INVEST IN Holland

The Netherlands: prospect for battery companies

EU's hotspot for next generation scalable battery technology

CONTENT – DUTCH ECOSYSTEM AND INFRASTRUCTURE FOR BATTERIES

1. Management Summary
2. Dutch Battery Value Chain
3. National Growth Funds (NGFs)
4. Talent
5. Fundamental and Applied Research
6. Collaboration cross border (NL-DE)
7. Enabling Technologies: (S)ALD
8. Test & Validation facilities
9. Show cases: What's happening
10. NFIA support and support

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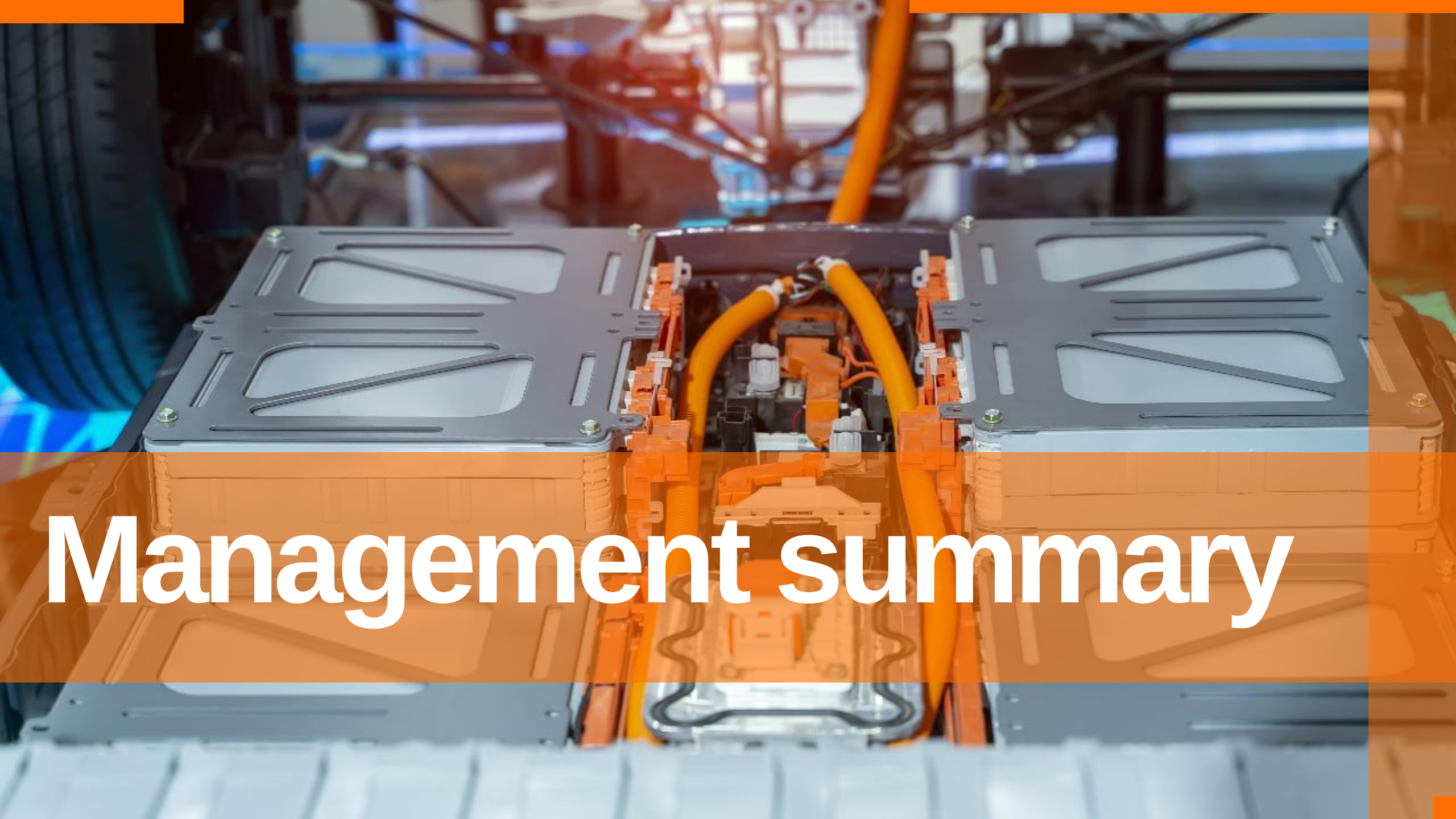

Management summary

UNIQUE ELEMENTS OF THE NETHERLANDS

The Netherlands as key supplier of next-gen battery components and production equipment in Europe

1. Strong fundamental research base with **top Dutch technical universities**, complemented with **nationally operating research institutes** as TNO that also offer a connection through applied research through eg. Holst Center.

2. Proven track record with decades of **high-tech industrialization** experience which has generated a strong and highly collabarative supply chain.

3. Both on fundamental research and industry driven innovation, the Netherlands runs **national innovation programs** where industry, universities and research collaborate in multi-year programs to develop next generation battery technology including the ecosystem that will enable this development.

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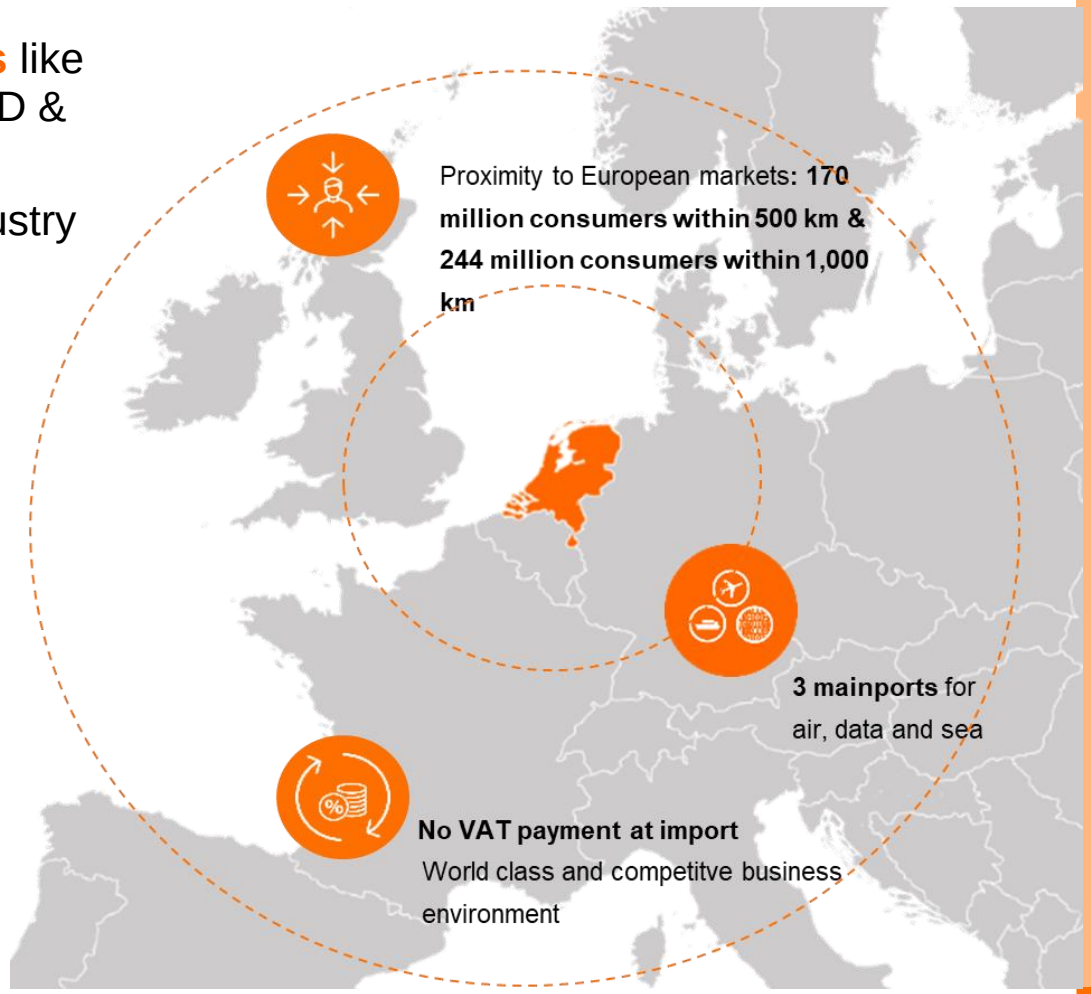
NETHERLANDS IN THE CENTRE OF EUROPE

A collaborative high tech industry developing the next generation of scalable battery technology

- Strong **high-tech equipment industry** including **scale-ups** like Leyden-Jar, Hyet Lithium, Delft IMP, E-magy, LionVolt, SALD & SparkNano
- Wide variety of **end-users in the heavy duty mobility** industry including OEMs lik DAF, Damen, VDL & Ebusco, Scania
- Strongly developed industries with **many suppliers for battery technology** (mechanical engeneering, chemicals & engeneering services)
- World Class **Test & Validation Centers** in Europe for electrical components
- Abundance of **talent** in Electrical Engineering & Material Science
- Strongly developed industries with **many suppliers for battery technology** (mechanical engeneering, chemicals & engeneering services)



Intern gebruik

DUTCH BATTERY TECHNOLOGY STRATEGY

Leading in six topics

- The Netherlands offers little space for giga battery factories but aims to be a big contributor to the European industry by acting as a major player in the supply chain of battery technology as well as in the re-use and recycling of battery components.

- The Netherlands aims to be a significant contributor in the development of battery technology by playing a leading role in six topics:

    1. Battery concepts: materials and cell design
    2. Equipment for cells, modules and packs
    3. Electric mobility: heavy duty & flying
    4. Stationairy storage: grid stability
    5. Safety and data security (incl. testing)
    6. Reuse, second-use and recycling

Intern gebruik

INNOVATION PROGRAM FOR A STRONG DUTCH BATTERY ECOSYSTEM

The Battery Competence Cluster – NL

Battery Competence Cluster - NL

- The BCC-NL is the innovation program for companies, knowledge institutions and organizations that want to work together to acquire knowledge and develop skills in the field of battery technology. The Dutch battery, transport and shipping industry join their forces in the Battery Competence Cluster – NL.
- The BCC-NL is developing activities to acquire the necessary knowledge and increase the competitive position of Dutch companies in the battery value chain:

1. Ecosystem Development

The BCC - NL contributes to the development of a strong battery ecosystem.
By connecting companies in the Netherlands and linking them to parties abroad, challenges and projects can be jointly addressed. Through valorisation of knowledge and collaboration, new businesses and opportunities will be generated.

2. Strategy formation

The BCC - NL is at the forefront of developing and implementing strategic plans for the Dutch battery sector.
By working together with different companies and organisations, BCC-NL works on the right challenges, opportunities and draw up joint technological roadmaps. The National Battery Systems Action Agenda is an example of this. By taking this approach, the participating parties are informed about each others latest technological developments and the OEMs and battery pack developers can anticipate to new technologies on time.

3. Innovation collaboration

The BCC - NL contributes to the realization of shared R&D facilities.
The development of battery technology is complex. A lot of testing and pilot production is needed to show that the technological compositions work. By investing in shared R&D facilities via the Battery Competence Cluster - NL, costs will be saved for a large number of companies in the Dutch battery chain. Such R&D facilities include test equipment, clean rooms, (pre-) pilot production lines and more.

Source: https://batterycompetencecluster.nl/en/approach

Intern gebruik

UNIQUE ELEMENTS OF THE NETHERLANDS

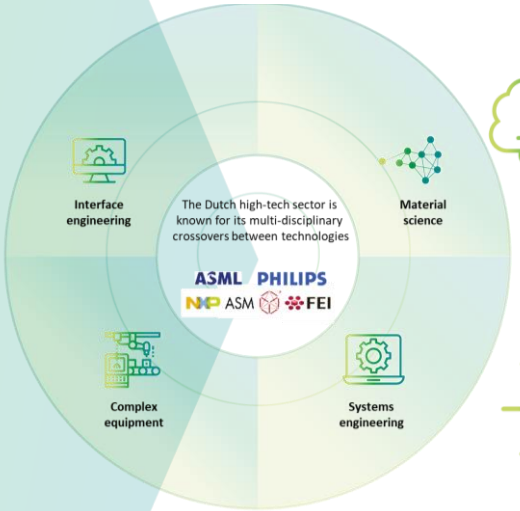
The Netherlands as key supplier of next-gen battery components and production equipment in Europe

Our Dutch high-tech competences:

The Dutch are forerunners in the high-tech industry.

Multiple high-tech disciplines are strengthening each other within the same ecosystem

A leading position in micro- and nano-electronics, such as thin-film deposition.



Our high-tech competences result in a strong battery ecosystem:

The Netherlands has a strong academic focus on researching next-gen battery development.

Empowered by an open innovation climate, the Netherlands is home to multiple highly promising start and scale-ups in thin-film deposition equipment, next-gen cell components and solid-state batteries.

Dutch equipment and component suppliers are backed by a strong surrounding mechatronics and systems engineering chain.

Intern gebruik

CONTRACT RESEARCH INSTITUTES

Easy access battery expertise in various research institutes

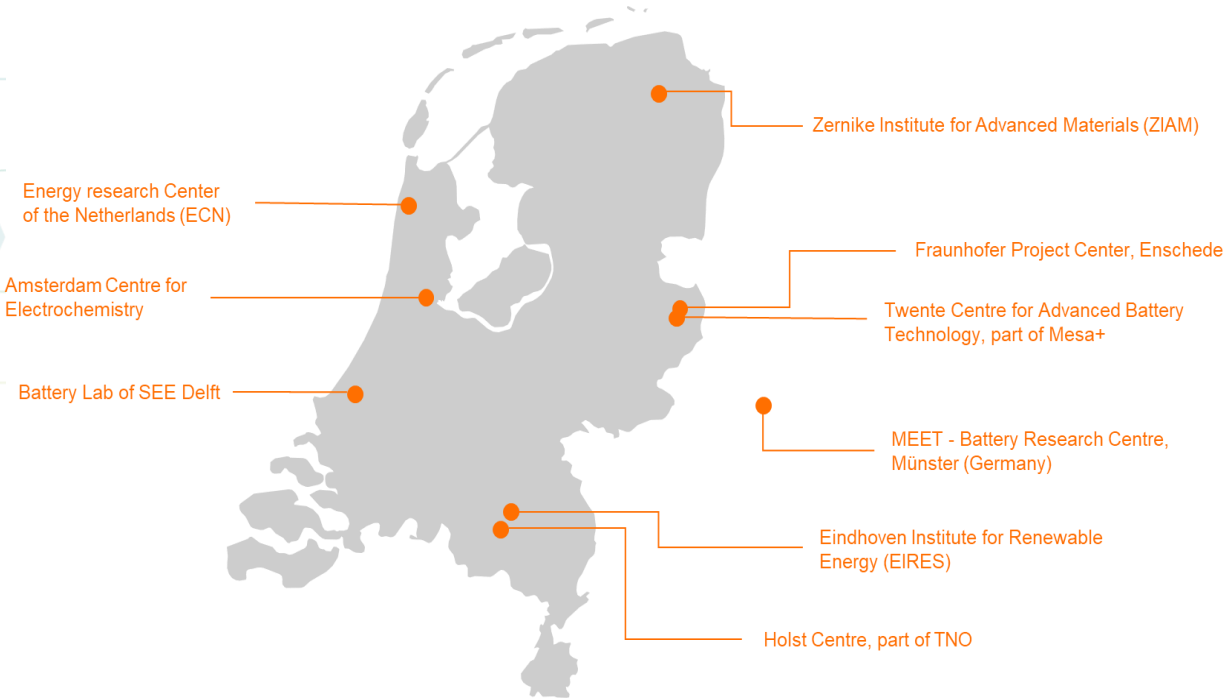
Our universities focussing on next-gen batteries

