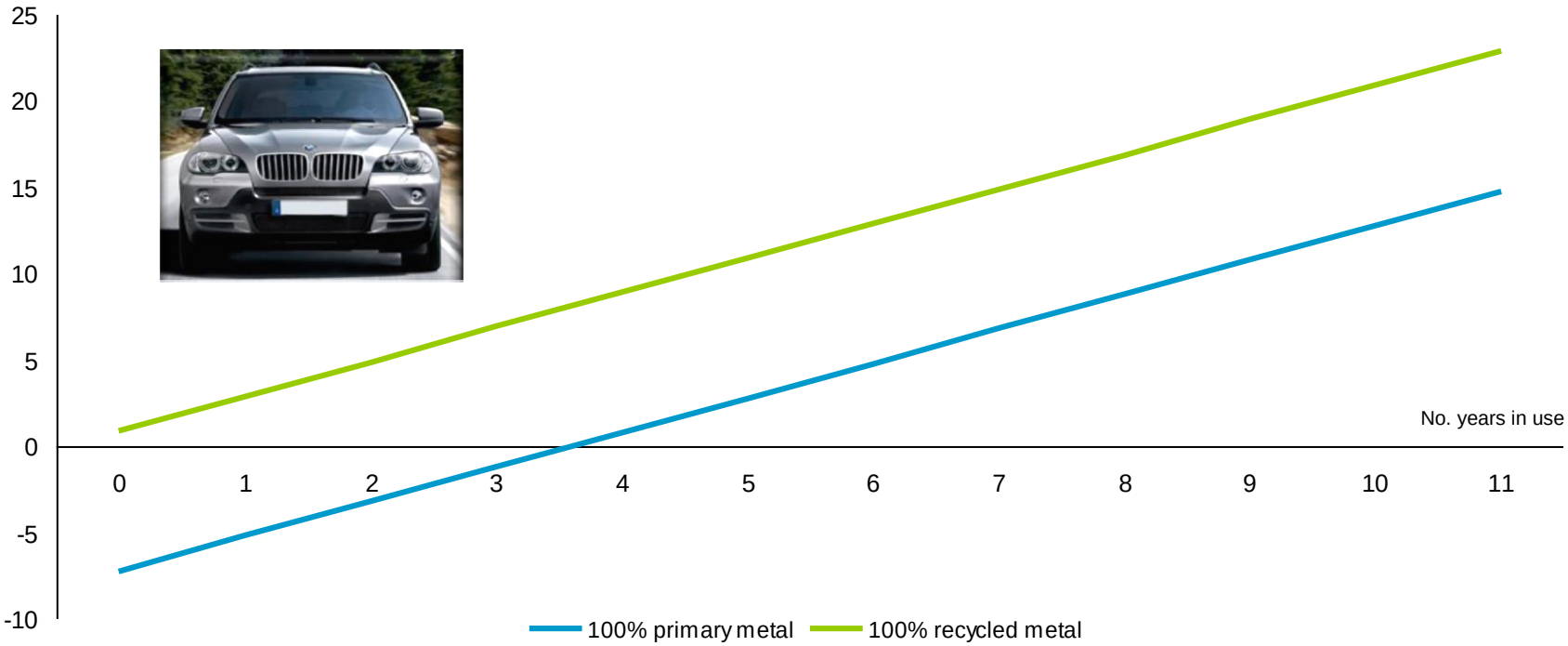
Lifecycle perspective: Replacing steel with aluminium in vehicles helps cut CO_2 emissions

Kg CO_2 saved/kg aluminium replacing steel in cars*



* Incl. Full value chain CO_2 emissions in production of (primary and recycled) steel and aluminium
Assuming 1 kg of aluminium replacing 2 kg of steel in car applications

Source: IFEU

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Hydro ambition: Carbon neutral in 2020

