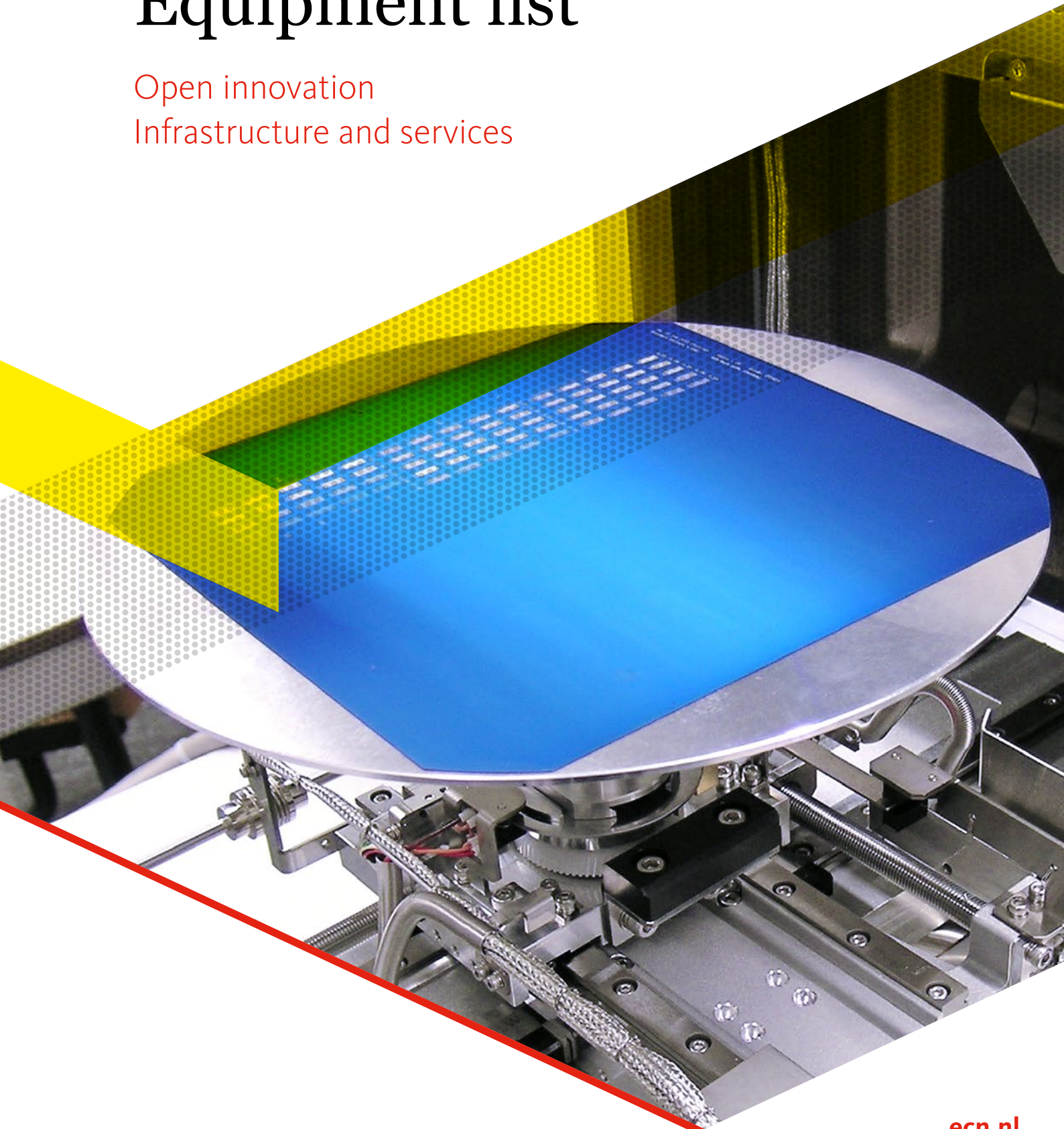


Equipment list

Open innovation
Infrastructure and services



Enabling your success

This equipment list shows the broad range of capabilities ECN offers to:

**Measure, test and analyse processes, products, emissions and materials;
Advise, develop and improve products and applications;
Realise, test, commission and produce.**

We have one of the highest concentrations of practical knowledge and capabilities available for all industries and application fields.

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ECN develops energy and environmental technology. Our research portfolio includes solar, wind, biomass, energy efficiency, soil quality, and air quality. We offer our expertise and equipment for testing, analysis, engineering, realization, and consultancy to many industries and application fields, beyond energy. We are valued for our practical approach and problem-solving skills.