TU Delft
Battery Lab

TU Eindhoven
ALD & CVD nanolab

Twente University
Twente Centre for Advanced Battery Technology

Working closely together with:
Fraunhofer
MEET



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Dutch competences combined with an open innovation climate and major private & public fundings lead to a highly promising start-and scale-up ecosystem:

Silicon anodes

LeydenJar ENERGISING TECHNOLOGIES

E-MAGY on with silicon

GDI

Solid-state batteries

LionVolt

Thin-film Deposition equipment

SPARKNANO

SAD

delftIMP INTENSIFIED MATERIALS PRODUCTION

KALPANA SYSTEMS

The start- and scale-ups are backed by a mature industry of renowned contract manufacturers

VDL ETG

SMIT

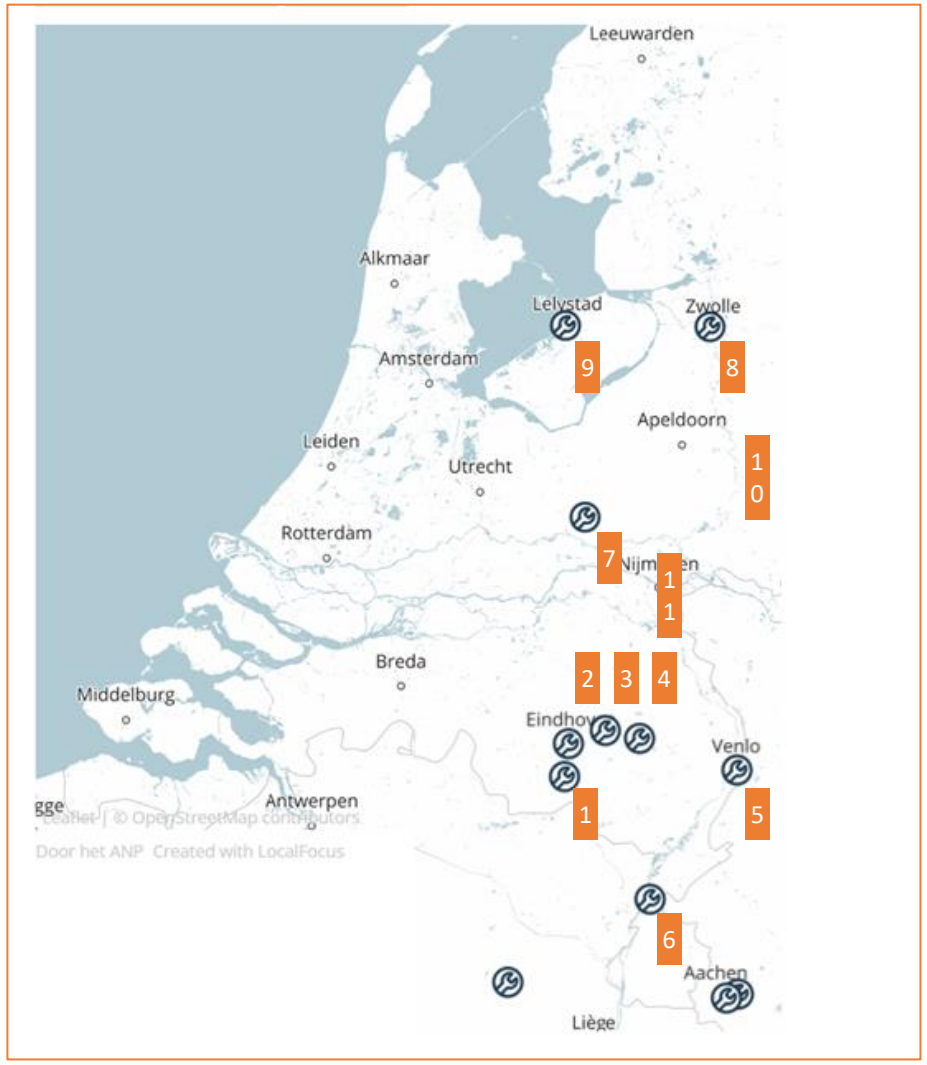
DEMCON

Battery Competence Center

Intern gebruik

DUTCH OEM LANDSCAPE FOR VEHICLE (RELATED) MANUFACTURING

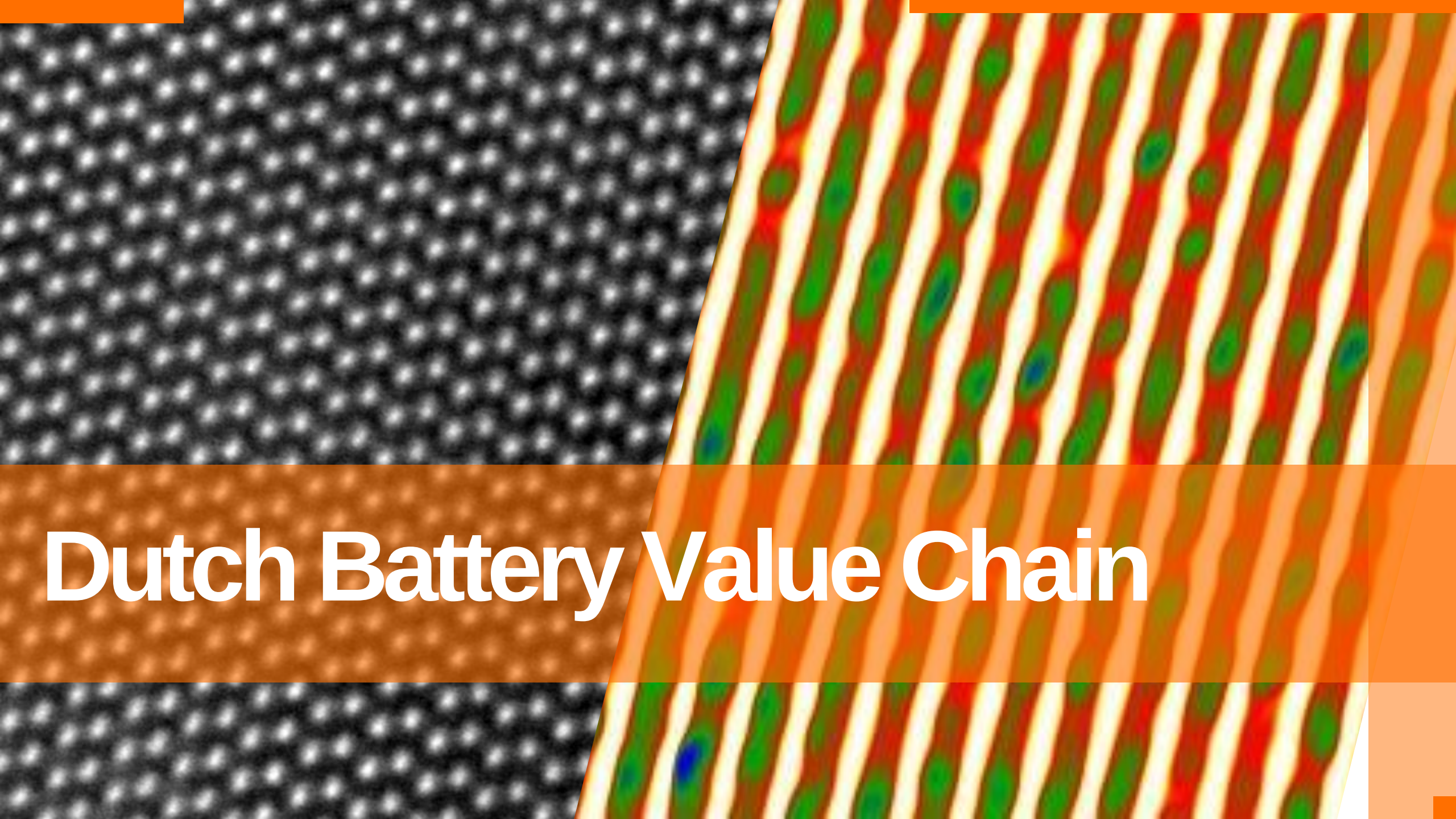
Heavy duty vehicles, Light commercial vehicles, batteries, passenger cars



Source: ACEA 2023

Dutch Automotive Production facilities

1. VDL Group : Busses (incl electrical)
2. DAF Trucks: Trucks (incl electrical)
3. ELEO Technologies: Batteries
4. Ebusco : Electrical Busses
5. VDL Group :Electric Mini Busses
6. VDL Group : EV Contract Manufacturing, Batteries
7. GINAF: Electric Heavy Duty vehicles
8. Scania Volkswagen AG: Trucks
9. Donkervoort: Electric Sports cars
10. AIH Group: Electric SUV Contract manufacturing
11. UMS : Electric Drive Trains Heavy Duty



Dutch Battery Value Chain

DUTCH VALUE CHAIN FOR BATTERY TECHNOLOGY

Key players

Raw & Active Materials

Differ
E-Magy
Leyden-Jar
LKAB minerals
RGS Development
Sald
Umicore
Delft IMP
Novocycle

Battery Cell & Pack

Aquabattery
Bredenoord
Cleantron
Dr. Ten
E Energy Storage
Elestor flow batteries
Elfa
EST Floattech
Exergy
Friday Energy
iWell
Koolen industries
LionVolt
LithiumWerks
Lyv
Ocean Grazer
Redox

Applications
Industrial, storage, e-mobility

Alfen
Alius
ATEPS
BAM
Batenburg
Centrica
Cleantron
Contour
DAF
Durapower
Ebusco
Edmij
Eneco
ePower
EST Floatech
Gigastorage
Greener P.S.
Indutecc
Kiwatt
Mennekes
MeterInsight
OTG Energy
Reco
RECovert
VDL
Wattsun
We Drive Solar
Withthegrid
Zenon Energy
EAFO

Applied technology
Charging, Service, IT

Allego
Alliander
Chargepoint
Chargesim
Chargetrip
Deftpower
Delta Electronics
Elaad NL
Enexis
Engie
Evoltify
Inepro Metering
Kongsberg
Rocsys
Tennet
VanderSijs

Testing & Validation

Battery Safety Test Centre
Battery Lab TU Delft
CESI-Kema Arnhem
DEKRA Arnhem
DNV
Green Village
Helmond Automotive Campus
KIWA
TüV Rheinland
UL

Recycling & Re-use

ARN
BASF
Beeplanet Factory
EcarACCU
Epac
Eramet
Nowos
Remondis
Stibat
SUEZ
Ter Horst Group
TES
Timeshift
Van Peperzeel

Knowledge Institutes

AMCEL
Eindhoven University of Technology
Energyresearch Center Netherlands (ECN)
Fraunhofer Batterien
Holst Centre part of TNO
Meet Munster
Technical University Delft
Twente Centre for Advanced Battery Tech.
Utrecht University
Zernike Institute for Advanced Materials

Intern gebruik

NATIONAL GROWTH FUNDS (NGF)

NATIONAL GROWTH FUNDS (NGF)

BCC-NL and NXT GEN HIGH TECH

What

Fostering Innovation:
Joint investing in research and development activities.

Building Ecosystems:
Facilitating triple helix collaboration to create robust ecosystems in specific technology domains.

Attracting Talent and Investment: Creating an environment that attracts talent, entrepreneurs, and investments in cutting-edge technologies.

How

Program based approach
Clear action lines and project leads. (university, research or industry)

Why

Stimulating Economic Growth:
Supporting initiatives that contribute to the Dutch future earning power and therewith economic growth by creating new business opportunities, jobs, and industries.

Global Competitiveness: Enhancing the global competitiveness of the country or region in specific technology sectors, building on the existing and complementary expertise base.

How

Relevant NGFs for Batteries:

Battery Competence Cluster - NL

NXT GEN HIGHTECH

BatteryNL
DUTCH BATTERY MATERIALS

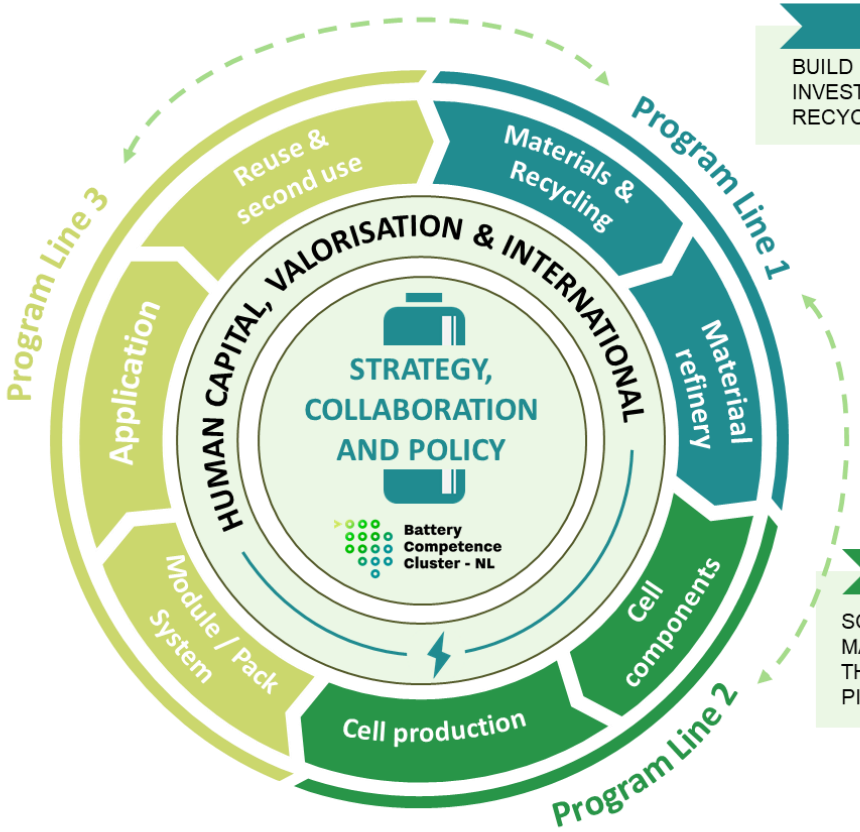
NATIONAL GROWTH FUND : BATTERY COMPETENCE CLUSTER NL

Multi-year innovation program for batteries

Battery Competence Cluster - NL

BCC-NL Hightech program:

- Applicants: Min. Economic Affairs and BCC-NL
- 65 project partners
- Duration : 8 years – Q1 2024 – Q4 2031
- 3 program lines and 6 work packages



STRATEGY

BUILD INNOVATION CLUSTER AND INVESTIGATE POSITION IN THE RECYCLING VALUE CHAIN

STRATEGY

DEVELOP BATTERY SYSTEMS FOR HEAVY DUTY MOBILITY AND CREATE PRODUCTION CAPACITY OF MODULES/PACKS IN NL.
CREATE PILOTS AND DEMO'S FOR BULK BATTERY SYSTEMS