Hydro carbon neutral in 2020

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Everlasting products

Aluminium – an energy bank

75%
still in use

5%
to recycle

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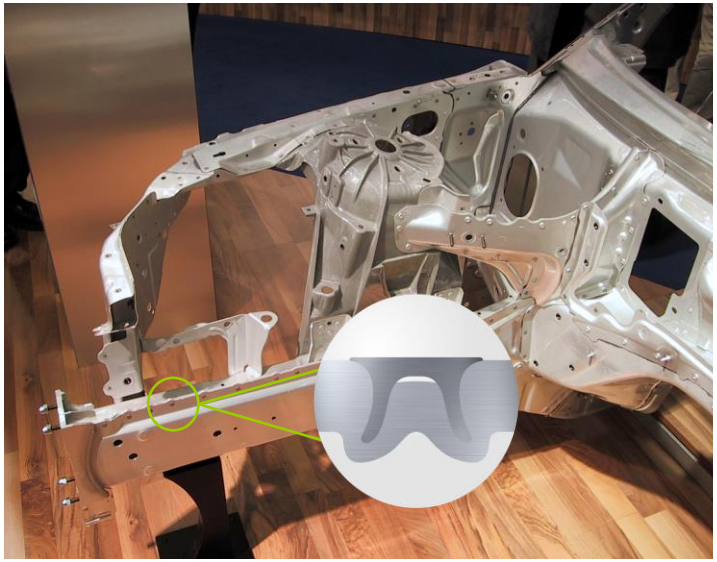
Recycling

Recycling and reusing aluminium

Reduce waste in a world of limited resources by recycling aluminium endlessly

Challenges:

- Technology for sorting alloys
- Metallurgy: effect of impurity elements and accumulated elements
- Design for recycling
- End of life perspective: on average recycling content limited to 30%



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Investing in developing our value chain

Making technology, R&D and innovation Hydro's competitive edge

€500 mill. Karmøy technology pilot

Targeting 12.3 kWh/kg on an industrial scale (world average 14 kWh/kg), financial R&D support pending ESA approval

€130 mill. to expand Grevenbroich «body-in-white» auto parts plant

Increasing capacity to 200,000 tpy to accommodate rapidly growing market of advanced aluminium alloys to lightweight cars

€45 mill. in new Neuss recycling line

Boosting recycling of used aluminium cans to 100,000 tpy with novel sorting technology, confirming commitment to Germany as industrial location

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Collaboration with academia

04

HYDRO

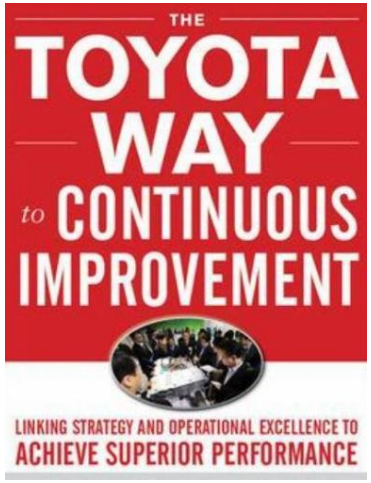
Historisk blikk på FoU og innovasjon

Tradisjonell industri

Standardisering, masseproduksjon, enhetskostnader

FoU internt i lukkede rom i den enkelte bedrift

1980-tallet



Desentralisert produksjon med underleverandører

Samarbeid i clustre, internasjonale nettverk og med konkurrenter, universiteter og eksterne institutter