Environmental Assessment

Brand/Type	Description	Application/Dimensions work piece
Air Quality		
Marga (x2)	Characterisation of gases and ultrafine particulate in environmental air	Concentration measurement of Na ⁺ , K ⁺ , NH ₄ ⁺ , Mg ²⁺ , Ca ²⁺ , Cl ⁻ , NO ₂ ⁻ , HSO ₃ ⁻ , NO ₃ ⁻ and SO ₄ ²⁻ in the ppb range
Sievers (x2)	Measurement of Total Organic Carbon in water	Online concentration measurement of TOC. Concentration range 0.01 up to 50 ppm
AiRRmonia (x2)	Measurement of trace level concentrations ammonia in ambient air	Online concentration measurement of NH ₃ in the ppm range
SMPS (TSI) (x2)	Measurement of ultrafine particulate in ambient air	Online measurement of physical distribution of aerosol from 15 up to 750 nm
SMPS (Grimm)	Measurement of ultrafine particulate in ambient air	Online measurement of physical distribution of aerosol from 10 up to 1000 nm
CPC (x4)	Measurement of ultrafine particulate in environmental air	Online measurement of total aerosol number > ~10 nm
EPC	Measurement of ultrafine particulate in ambient air	Online measurement of total aerosol number > 10 nm
FIDAS	Measurement of ultrafine particulate in ambient air	Online measurement of physical distribution of aerosol from 0.18 to 18 µm
FSSP	Measurement of fine particulate in ambient air	Online measurement of physical distribution of aerosol from ~1 to ~50 µm
Leckel (x4)	Semi-automatic sampling system for fine and/or ultrafine particles in ambient air (PM ₁ , PM _{2.5} , PM ₁₀)	Ultrafine particulate samples over a sequence of 14 filters. The sampled filters may be subjected to chemical analyses and weighing.
AirBox	Measurement of fine particulate and gases in ambient air	Online measurement of PM _{2.5} and PM ₁₀ ; NO ₂ , down to ppb level; ozone and other sensors at request
CAIRE	Handheld measurement of fine particulate in ambient air	Online measurement of PM _{2.5} and PM ₁₀ ;
Las-X (2x)	Measurement of ultrafine particulate in ambient air	Online measurement of particle size of aerosols from 0.12 up to 7.5 µm
Coulomat 702	Measurement of Elementary Carbon and Total Organic Carbon in solid and water samples	Measurement range from 0,001 to 100%, in 10 to 1000 mg sample
Eco Physics CLD 700 AL (x3)	Measurement of trace level concentrations NO and NO ₂ in ambient air	Online concentration measurement of NO and NO ₂ in 0 up to 200 ppb range
Thermo 42i	Measurement of trace level concentrations NO and NO ₂ in ambient air	Online concentration measurement of NO and NO ₂ in 0 up to 200 ppb range
Thermo 43s	Measurement of trace level concentrations SO ₂ in ambient air	Online concentration measurement of SO ₂ in 0 up to 200 ppb range
Thermo 48	Measurement of trace level concentrations CO in ambient air	Online concentration measurement of CO in 0 up to 200 ppb range
Thermo 49i	Measurement of trace level concentrations O ₃ in ambient air	Online concentration measurement of O ₃ in 0 up to 1000 ppb range
Agilent GC6890N	Measurement of trace level concentrations CH ₄ , CO, SF ₆ and N ₂ O in ambient air	Online concentration measurement of CH ₄ , CO, SF ₆ and N ₂ O in ppt to ppm range
LiCOR 7000 and 6262 (x3)	Measurement of trace level concentrations CO ₂ in ambient air	Concentration measurement of CO ₂ in 0 up to 1000 ppm range
TDL (x2)	Measurement of trace level concentrations CH ₄ and N ₂ O in ambient air	Online concentration measurement of CH ₄ and N ₂ O in ppb to ppm range
QCL	Measurement of trace level concentrations CH ₄ , NH ₃ and N ₂ O in ambient air	Online concentration measurement of CH ₄ , NH ₃ and N ₂ O in ppb to ppm range
Spectronus (FTIR)	Measurement of trace level concentrations CH ₄ , CO ₂ , ¹³ C, CO and N ₂ O in ambient air	Online concentration measurement of CH ₄ , CO ₂ , ¹³ C, CO and N ₂ O in ppb to ppm range
Mini C	Aerosol flow through test chamber	Continuous generation of test aerosol for the characterisation of environmental measurement instruments

Brand/Type	Description	Application/Dimensions work piece
Measurement truck	Truck equipped for mobile measurement to identify complex sources	This truck can be equipped with all types of measurement instruments
Mobile measurement unit	Temperature regulated mobile unit for environmental measurement campaigns	This unit can be equipped with all types of measurement instruments
Nephelometer (x2)	On-line measurement for determination of optical characteristics of aerosol	Measurement in a visual range from 1 to >40 km
Impactors (x6)	Sampling systems for micron and submicron particles in ambient air	Measurement from ~100 nm to 10 µm
MAAP	On-line Standardised black carbon measurements	Measurements of whole aerosol range with upper limit of PM ₁₀
β-stof monitor	On-line Standardised PM ₁₀ measurements	Total aerosol mass with a radioactive source
ANSTO Rn monitor (x2)	Measurement of trace level concentrations Radon in ambient air	Concentration measurement of Radon in ppb to ppm range
Picarro	Measurement of trace level concentrations CH ₄ , CO ₂ and H ₂ O in ambient air	Online concentration measurement of CH ₄ , CO ₂ and H ₂ O in ppb to ppm range
RGA	Measurement of trace level concentrations H ₂ and CO in ambient air	Concentration measurement of H ₂ and CO in ppb to ppm range
Vaisala Carbocap GMP 343 (x5)	Open Path measurement of CO ₂ in ambient air	Concentration measurement of CO ₂ in 0 up to 1000 ppm range