STRATEGY

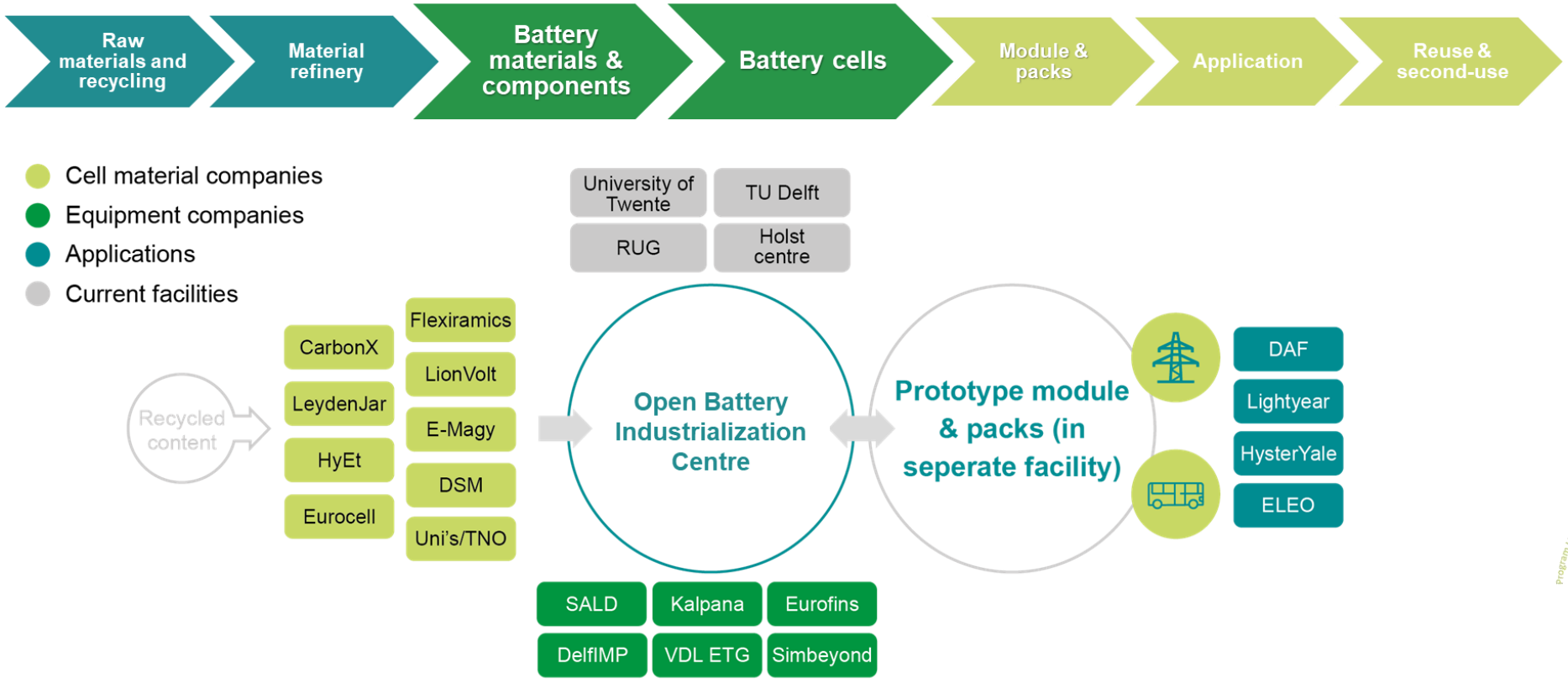
SCALE UP PROMISING SUSTAINABLE MATERIALS AND BRIDGE THE GAP WITH THE MARKET WITH CENTRAL CELL PILOT LINE

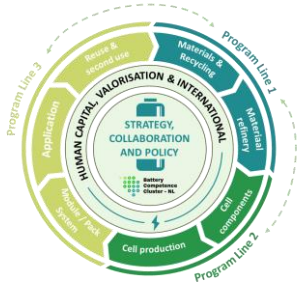
NATIONAL GROWTH FUND : BATTERY COMPETENCE CLUSTER NL

Multi-year innovation program for batteries

Battery Competence Cluster - NL

Project line example: Scaling promising sustainable next-gen battery cell technology



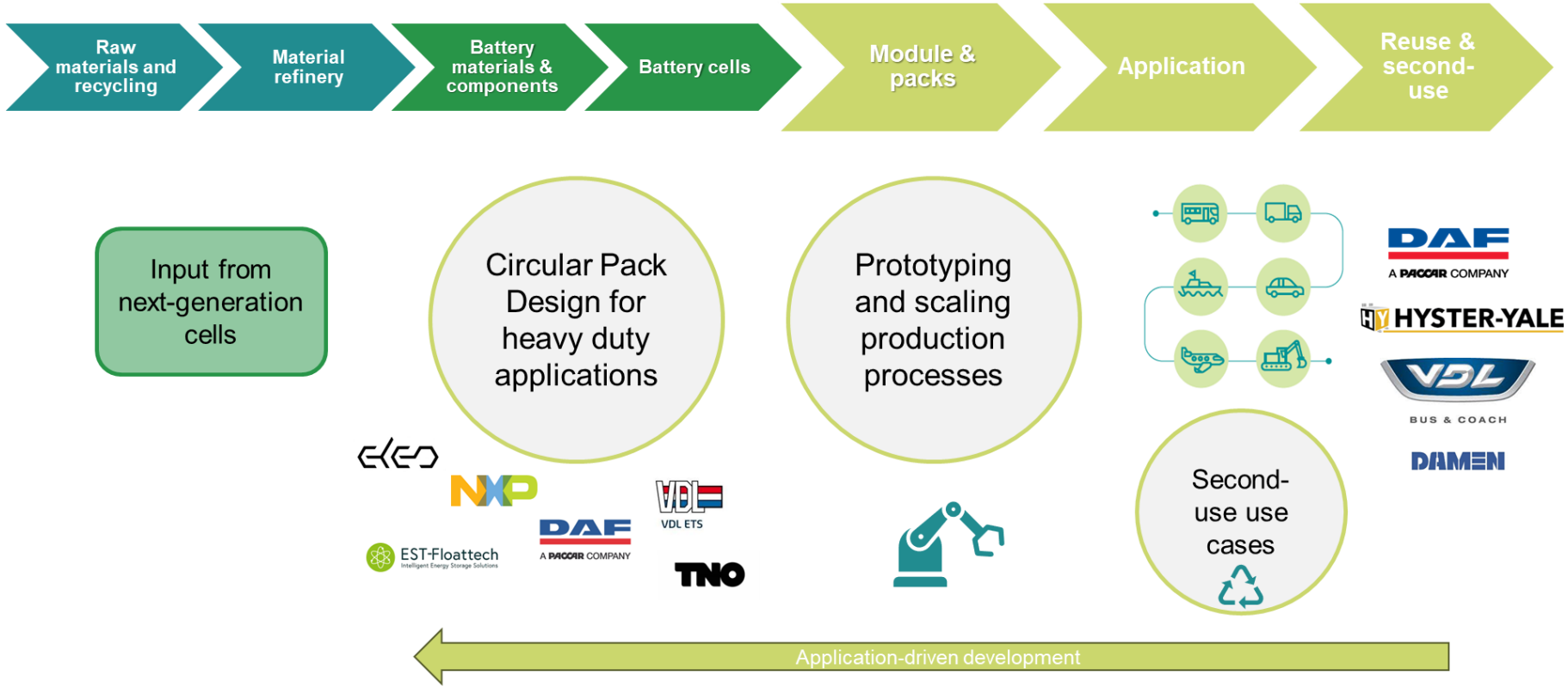


NATIONAL GROWTH FUND : BATTERY COMPETENCE CLUSTER NL

Multi-year innovation program for batteries

Battery Competence Cluster - NL

Project line example : develop competing edge with battery as core component of heavy-duty vehicles



NATIONAL GROWTH FUND : NXT GEN HIGHTECH

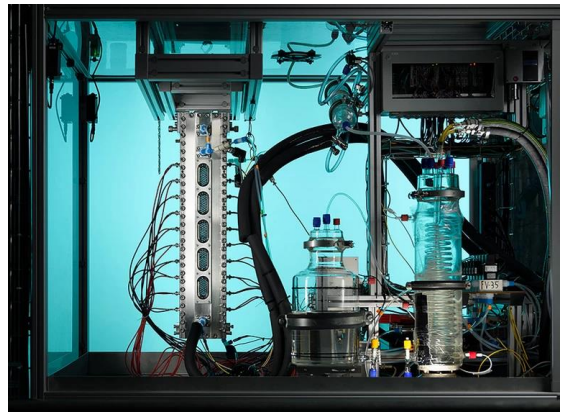
Multi-year innovation program for energy & batteries

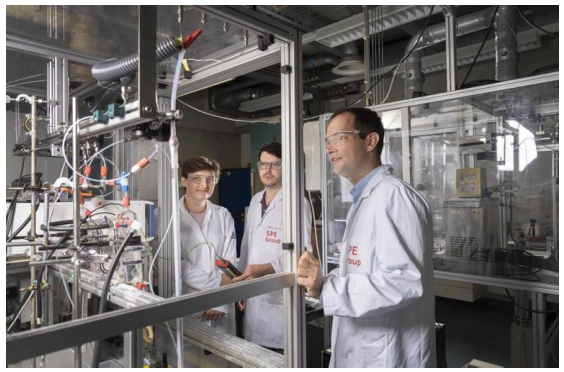
NXTGEN Hightech program:

- Is part of the National Growth Fund program
- runs til 2030
- total investments of € 1B euro.*
- involves 330 partners (industry, universities, research institutes)

Projects that are active within the Energy domain:

- 3D Battery Pilot Line Production
- Next-gen Equipment for Batteries and Battery materials
- Plasma Conversion of Methane
- Alkalina
- Third Generation Electrolyzers
- Mass production of Zero Emission Fuels micro-plants for affordable solar fuel





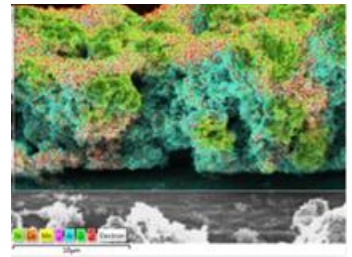
*450M euro invested by the government through the NGF

NWO PROJECT: BATTERYNL

Next generation batteries based on understanding material interfaces

BatteryNL program:

- will realize safer next-generation batteries with higher energy densities and longer cycle life,
- Investigates the electrolyte-electrode interface to reveal the bottle-neck processes and improve with scalable interface technology
- Is part of the Dutch Research Agenda (NWA)
- runs til 2030
- involves >30 partners (industry, universities, research institutes)



Work packages (WP#) within BatteryNL:

- WP1: 2-dimensional Li-ion battery model systems: understanding interface reactions and strategies towards stable interfaces
- WP2 > Development of Interface Strategies and translation from 2D to 3D
- WP3 > Operando Characterization
- WP4 > Upscaling strategies for interface engineered battery materials
- WP5 > Safety, Performance and integration
- WP6 > Socio- and Techno-economic Studies
- WP7 > BatteryNL network, collaboration and outreach

BatteryNL
DUTCH BATTERY MATERIALS

Source: Project workpackages | BatteryNL

Talent

FINDING YOUR FUTURE EMPLOYEES

Availability of talent

Universities all over the country offer education related to the development of battery technology. Some examples are:

- Delft: Delft Energy Initiative
- Enschede: Inorganic Materials Science (IMS)
- Enschede: Faculty of Engineering Technology (ET)
- Arnhem: Electrical and Electronic Engineering
- Eindhoven: Energy Technology
- Eindhoven: Electrical and Electronic Engineering
- Groningen: Zernike Institute for Advanced Materials
- Groningen: Centre of Expertise Energie
- Amsterdam: Van 't Hoff Institute for Molecular Sciences
- Utrecht: Materials Chemistry and Catalysis

In close proximity

- Aachen: Institute for Power Electronics and Electrical Drives

Fundamental and applied research for battery technology

FUNDAMENTAL AND APPLIED RESEARCH GROUPS AND PROGRAMS

Outline of battery focus areas for leading technical universities

UNIVERSITY OF TWENTE.

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

TU Delft

TNO

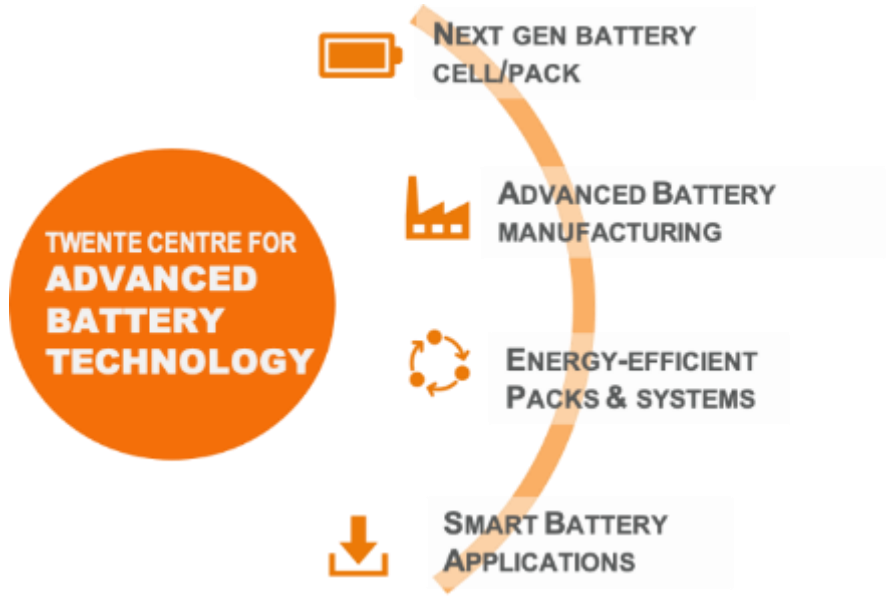
Holst Centre

Open Innovation by imec and TNO

TWENTE CENTRE FOR ADVANCED BATTERY TECHNOLOGY

Advanced research for next-generation solutions

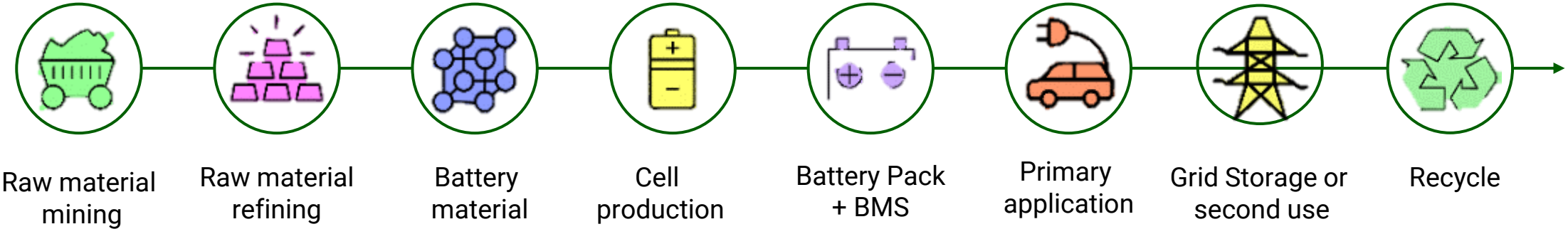
- 25 research groups
- full battery value chain
- 100 researchers
- many industrial partners
- member of (inter)national battery R&D&I networks



TWENTE CENTRE FOR ADVANCED BATTERY TECHNOLOGY

The production chain

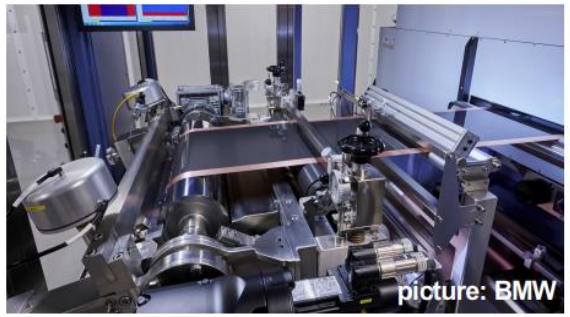
- **Integral approach:** UT competences contribute to battery challenges all along the value chain, multidisciplinary
- Accelerate the pace of impact with **mission driven roadmaps** together with our partners