Tilgang til ny teknologi viktigere enn egen ekspertise

Åpne, globale innovasjonsnettverk

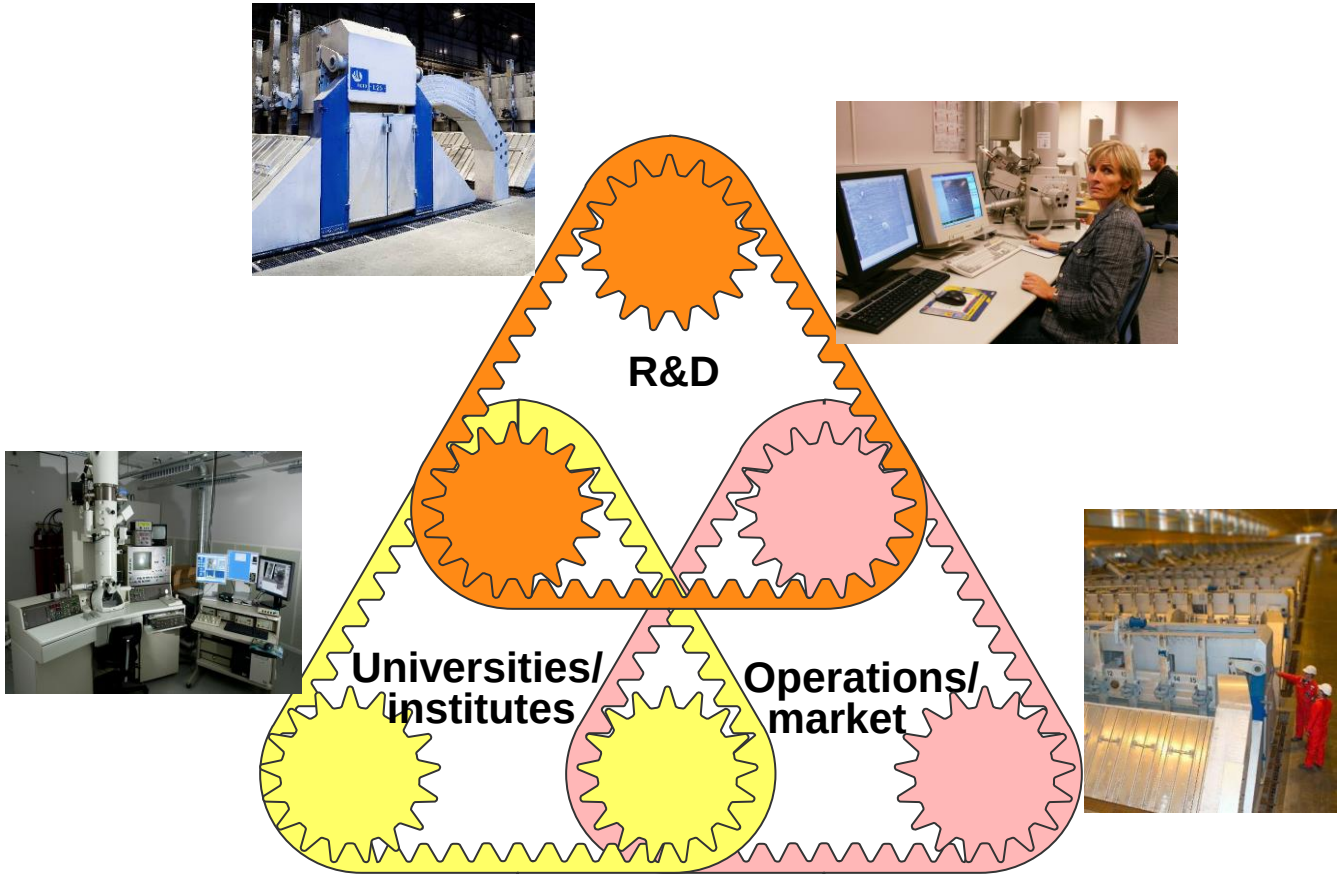
Markedsorientert innovasjon og kunnskapsutveksling i åpne, globale innovasjonsnettverk

Innovasjon gjennom samspill med kunder, leverandører og akademia, og andre partnerskap

Strukturerte måter å sette innovasjon ut i livet

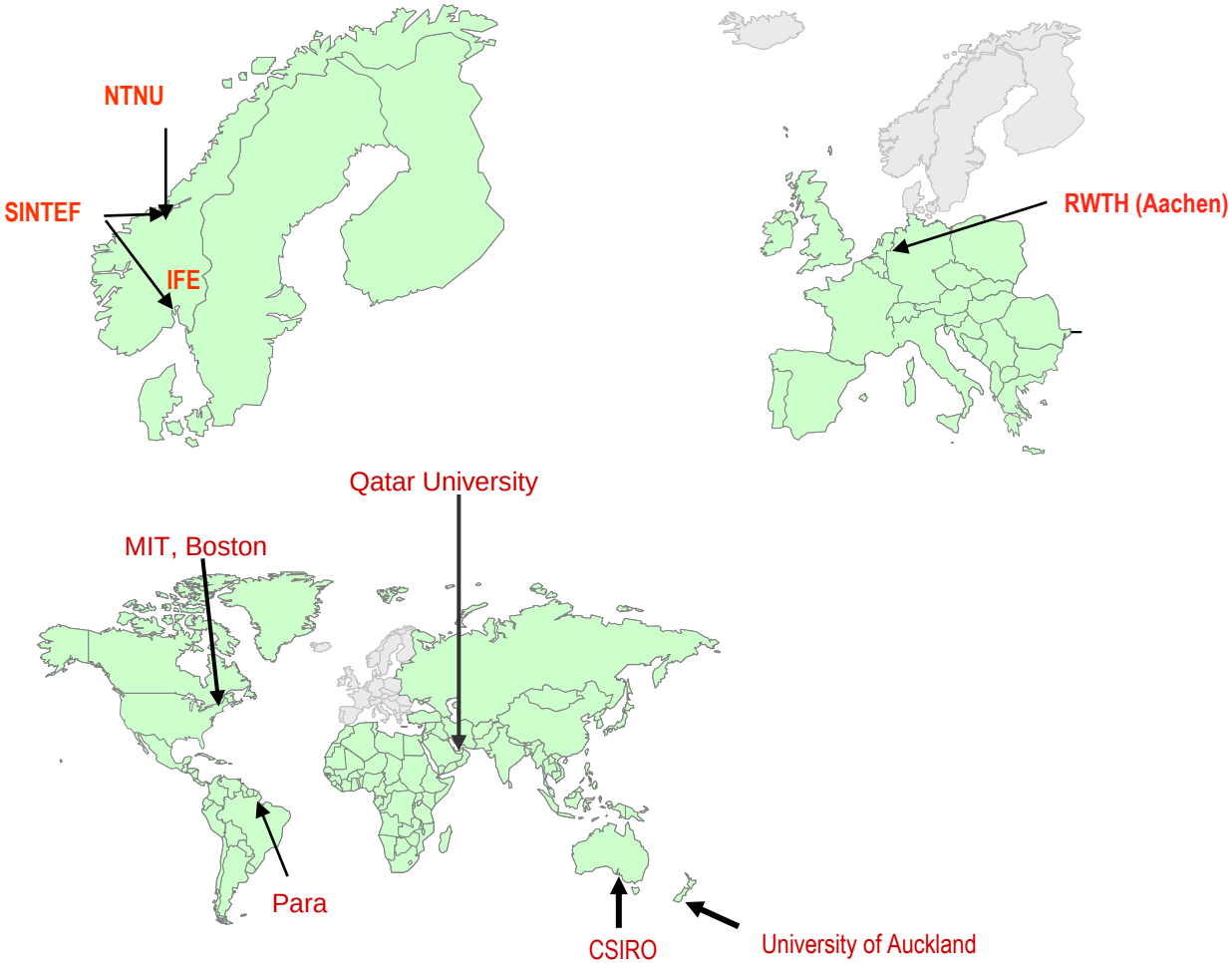
HYDRO

Academic network part of R&D value creation and innovation



HYDRO

Academic network important part of R&D organisation



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Public funding

Excellent public funding opportunities in Norway

- **NFR, Innovasjon Norge, ENOVA**
- **Enables long-term partnerships with academia**
- **Innovation engine**

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Norsk prosessindustri i et nasjonalt og globalt perspektiv