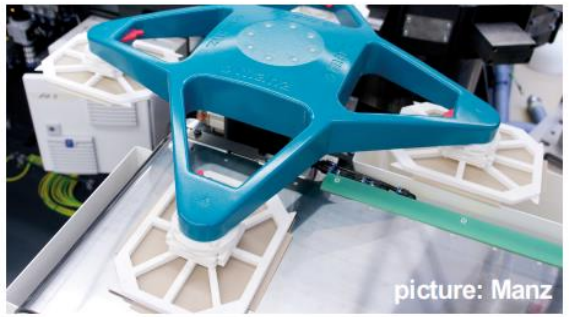


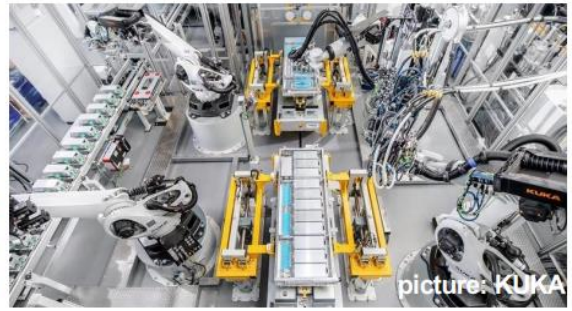
Mineral exploration
Metallurgy
Material Sc
Mechanical Design
Safety
Power Electronics
Digital /Software
Electrical
Advanced Manufacturing
Metallurgy
Policy/ Socioeconomics/ Behaviour
Life Cycle Analysis and Optimization

BATTERY RESEARCH @ UT TWENTE

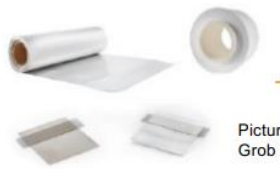
Cooperation Frauenhofer and Meet Munster







Electrode Production	Cell Assembly	Formation/Finishing	Module/pack assembly
Mixing, Coating, Drying, Calendaring	Stacking, drying, can cutting forming, electrolyte filling, sealing (takes place in dry room)	Electro-chemical activation and testing	Assembly of cells and further components to modules, contacting
continuous/batch process	discrete manufacturing	batch process in test/charging rigs	discrete manufacturing



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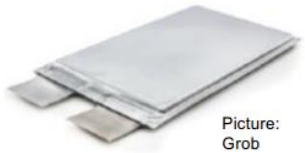


Picture: Grob

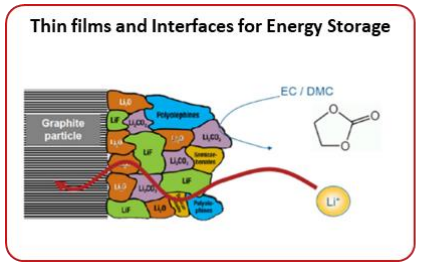
Source: AUDI AG

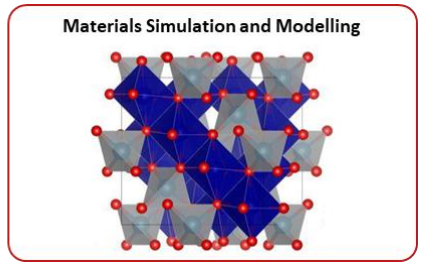
TWENTE CENTRE FOR ADVANCED BATTERY TECHNOLOGY

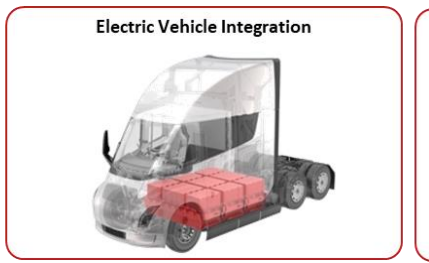
Advanced research for next-generation solutions

For Batteries, TU/e focusses on the following areas:

- **New chemicals:**
  - Atomic layer depositions (to apply for production of electrodes)
  - Materials simulations and modelling (eg graphite in cathode)
- **Bulkbatteries** (stationaire opslag):
  - Membranen voor redox-flow batterijen
- **Integration:**
  - Battery management systems (battery intelligence: balancing, fast charging, predictive maintanance, lifetime opitimization)
  - Integration of batteries in EVs
  - Life Cycle Analysis (LCA) of the complete technological chain for batteries.



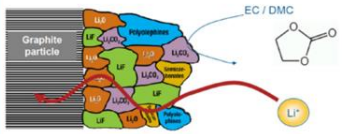




TECHNICAL UNIVERSITY OF EINDHOVEN

Characteristics of the key focus areas

Thin films and Interfaces for Energy Storage

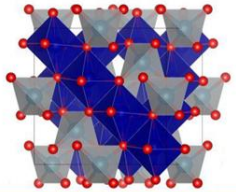


Keywords: gas phase deposition methods, atomic layer deposition, plasma processing, in situ film growth studies, interface engineering

Membrane Materials and Processes

Keywords: Redox-Flow, architected microstructures, electrochemical interfaces

Materials Simulation and Modelling



Keywords: electronic structure theory, machine learning, reactive molecular dynamics, complex oxides for Li/Na batteries, novel cathode materials, high energy density, ion diffusivity, structural stability.

Keywords: fuel cell, flow battery, ion-exchange membrane, molecular dynamics, multiscale modelling, ion transport, polyelectrolyte

Battery Modelling and Battery Management Systems

Keywords: empirical and physics-based modelling, parameter estimation, state (SoX) estimation, fast-charging, active balancing control, impedance spectroscopy

Electric Vehicle Integration

Keywords: multidisciplinary optimization; pack topology and shape design; battery thermal management systems; control systems; cell-to-vehicle integration; energy management; system design

Innovation & Societal Perspective

Keywords: carbon footprint & circularity, impact assessment of emerging technologies, transition pathways, socio-technical system integration & sectoral coupling, feasibility studies, energy communities

BATTERY RESEARCH @ TU DELFT

Next generation battery materials, systems and recycling

- >100 researchers across all 8 faculties covering the full battery value chain
- Engaged in many (inter)national battery networks and collaborations
- Closely collaborating with top notch industrial partners
- Situated @ TUD Campus, home for battery related start-ups

BATTERY RESEARCH @ TU DELFT

Focus, competences and facilities

Focus area's

- Battery material development and production
- New battery material technology (solid state, Na-ion, F-ion, flow batteries, MXene supercaps)
- Recycling & use of critical materials & cycle life assessment
- Battery power and energy management
- Grid Storage or second use
- Battery passport, energy access & justice

Facilities

- Battery lab (material development, processing, assembly and testing)
- Advanced battery characterization (impedance, Raman, IR, XPS, solid state NMR, SEM, TEM, X-ray and Neutron scattering)
- Electrical Sustainable Power Lab incl digital twin, various environment control chambers for battery testing
- 24/7 autonomous living lab @ TGV
- Energy transition lab @ TPM

STORAGE OF ELECTROCHEMICAL ENERGY (SEE)

Battery Lab University of Delft

- SEE aims at understanding of fundamental processes in, and the improvement, development and preparation of battery materials. The battery chemistries investigated include **Li-ion, Li-metal, Li-air, solid state (both inorganic and polymer based), Mg-ion and Na-ion as well as aqueous battery chemistries**. One of the focal areas is operando research of the structural evolution and ion mobility.

- It has a **Electrical Sustainable Power Lab**.

- The group has direct access to **neutron facilities** located at the institute. Solid state NMR, on the group's **500 MHz machine**, is used to investigate the local environment in battery materials, as well as the Li-ion (or other ion) mobility within solid electrolyte and electrode materials, as well as between different phases.

- The **battery lab** of the group has the **complete facilities to prepare materials, batteries and to perform battery testing**. With this research the aim of the group is to support the world wide efforts in developing safe and high performance energy storage in batteries.

Intern gebruik

TNO - HOLST CENTRE

World-leading open-innovation R&D center with expertise in flexible electronics

The Holst Centre uses its thin-film expertise to enhance lithium battery performance in two ways:

1. Our interfacial engineering improves the safety and lifespan of existing lithium-ion technologies. We **use spatial atomic layer deposition (sALD)** to optimize the interface between the electrodes and the electrolyte materials in many different battery designs and cell chemistries. sALD can be scaled through a large-area roll-to-roll process that Holst Centre has also developed.
2. Secondly, we are pioneering a novel 3D solid-state architecture that combines safety, short charging times, high charge density and a longer lifespan. Here too, atomic-scale control of sALD allows us to create extremely high aspect-ratio structures (100:the1) that maximize the internal surface area while ensuring excellent layer thickness and homogeneity. Recently, SALD deposition of lithium phosphorus oxynitride (LiPON) was demonstrated. This material serves as the solid-state electrolyte in the **3D solid-state thin-film batteries** but could also be applied in traditional batteries.

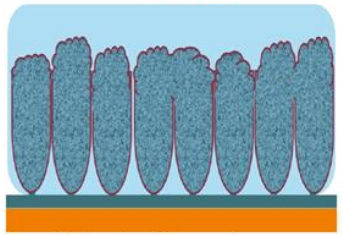
For both areas, they are active in both shared research and one-to-one projects to a level of Proof of Concept and prototyping.

Intern gebruik

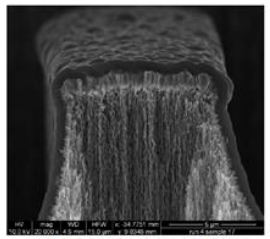
TNO - HOLST CENTRE

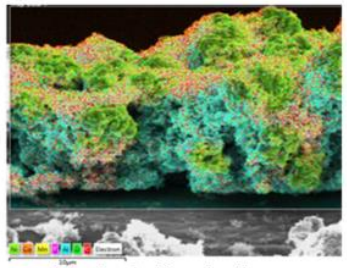
Focus areas and core technologies

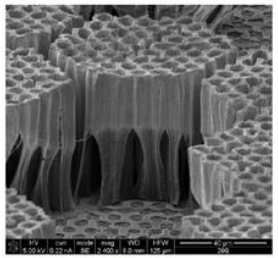
Battery @ Holst


Si Anode Processing

(3D) Li Anode

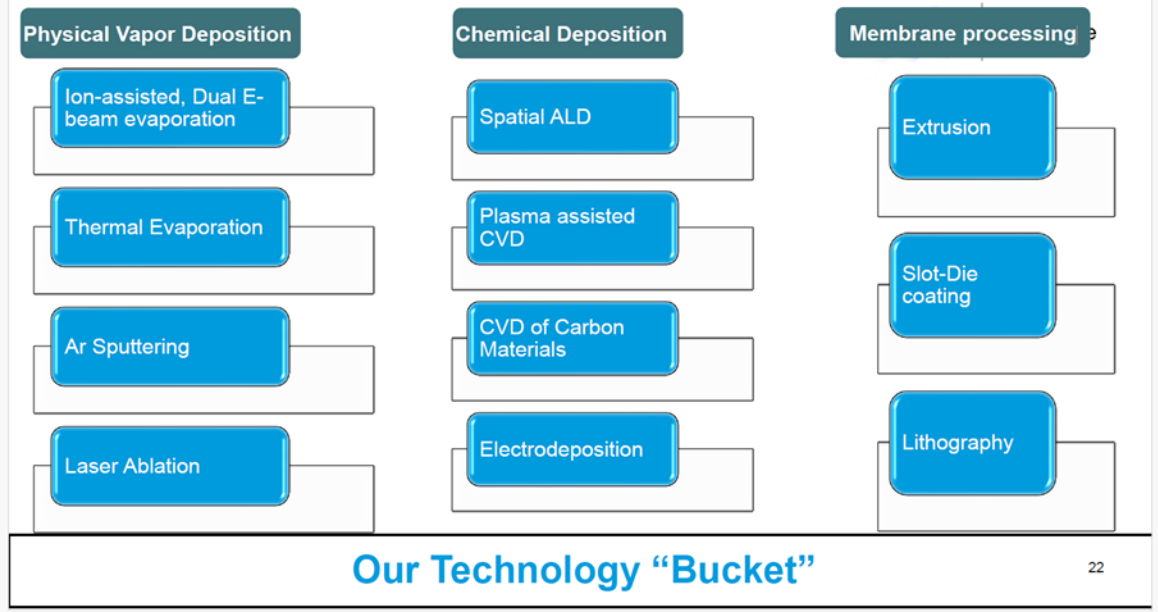

Monolithic Integration


Electrode Passivation

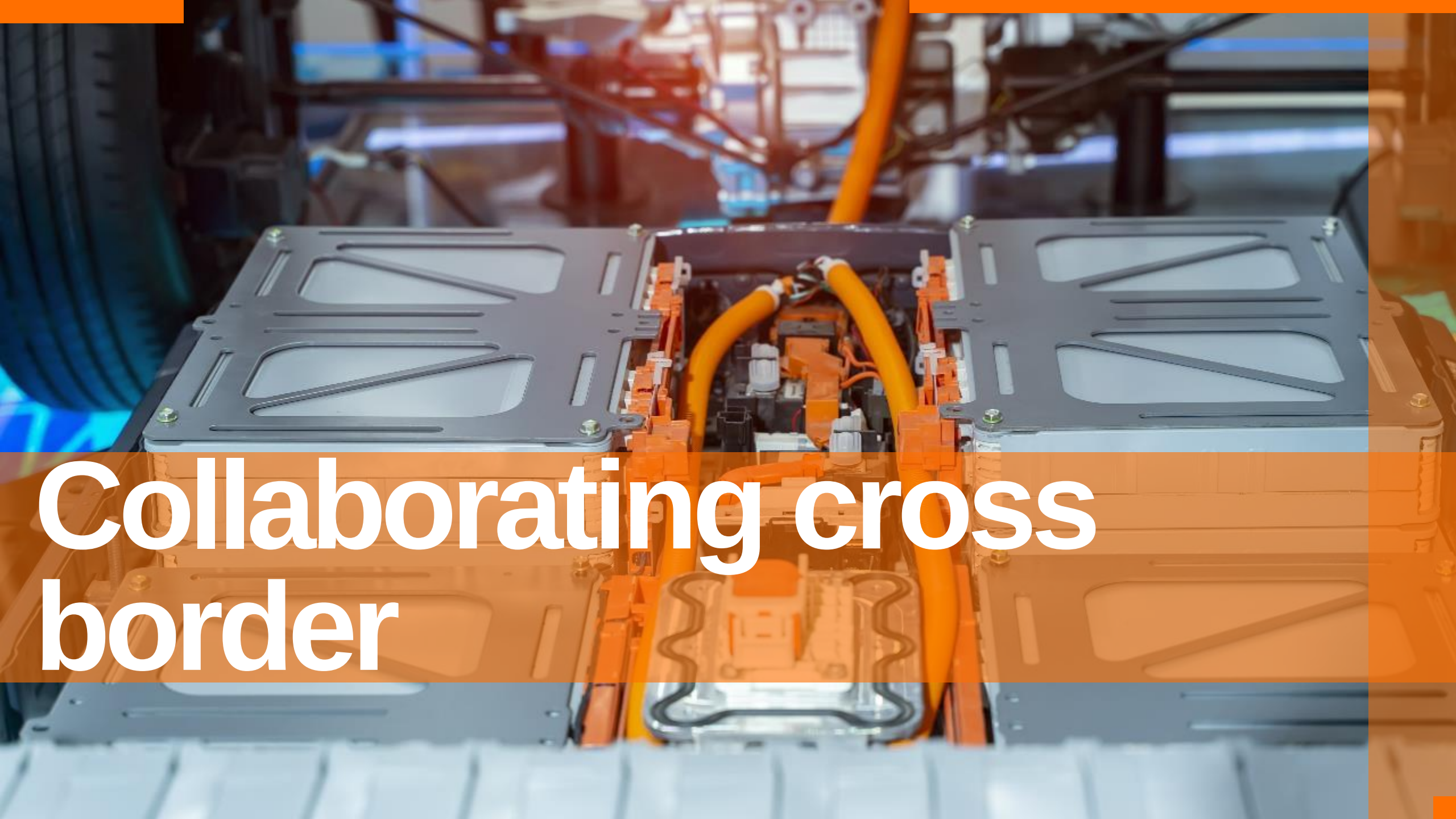

Materials Structuring


Testing

- Alternative Binders
- Dry processing
- Beyond Li batteries



Intern gebruik



Collaborating cross border

CROSS-BORDER BATTERY PROGRAM

Europe

BEPA
Batteries European Partnership Association

BATT4EU
Batteries European Partnership

Battery Competence Cluster - NL

ALISTORE
European research institute

destiNY
Doctorate programme on Emerging battery Storage Technologies INspiring Young scientists
Marie Skłodowska-Curie actions COFUND PhD

Energy Storage NL

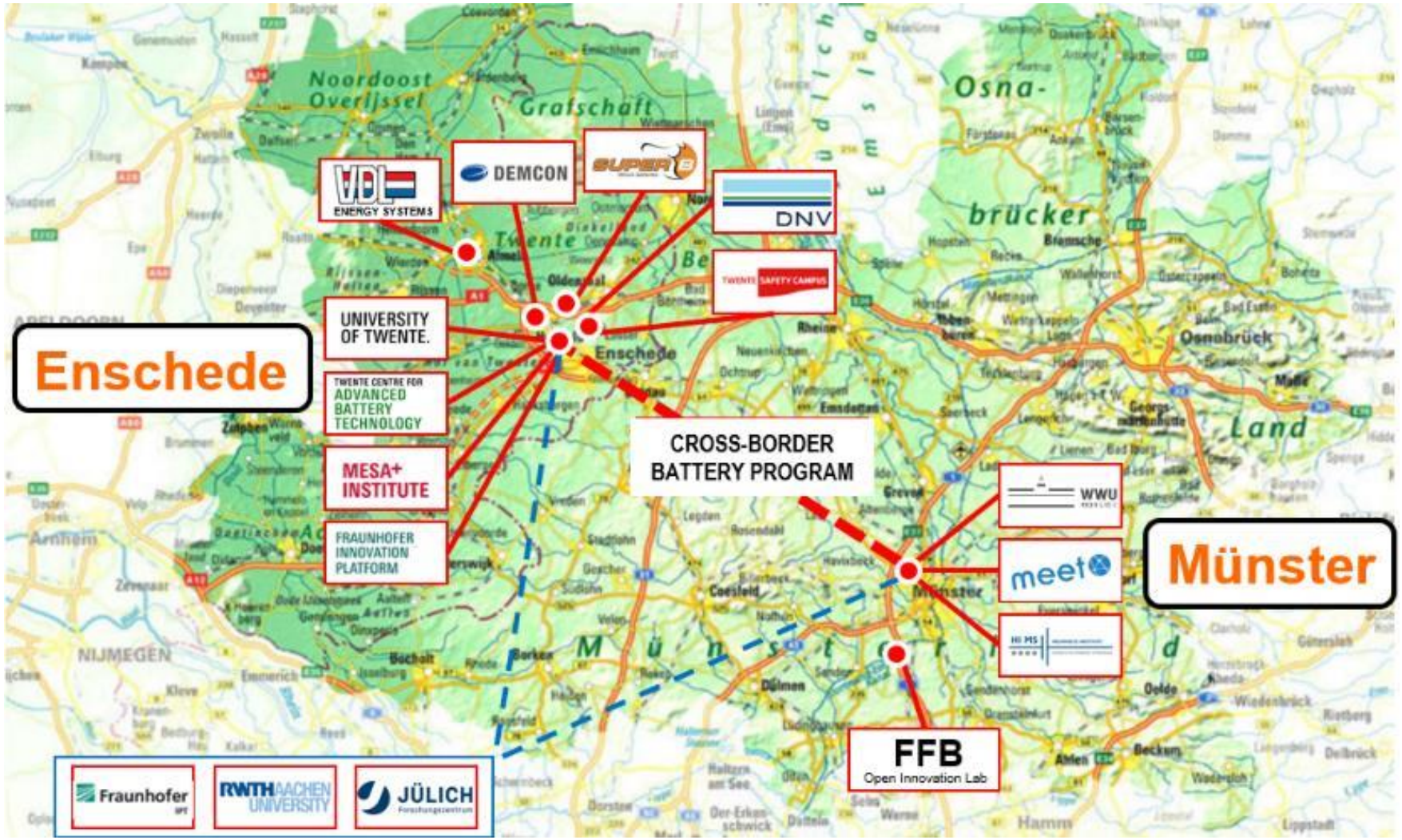
BATTERY 2030+

BatteryNL
DUTCH BATTERY MATERIALS

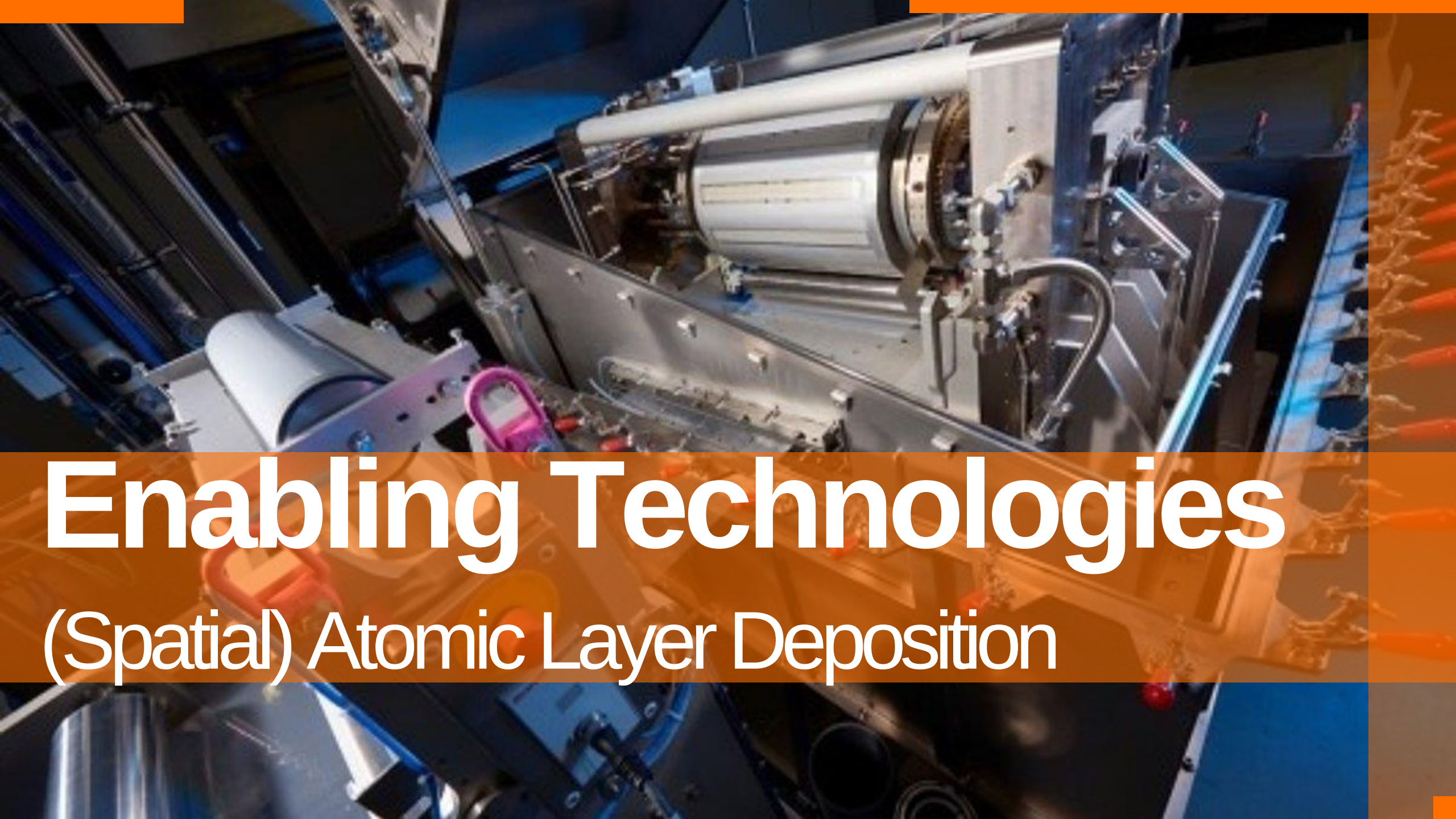
Intern gebruik

CROSS-BORDER BATTERY PROGRAM

Enschede & Münster



Intern gebruik

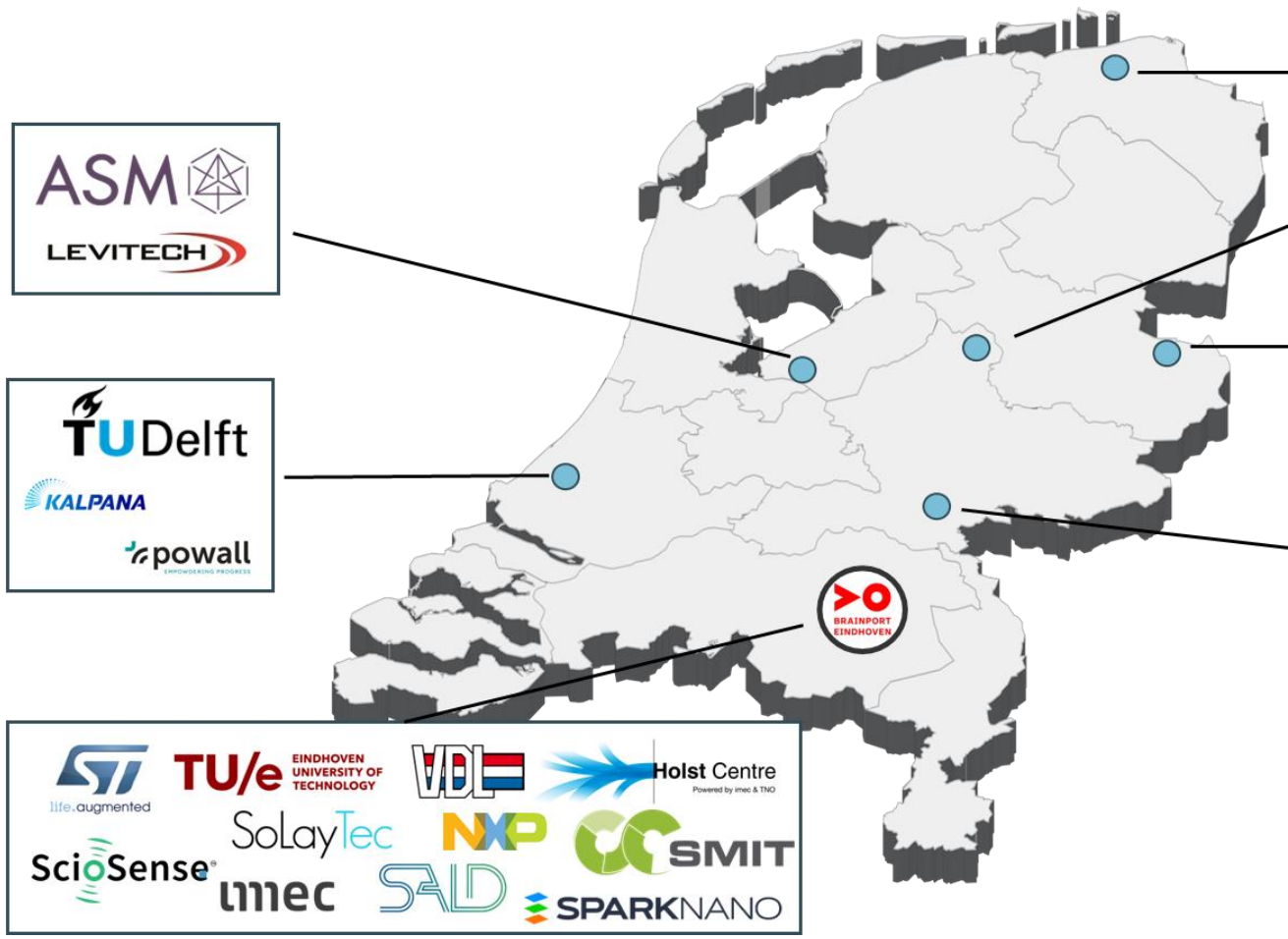


Enabling Technologies

(Spatial) Atomic Layer Deposition

LEADING IN ENABLING TECHNOLOGY SUCH AS ATOMIC LAYER DEPOSITION

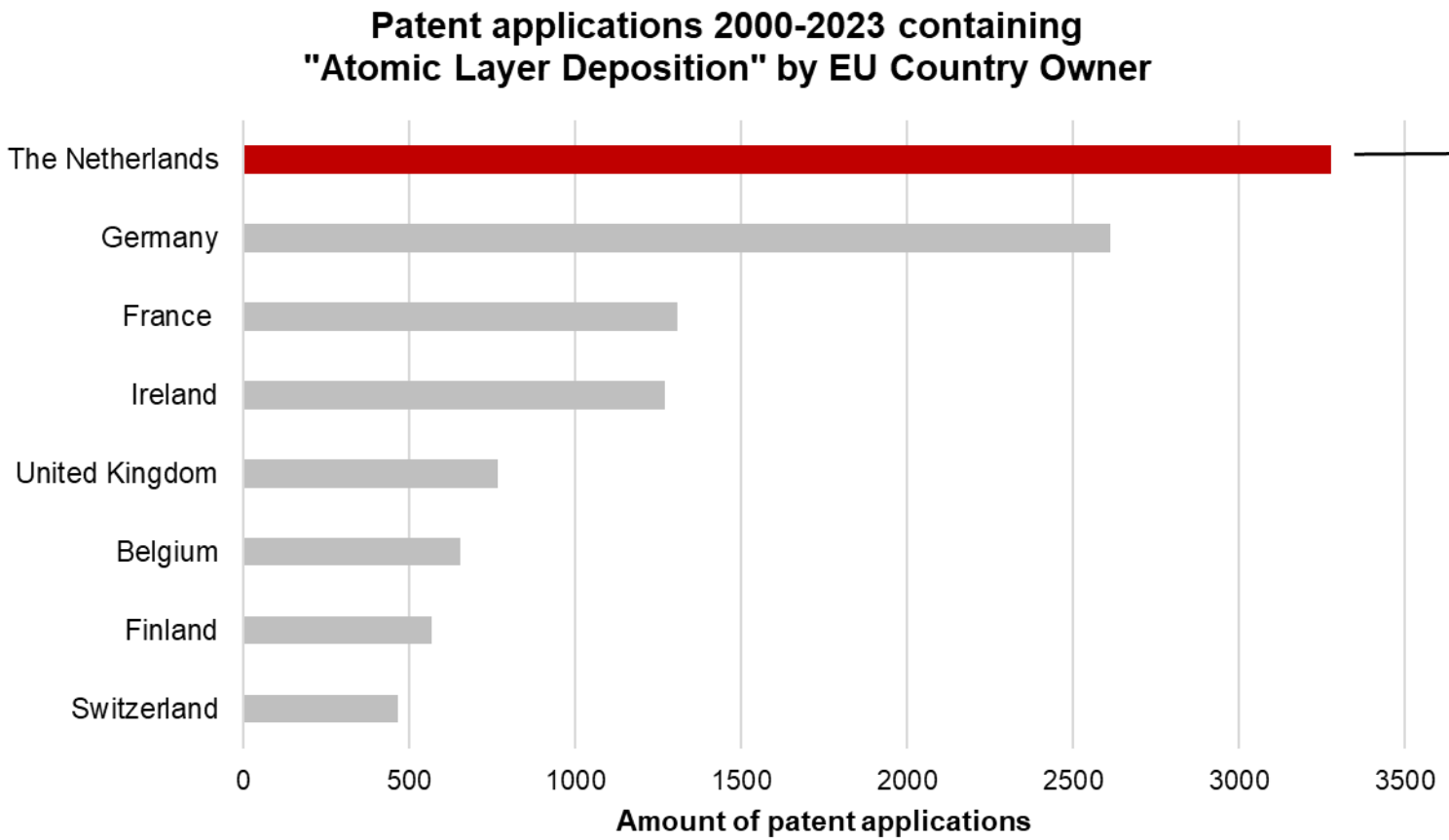
Dutch thriving ecosystem with both academic and industrial expertise