05

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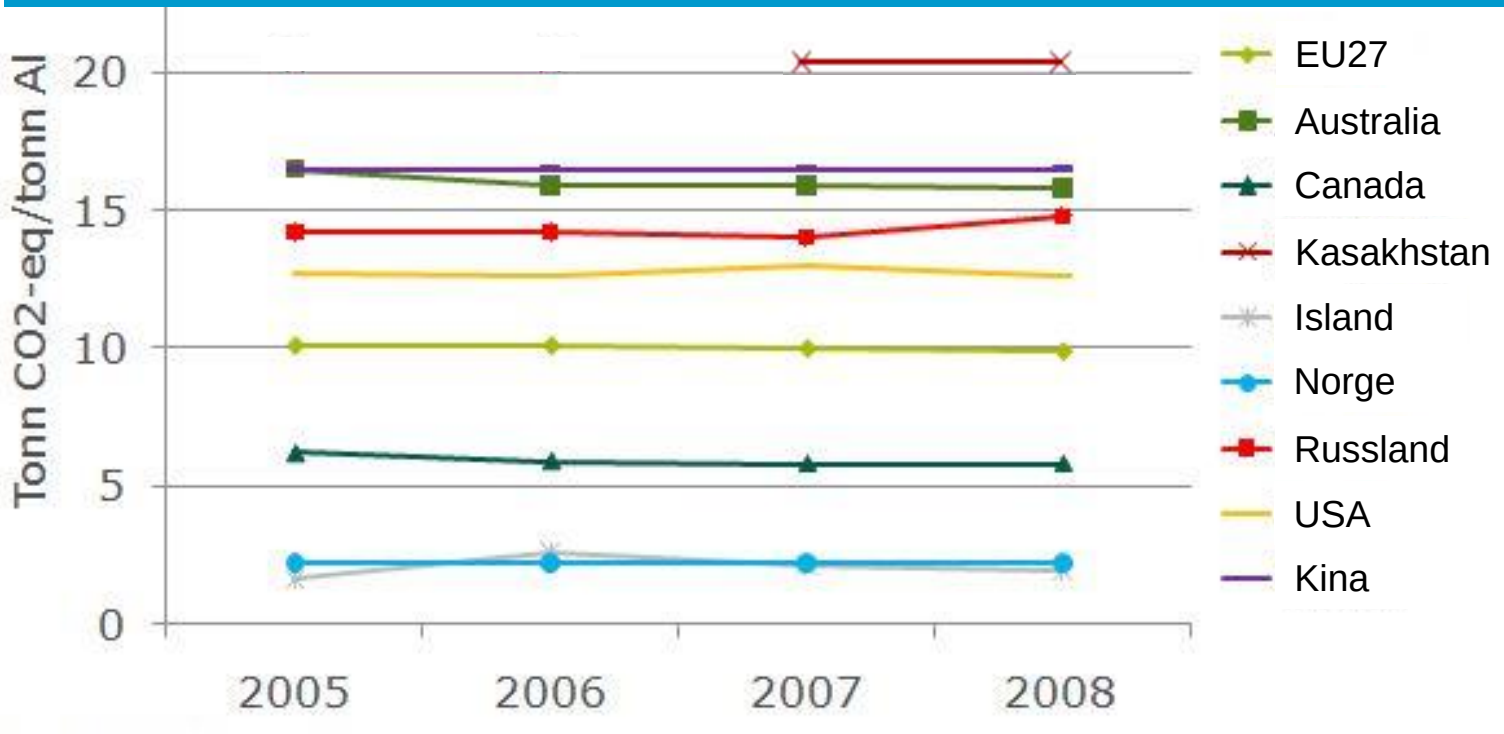
Norsk og islandsk aluminium best på klima

Å produsere 1 mill. tonn/år aluminium i Norge sparer verden for 15 mill. tonn CO_2 pr. år i forhold til alternativ produksjon i Kina



Source: Institut für angewendte Ökologie (Öko-institut e.V.), 12.5.2011

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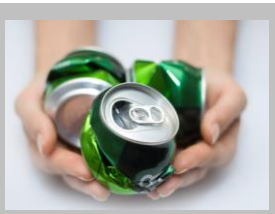
Norges og Hydros rolle som kraftforedler

Lysere fremtid for norsk prosessindustri

Verden trenger aluminium:
- **Infrastruktur, vekst, velstand**
- **Muliggjørende teknologi for energisparing i produkter**






Verdens grønneste aluminium:
- **Fornybar energi**
- **Verdens grønneste teknologi**



Kraftoverskudd i Norden:
Sysselsetting og teknologisk utvikling som supplement til ren krafteksport




Optimale forutsetninger for bruk av norske naturressurser og ekspertise til å skape sysselsetting, bygge kompetanse og bidra til å løse verdens klimautfordringer

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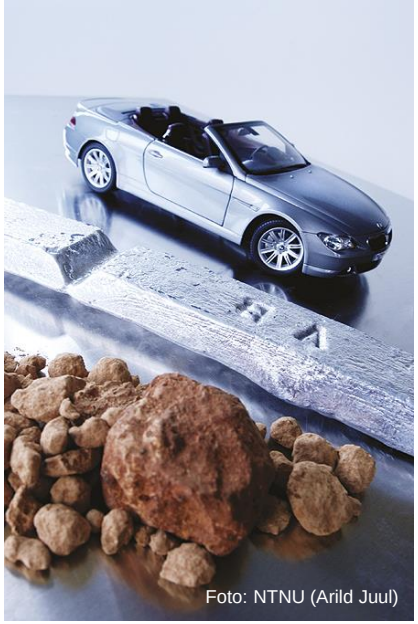
Sett kraften i arbeid!