Intern gebruik

LEADING EU PATENT POSITION IN ALD TECHNOLOGY & APPLICATION

Strong collaboration with innovative industry partners

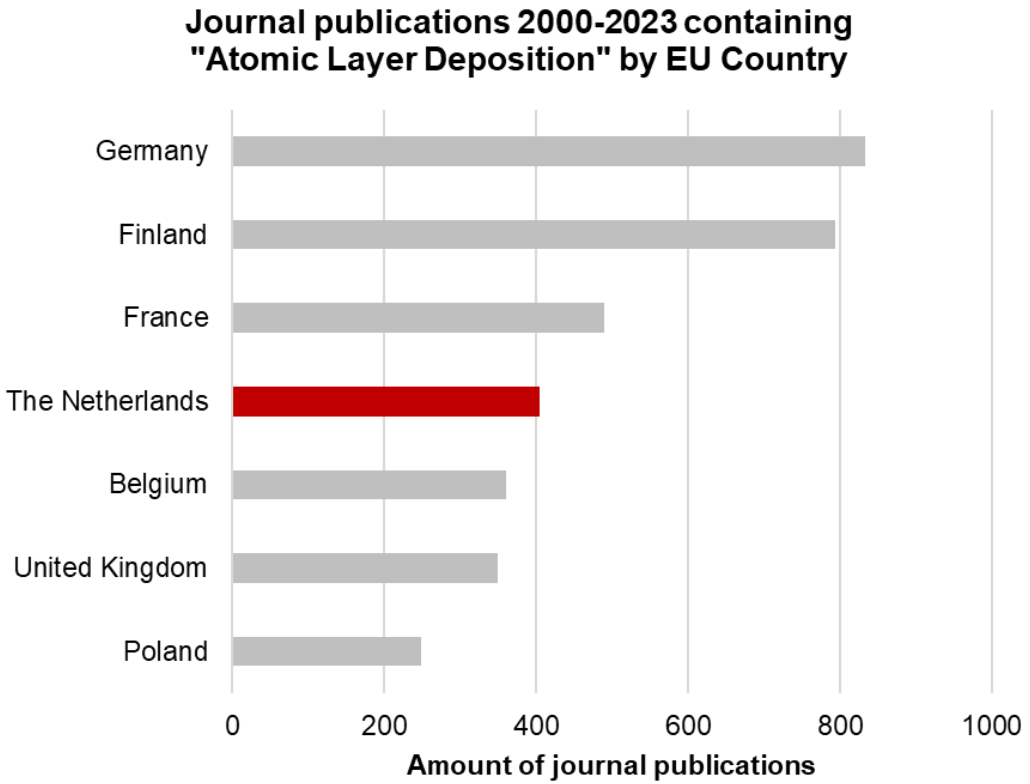


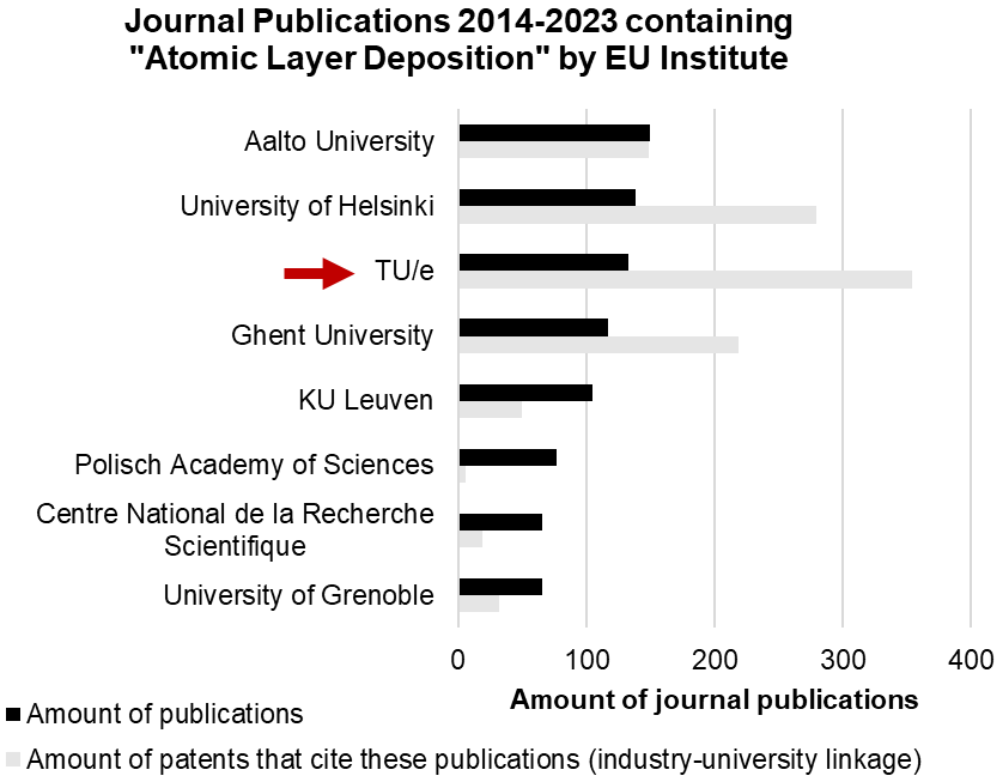
Source: Via Lens.org including EPO/WIPO/USPTO/IP Australia

Brainport Development BI

THE NETHERLANDS HAS A STRONG RESEARCH POSITION IN EUROPE

Universities closely work with the industry for further innovation and IP generation



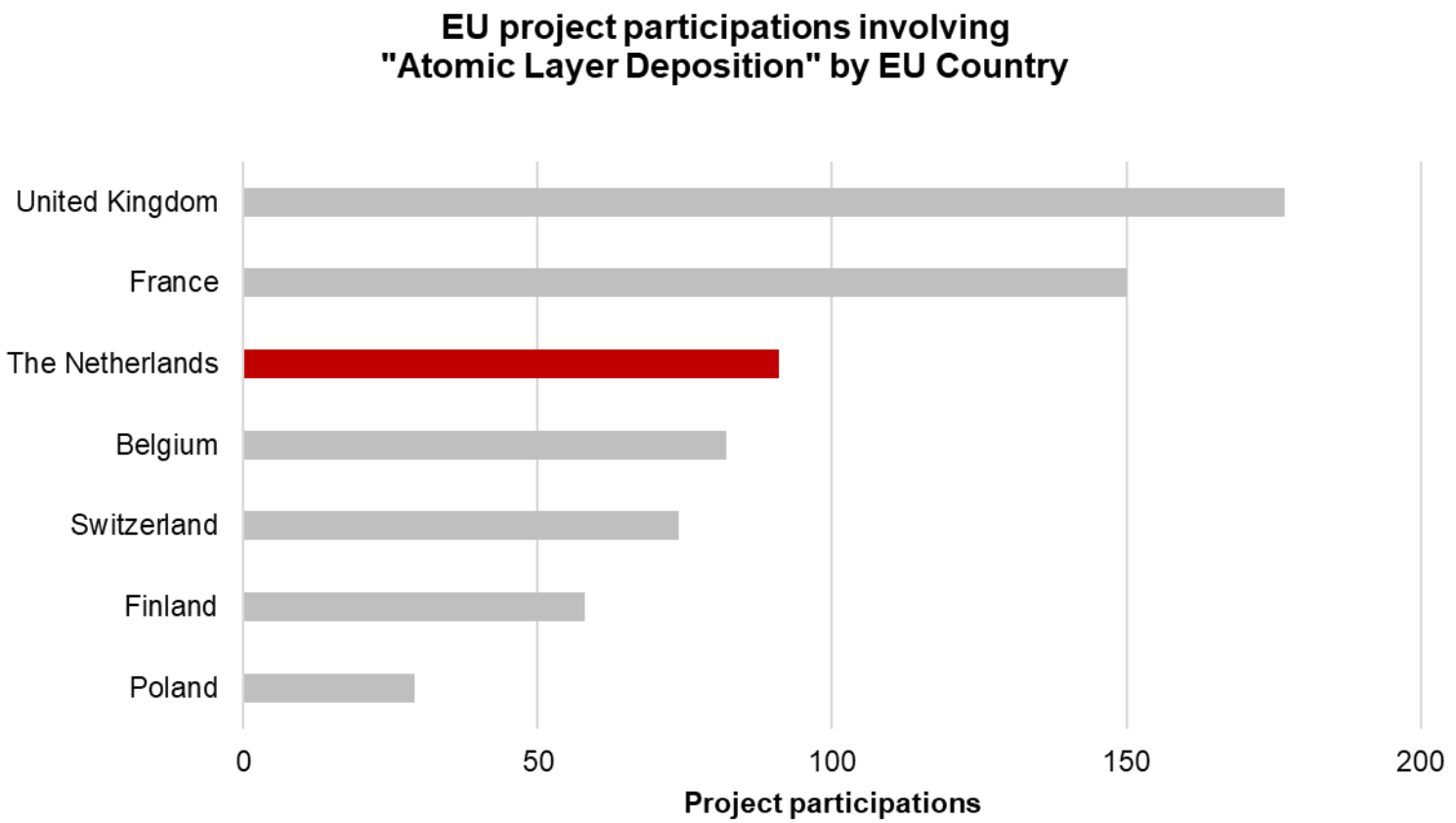


Source: Via Lens.org including PubMed/ORCID/CrossRef/Microsof Academic/Impactstory/CORE