Utvikling av norsk fremtidig industri

Fremtidig konkurranseevne = evne til å skape og omsette kunnskap til verdier

Kompetanse/teknologi



Produksjonskompetanse, FoU/virkemiddelapparatet

Naturressurser

Olje, gass, hav

Fornybar energi

Vann-/vindkraft

Kultur/historisk pos.

Marine næringer, prosessindustri

Kompetanse og teknologi + naturgitte fortrinn + kultur → Løse globale behov

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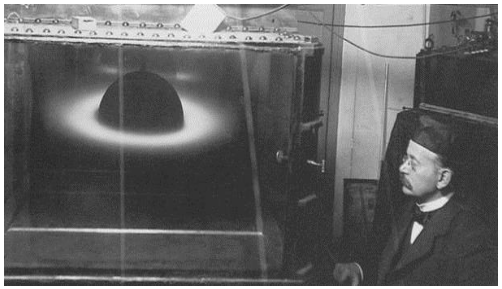
Eksempel: Norsk Hydro

Kompetanse/teknologi



Naturressurs

Globalt behov

Kompetanse og teknologi + naturgitte fortrinn + kultur → Løse globale behov

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Eksempel: Det norske soleventyret

Kompetanse/teknologi

Kultur/historisk posisjon

Globalt behov

Kompetanse og teknologi + naturgitte fortrinn + kultur → Løse globale behov

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Aluminium til havs – et hav av muligheter

Kombinasjon av sterke kompetansemiljøer – bygg på det vi kan!

- Teknologisk match:
  - Norge verdensledende innen aluminium og metallurgi
  - Norge verdensledende innen olje/gass, skip og andre marine anvendelser
  - Aluminium: Vekt, korrosjonsegenskaper og vedlikeholdsbehov, lavtemperaturegenskaper

Bygg på de områdene der vi allerede er gode eller har et naturlig fortrinn

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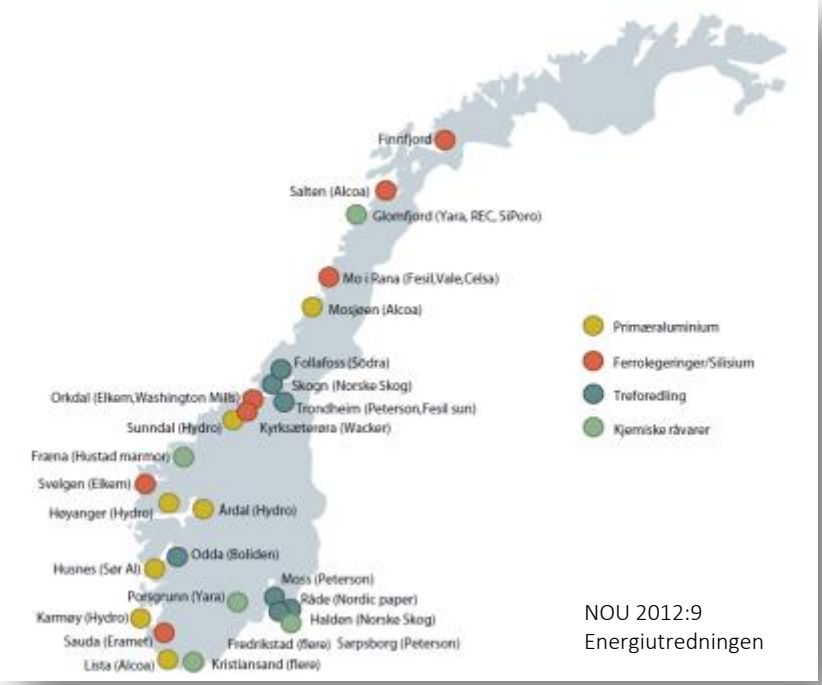
Stolte tradisjoner, spennende fremtid

Industrien er avhengig av kunnskapssamfunnet – og kunnskapssamfunnet er avhengig av industrien



NOU 2012:9
Energiutredningen

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Summary

05

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Technology and innovation essential to fulfill Hydro's ambitions and make aluminium part of the solution

- **Innovations in these areas are needed for sustainability and a sustainable aluminium industry**
- **On good track for electrolysis and Karmøy Technology Pilot**
- **Many new actors consider Al for new product applications**
- **Aluminium production in Norway makes sense**

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