Brainport Development BI

THE NETHERLANDS AS A EUROPEAN R&D PARTNER FOR ALD

Participation in Framework Programs, Horizon Europe, Horizon 2020

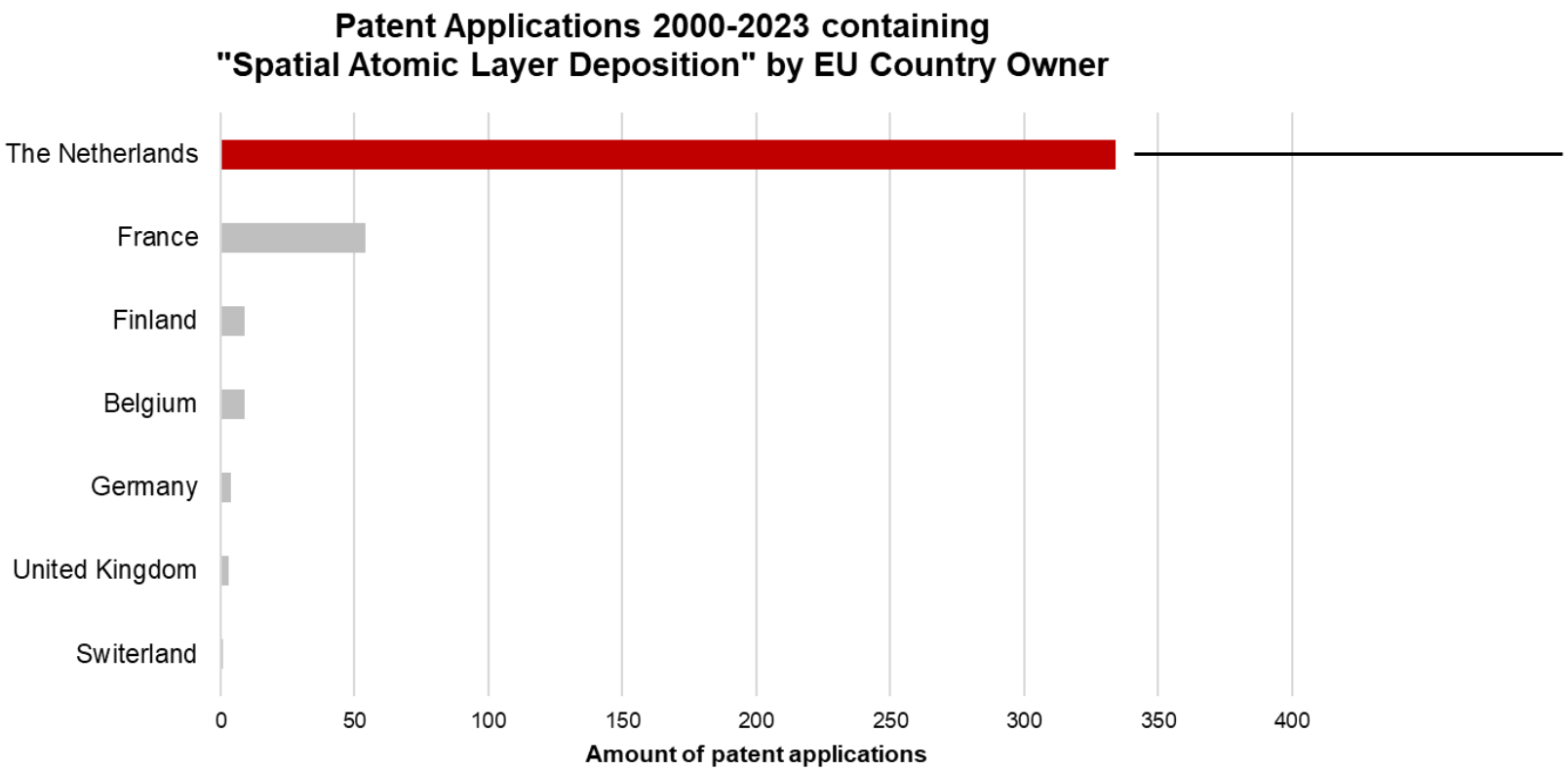


Source: CORDIS

Brainport Development BI

UNIQUE EU PATENT POSITION IN SALD TECHNOLOGY AND APPLICATION

Patent applications by university, research institute and companies



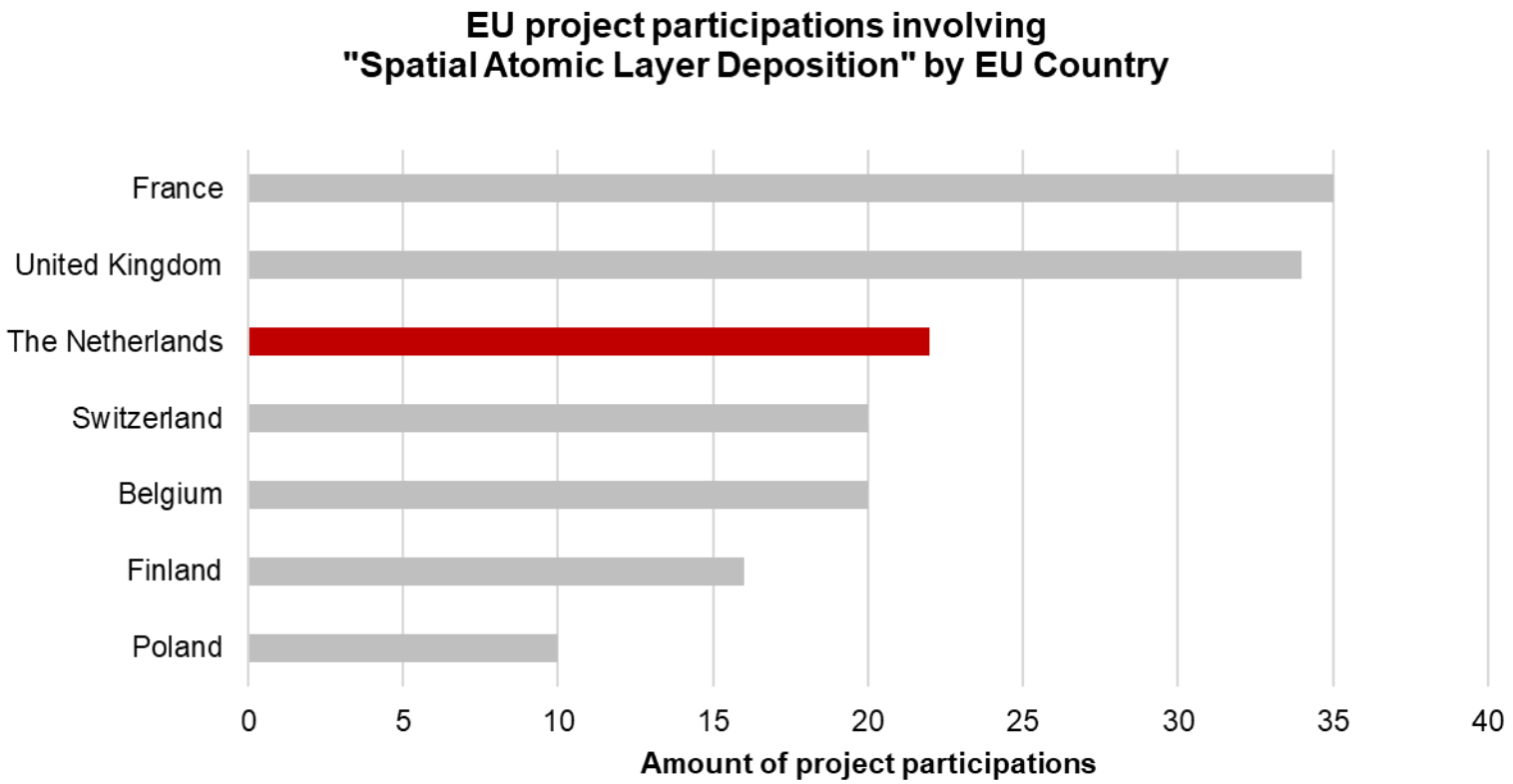
TNO ASM SPARKNANO imec SAL LEVITECH

Source: Via Lens.org including EPO/WIPO/USPTO/IP Australia

Brainport Development BI

THE NETHERLANDS AS A EUROPEAN R&D PARTNER FOR SPATIAL ALD

Participation in Framework Programmes, Horizon Europe, Horizon 2020

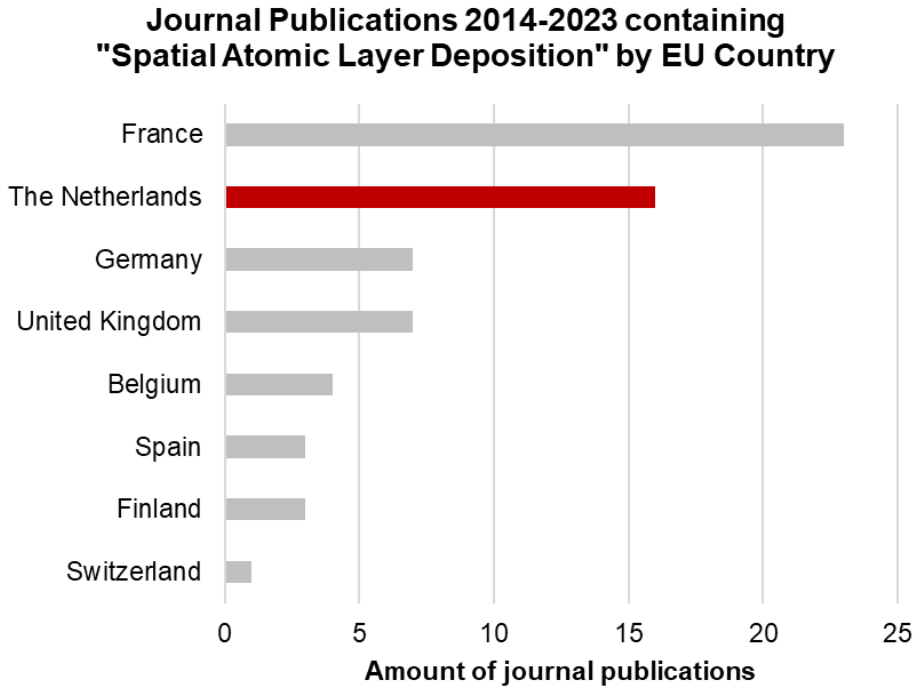


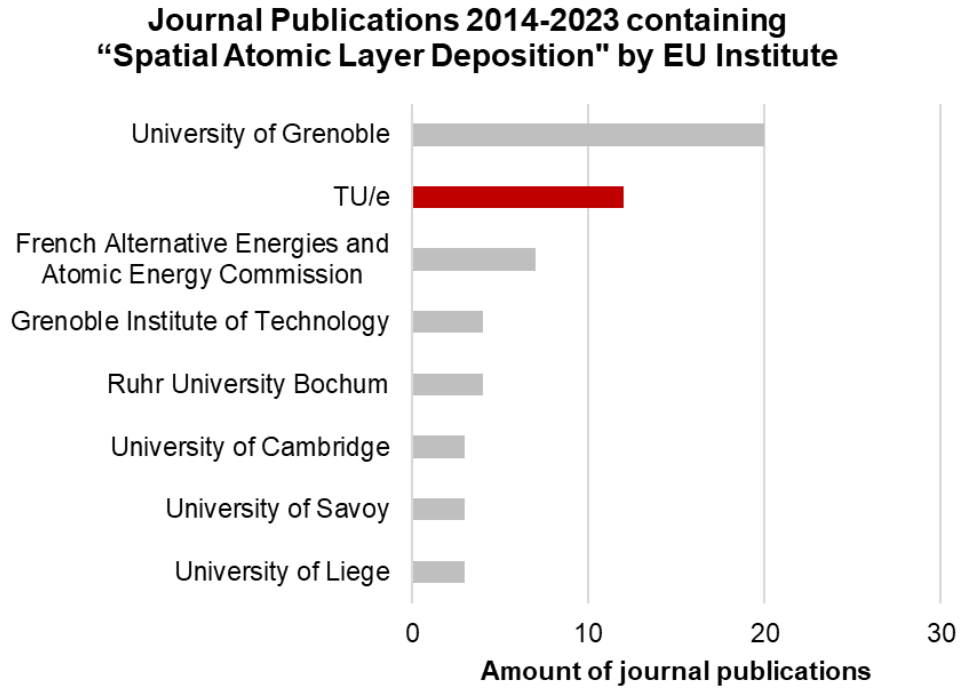
Source: Via Lens.org including EPO/WIPO/USPTO/IP Australia

Brainport Development BI

UNIQUE RESEARCH POSITION IN EU ON SPATIAL ALD

Eindhoven as a European hotspot for Spatial ALD

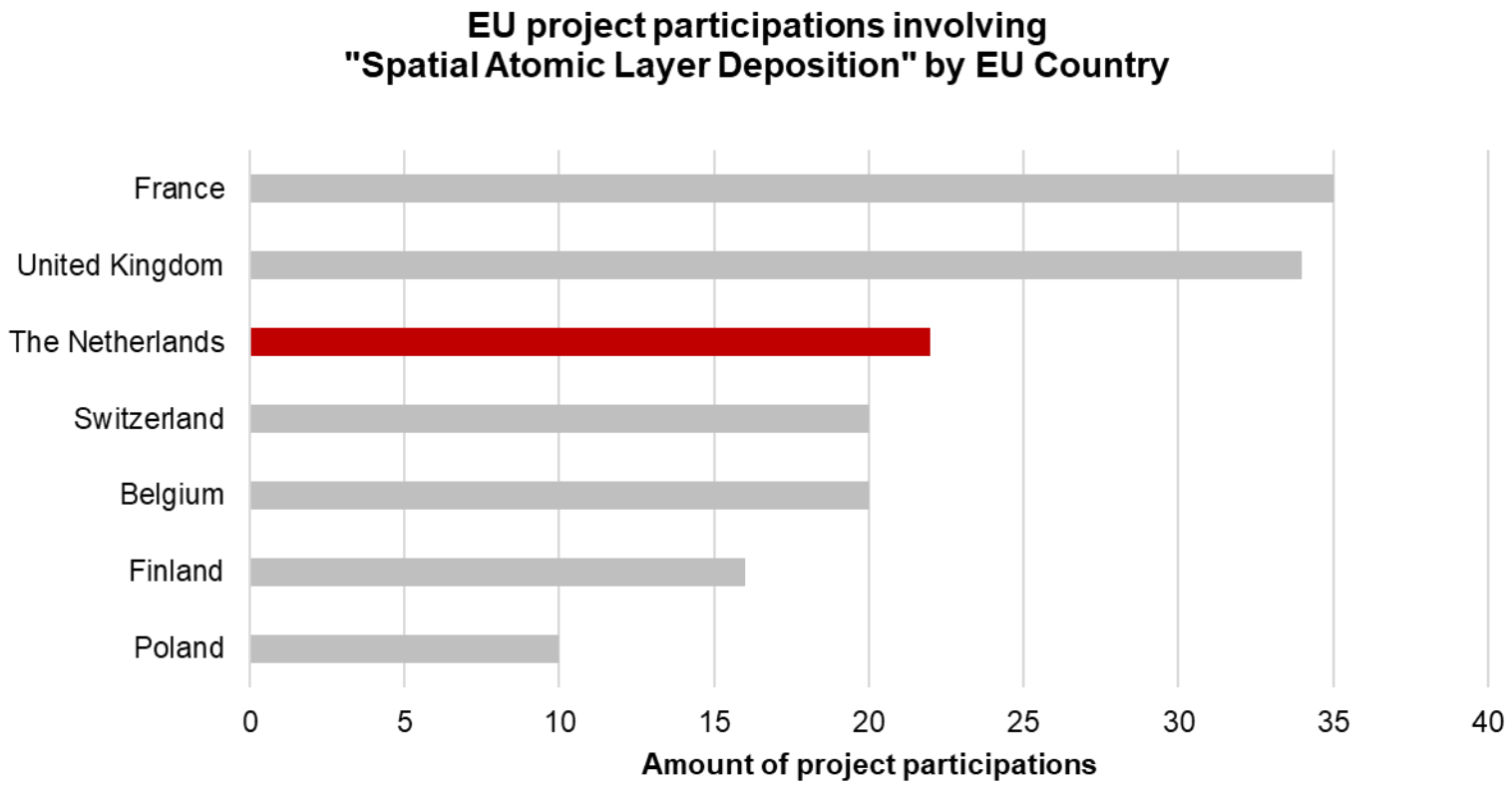




Source: Via Lens.org including PubMed/ORCID/CrossRef/Microsof Academic/Impactstory/CORE
Brainport Development BI

UNIQUE RESEARCH POSITION IN EU ON SPATIAL ALD

Participation in Framework Programmes, Horizon Europe, Horizon 2020



Source: CORDIS

Brainport Development BI

Test & Validation facilities

TESTING FACILITIES AND EXPERTISE FOR BATTERIES

Various facilitities able to test from battery safety to battery system and recycling

cleantron® cleantech batteries

MLAB TESTING

TU Delft

CONNECTR energy innovation

fev

TU/e

KEMA Labs

UNIVERSITY OF TWENTE.

VDL ETS

SUPER B lithium batteries

rijksuniversiteit groningen

DEKRA

eurofins

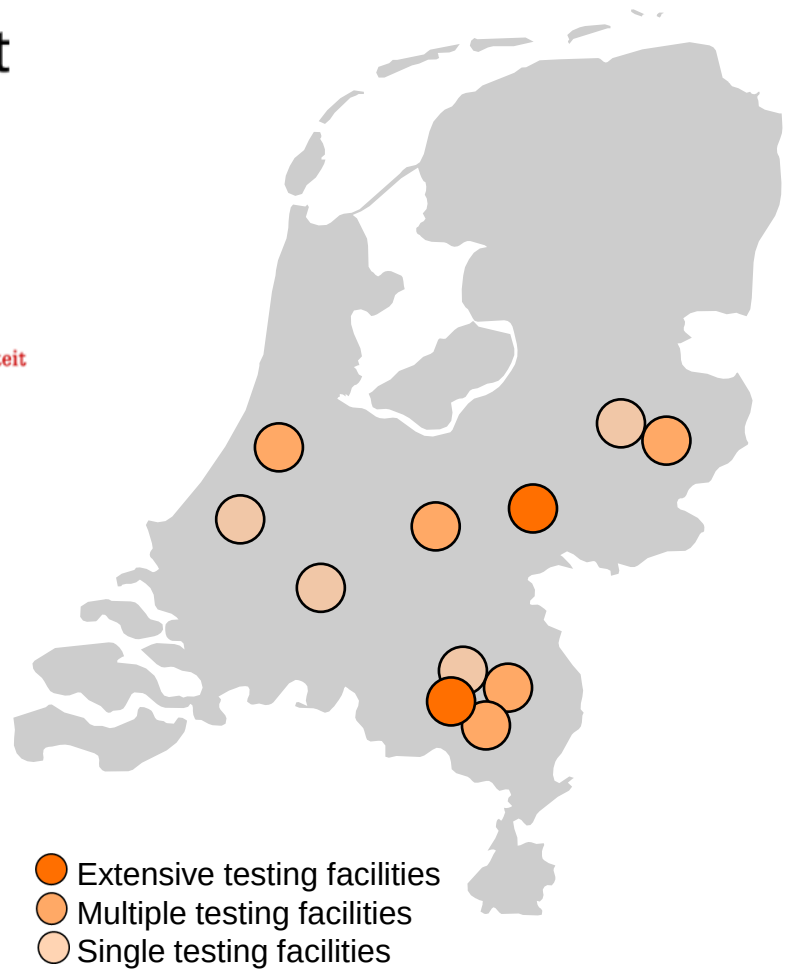
TWENTE SAFETY CAMPUS

DAMEN

Elaadnl

TNO innovation for life

Holst Centre



Source BCC-NL: Battery test facilities in the Netherlands (batterycompetencecluster.nl)

TEST & VALIDATION FACILITIES

Test & Validation facilities

KEMA Labs S&ST Charging Stations Service - CESI

Innovation lab - Connectr

EV Battery Testing | DEKRA

Advanced battery technology Centre

Battery Lab - TU Delft | SEE

Automotive Battery Research | TNO Helmond

Holst Centre - Open-Innovation by imec and TNO

Battery safety test lab

Clean Mobility Center

MEET Battery Research Center

Test, analyse, and research – Automotive Campus

VDL ETS – Battery testing facility

Intern gebruik

OPEN INNOVATION CENTER

Battery Safety Lab

- Operational from Q2 2022 onwards DNV and Twente Safety Region run an unique facility for testing complete battery systems for grid storage and maritime applications
- Lab will offer **safety testing, validation and certification services** and allow emergency services to develop protocols for dealing with incidents
- Battery Safety Laboratory in the Netherlands (dnv.com)

TEST & VALIDATION FACILITIES

Tests for Battery Concepts

- Experts cell level **battery cycling and analysis** (cycle life, power, temperature dependence, pressure dependence)
- Material to electrode to pouch/coin cell assembly
- Experience on a **wide range of battery chemistries** (Li-metal, Si, graphite, hard carbon, LFP, NMC, LMNO, LFP etc, solid state electrolytes, sulfides, halides, oxides, Na-ion chemistries, Mg-ion chemistries, F-ion chemistries)
- Analytical tools to monitor **structural, chemical changes and morphological changes** (direct access to X-ray and Neutron diffraction, solid state NMR, SEM)
- Unique experimental approaches to monitor Li in electrodes during battery operation to establish **degradation mechanisms**, origin of the internal resistance etc (operando Neutron Depth Profiling, operando solid state NMR).
- **Computational models** to predict impact electrode/battery morphology and dimensionality on power performance, as well as ab-initio to predict ion mobility, material stability.
- Interface engineering (**PLD, ALD, PECVD**)

Intern gebruik

TEST & VALIDATION FACILITIES

Tests on Battery concepts

- Tests for the safe operation of portable sealed secondary cells and batteries, under intended use and reasonably foreseeable misuse **IEC 62133**
- Test methods for primary and secondary (rechargeable) lithium cells and batteries to ensure their safety **IEC 62281**
- Tests for the safe operation of secondary lithium cells and batteries used in industrial applications including stationary applications. **IEC 62619**
- Tests for lithium secondary cells and batteries used in industrial applications **IEC 62620**
- Test procedures to observe the reliability and abuse behavior of secondary lithium-ion cells and cell blocks used for propulsion of electric vehicles including battery electric vehicles (BEV) and hybrid electric vehicles (HEV) **IEC 62660**

Intern gebruik

Institutes and facilities

AUTOMOTIVE BATTERY TECHNOLOGY CENTER

Applied knowledge on Powertrains by TNO

- In Helmond TNO develops control strategies for:
  - CR dosing, flex-fuel engine, battery management systems and predictive energy management.

- TNO provides ultimate system validation. This is performed on in **state-of-the-art experimental facilities**:
  - Unique Climatic Altitude Chamber for Engines vehicle testing at temperatures from –45 to +55 ºC and up to an altitude of 4000m
  - 4 transient engine test benches equipped with Extensive state-of-the art measurement equipment for emissions and GHG: NOx, NO, CO, THC, CO2, O2 (CH4, EGR CO2)
  - Portable Emission Measurement Systems (PEMS) for real world measurements
  - Automated test benches for battery cell, module, pack and vehicle testing with thermal conditioning
  - Extensive fuel infrastructure for liquid (diesel, petrol) and gaseous types (LPG,NG) as well as biofuels
  - Fuel Cell test and validation facilities (under development)
  - Fully configurable Truck- and Car-Labs (combustion, hybrid, fuel cell) for real-world on-road experiments

- Automotive Battery Research | TNO

Intern gebruik

ENABLING COOPERATION

Connectr

- Connectr is a triple helix cooperation program, that focuses on three key technologies that are already developing strongly in the region and that are **of excellent value at a global level**:
  - Electrical Power Engineering
  - Electrochemical Energy Storage
  - Sustainable Driveline System
- Currently, Connectr is in the process of the development of **a new energy innovation facility** of 12,000 m2.
- The facility will cover the value chain with R&D, education and shared test facilities, offices and meet & greet solutions to host energy-tech related companies and institutes and to support them in their plans.
- **The facility is located in Arnhem**, where most of the energy, tech and hydrogen related companies are located.

Intern gebruik

UNIVERSITY OF TWENTE

Fraunhofer Project Center

- The Fraunhofer Project Center at the University of Twente is a joint venture of three partners: the University of Twente, the hosting university, the Fraunhofer-Gesellschaft represented by its Fraunhofer Institute for Production Technology IPT in Aachen, Germany and Saxion University of Applied Sciences.

- The central task of the Fraunhofer Project Center is to **transfer current research** in **advanced manufacturing** directly into industrial practice. For this, they focus on the development of technological solutions in the area of production processes, production equipment, digital manufacturing and manufacturing value chain organization. Together with industry, the Fraunhofer Project Center builds synergies to achieve high-tech excellence within the fourth industrial revolution and to train the high-tech talents of tomorrow.

Intern gebruik

MÜNSTER ELECTROCHEMICAL ENERGY TECHNOLOGY (MEET)

Battery Research Center

- Top-level research in the fields of battery materials, cells and electrochemistry.

- MEET pursues a holistic, systemic research and development on electrochemical energy storage systems and transducers, which, in addition to synthesis and production, characterization and analysis of materials, components and cells, naturally also covers the various aspects of application, including economic efficiency, environmental impact and social impact.

- Cross-national cooperation in multiple projects
  - Nanostructured interfaces for next-generation batteries
  - Next Generation Batteries based on Understanding Materials Interfaces

- *“Our research covers the entire value cycle for batteries: from analytics and the development of new or improved materials to battery cell production and the recycling of energy storage devices.”*
  Prof. Dr. Martin Winter, Scientific Lead

- MEET - MEET (uni-muenster.de)

Intern gebruik

EINDHOVEN INSTITUTE FOR RENEWABLE ENERGY SYSTEMS

EIRES

- The research group Energy Technology and Fluid Dynamics consists of some 70 persons comprising faculty, support staff and PhD students. The group is part of the Department of Mechanical Engineering of Eindhoven University of Technology in the Netherlands.

- The group has three main research themes:
  1. Renewable Energy Storage
  2. Fluid-Solid Interactions
  3. Cooling and separation

- Our Darcy Laboratory is equipped with state-of-the art CT and MRI scanning instruments to probe the transport of moisture and ions in porous materials.

Intern gebruik

OPEN INNOVATION CENTER

Connectr

- Connectr is government subsidized triple helix R&D cooperation program, that focuses on three key technologies that are **of excellent value at a global level**:
  - Electrical Power Engineering
  - Electrochemical Energy Storage
  - Sustainable Driveline System (Hydrogen included)

- Currently, Connectr is setting up **a new energy innovation facility** of 17,000 m2 for new companies and institutes.

- The facility will cover the value chain with R&D, education and shared test facilities, offices and meet & greet solutions to host energy-tech related companies and institutes and to support them in their plans.

- **The facility is located on the cleantech campus IPKW in Arnhem**, where many energy, tech and hydrogen related companies are located.

Intern gebruik

OPEN INNOVATION CENTER

EnTranCe

- EnTrance is a public-private partnership that offers room for open knowledge-sharing.
- Scientists, students, businesses, authorities and social institutions all come together to share their knowledge at our centre of expertise.
- Testing facilities for start-ups with a new energy service or companies with a product prototype to (international) consortia seeking to change the energy system.

Intern gebruik

ZERNIKE INSTITUTE FOR ADVANCED MATERIALS

ZIAM

- Research in the Materials Chemistry group focusses on the development and application of operando spectroscopy techniques in catalysis and materials research, to understand properties and reactivity, with a focus on X-ray spectroscopy techniques.

- Application of the techniques to fundamentally or industrially interesting catalytic processes and materials has been pursued, providing unprecedented insights in catalysts properties and reaction mechanisms, including electrochemical processes in batteries and fuel cells.

- Materials Chemistry | Zernike (ZIAM) | Rijksuniversiteit Groningen (rug.nl)

Intern gebruik

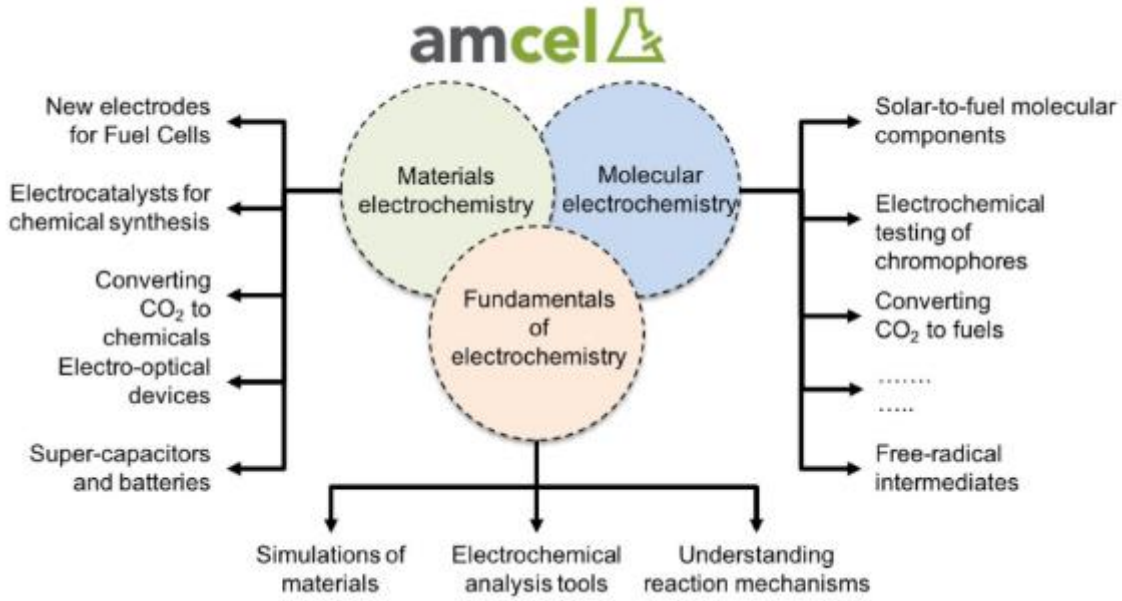
AMCEL

Amsterdam Centre for Electrochemistry

- The aim of the Amcel research is to improve the sustainability and energy efficiency of chemical synthetic routes by developing new catalytic reactions for desirable transformations in which the use of high-energy reactants is avoided.

- In Amcel the following technologies are considered to be most promising: Fuel cells, redox flow batteries, structural batteries, hydrogen storage materials and chemical energy storage in molecules other than dihydrogen.

- Amcel has three predominant focus areas:



Intern gebruik

Showcases
What's happening?

TECHNOLOGIES & INNOVATIONS

What do we do already?

There’s a solid basis to be key player in six innovation topics

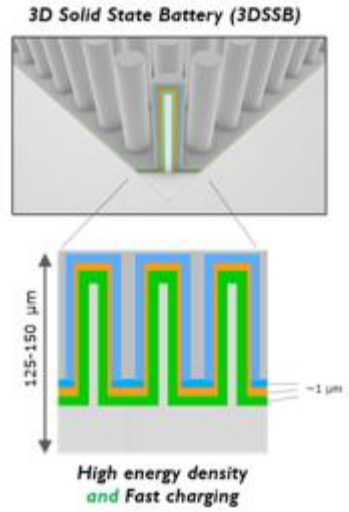
1. Battery concepts: materials and cell design
2. Equipment for cells, modules and packs
3. Electric mobility: heavy duty & flying
4. Stationairy storage: grid stability
5. Safety and data security (incl. testing)
6. Reuse, second-use and recycling

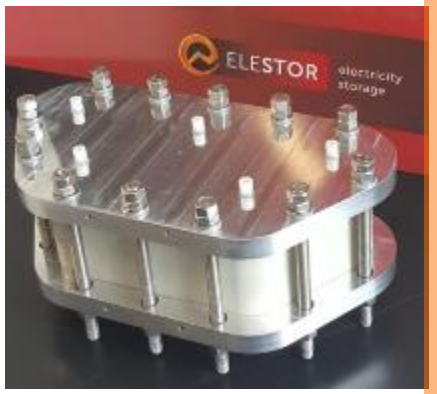
Intern gebruik

TECHNOLOGIES & INNOVATIONS

Battery concepts: materials and cell design

- Experts are working with partners to create a revolutionary type of battery based on **3D technology and solid-state**.
- **Redox Flow batteries** stores electricity at a fraction of the cost of traditional batteries, safely and with a long lifetime.
- **Bulk-type batteries** like Sea salt batteries, the Aquabattery and the Battolyser
- **Lithium Titanate Oxide** batteries
- Cell-type batteries based on improved **silicium-anode technology**
- Many suppliers of **electrode materials** (Anode, Cathode, Coatings & Membranes)
- **Platform technology** to improve thin battery layers.





Intern gebruik

TECHNOLOGIES & INNOVATIONS

Equipment for cells, modules and packs

- Promising scale-ups are working with large machine manufacturers on:
  - Equipment for cell manufacturing
  - Pilotlines for new technologies
  - Machinery for cell production lines

- Over 40 OEMs in the Netherlands joined forces in the **Battery Competence Center** innovation program to develop new battery systems for maritime, aerospace, automotive and non-road machinery applications

- European projects like REACT-EU and GTD-E are focused on scaling production processes. The **Advance Manufacturing Center** is developed as pilot factory for battery production

Intern gebruik

TECHNOLOGIES & INNOVATIONS

Electric mobility: heavy duty & flying

E-trucks (OEM presence)

E-heavy duty

Full Electric vessels
(OEM presence)

The electric barge – the Gouwenaar II

E-Airplanes

Intern gebruik

TECHNOLOGIES & INNOVATIONS

E-Mobility: The Netherlands leading in charging infrastructure

- The Netherlands has strong players in developing and producing loading infrastructure. Both for regular electric vehicles and heavier carriers such as loading docks for public busses.

- The Netherlands produces world class smart energy management solutions that are tailored and scalable within a fast changing e-mobility landscape.

Intern gebruik

TECHNOLOGIES & INNOVATIONS

Stationairy storage: grid stability

- Large scale **bulk battery storage** at solar- & windparcs to avoid grid-congestion and to reduce curtailment.
- The development of new battery concepts (f.i. redox flow and saltwater) for storage with longer discharging times.
- **Bi-directional** charging infrastructure.
- Rapid development of small scale ‘home’- and neighbourhood battery storage

Intern gebruik

TECHNOLOGIES & INNOVATIONS

Safety and data security (incl. testing)

- Key players in battery data collection and monitoring
- Global #1 in testing, certifying and inspecting high- and mid voltage components. Including unique high-voltage testfacilities for large systems (MW-scale and voltage ≥ 10kV)>1MW / 10kV+).
- Very experienced in modelling, validating and testing of automotive/mobility/stationairy batterysystems for heavy duty EV
- Battery climatechambers and testfacilities for loading and decharging battery cells, -modules, -packages as well as hardware in the loop testing.
- DNV and Dutch emergency services to open a battery safety test lab
- Recently opened a new energy demo facility of 17.000 m² for new companies and institutes.

Intern gebruik

TECHNOLOGIES & INNOVATIONS

Reuse, second-use and recycling

- Battery modules made up of **2nd-use batteries** including a developed BMS.
- A 10,000 square metre battery **recycling facility** in the Port Of Rotterdam, Europe's largest seaport.
- Breathing new life into lithium batteries by using various battery packs from (PH)EV cars, **dismantle and refurbish** them up to a 98% recycling percentage.
- ERAMETs 'Relieve': an innovative process for **recycling lithium-ion batteries from electric vehicles**

Source: ReLieVe projectwebsite

Intern gebruik

NFIA support with 27 offices worldwide

NETHERLANDS FOREIGN INVESTMENT AGENCY

Worldwide offices

List of NFIA offices

- San Francisco
- Chicago
- Atlanta
- Washington
- New York
- Toronto
- London
- **The Hague (HQ)**
- Stockholm (2024)
- Munich
- Paris
- Istanbul
- Tel Aviv
- Dubai
- Cape Town
- Mumbai
- New Delhi
- Bangalore
- Singapore
- Guangzhou
- Beijing
- Shanghai
- Seoul
- Taipei
- Osaka
- Tokyo
- Sydney

PROVIDE FREE, CONFIDENTIAL SUPPORT SERVICES

Supporting your expansion to the Netherlands

- Provide information, advice and support
- Connect you to relevant partners
- Jumpstart your network
- Introduce you to public-private partnerships
- Support business development
- Put your feedback in the right hands

More information on how the NFIA network supports investor relations in the Netherlands

BATTERY FOCUSTEAM INVEST IN HOLLAND NETWORK

We welcome you!

Elmar Bouman

SECTORMANAGER ENERGY
INVEST IN HOLLAND NETWORK/ NFIA

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