Leaching characterisation

pH-stat	pH dependent leaching behaviour of materials	Leaching at eight different pH values from pH 2 to 12 and subsequent chemical analyses of the filtered eluates (B-U1000)
Column test	Measurement of the cumulative emission of contaminants from granular materials	Upflow percolation leaching test at seven liquid to solid ratios ranging from 0.1 to 10 L/kg and subsequent chemical analyses of the filtered eluates (B-U7373)
Tank test	Measurement of the cumulative emission of contaminants from monolithic materials	Diffusion leaching test of monolithic samples over a cumulative time of 64 days. Eight different renewal steps are performed and the filtered eluates are subjected to chemical analyses (B-U7375)

Materials, Testing & Analysis

Brand/Description	Description	Application/Dimensions
Chemical Analysis (List of ISO17025 accredited analyses available at https://www.rva.nl/scopes/details/L135)		
Spectro Analysis		
ICP-AES (Inductively Coupled Plasma Atomic Emission Spectroscopy)	Solid fuels, ash, sludge, biomass, water	Al As B Ba Ca Cd Co Cr Cu Fe K Li Mg Mn Mo Na Ni P Pb S Sb Se Si Sn Sr Ti V Zn Hg, other elements on request.
ICP-MS (inductively Coupled Plasma Mass Spectrometry)	Water samples	
CV-AFS (Cold Vapour Atomic Fluorescence Spectroscopy)	Other solid samples	
Raman	vibrational, rotational modes of atoms	512+633 nm, >150 cm ⁻¹
Wet Chemical Analysis		
Oxygen Bomb Calorimeter	Solid fossil fuels, solid biofuels, biomass, solid recovered fuels, sludges, etc.	Ash, moisture, volatile Calorific value (UHV LHV) Alkalinity Ammonia/Kjeldahl-N / TN Anions: F Cl NO ₃ SO ₄ Br PO ₄ I SO ₃ NO ₃ Chemical Oxygen Demand / COD Elements: C H N O S EOX analysis Total Organic Carbon (TOC) and Inorganic Carbon
Titrimetry	Water samples, eluates	
FIA (Flow Injection Analysis)	Fossil fuels, biofuels, biomass, etc.	
IC (Anion Chromatography)	Solid samples	
Element Analysis		
Coulometry		
TOC analyser		
Chemiluminescence		
Organic Analysis		
GCMS, FID (Gas Chromatography Mass Spectrometry, Flame Ionization Detector) GC, PFPD (Pulsed Flame-Photometric Detector)	Tar samples, environmental samples Tar/pyrolysis samples Biomass, polymers, and other Biomass conversion	Pyrolysis experiments by PyrGCMS Pyrolysis products Monosaccharides and other carbohydrates Polycyclic aromatic hydrocarbon (PAH) Polycyclic Aromatic Sulfur-Containing Hydrocarbons (PASH)
HPLC (High-Performance Liquid Chromatography)		
Pyr-GCMS (GCMS with pyrolyzer)		
HPAED-PAD (High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection)		
Gas analysis		
MicroGC, NDIR, Chemiluminescence	Syngas, biogas, flue gas, producer gas, process gas	H ₂ , N ₂ , O ₂ , CO, CO ₂ , CH ₄ , H ₂ S, COS, CO, CO ₂ , CH ₄ , N ₂ O, He, Ne, Ar, NO _x , SO _x , C1-C6 Hydrocarbons, Benzene, Toluene, Xylenes, Sulfur compounds
Tar guideline, SPA	Tar in flue gas, producer gas	Sampling, post-sampling and analysis
Washing bottle gas sampling	Syngas, biogas, flue gas, producer gas, process gas	NH ₃ , HCN, HCl
Cascade Impactor PILAT MARK III Cascade Impactor PILAT MARK V	Syngas, biogas, flue gas, producer gas, process gas	Aerosol mass and particle size distribution Cut-off < 0.1 µm
Dust/gas sampling probe	In-duct measurements In-boiler measurements	Pressure, temperature, gas Approx 2900 mm length, Ø76.1mm
Mobile diagnostic probe	In-boiler measurements	Deposit sampling, dust sampling, heatflux/surface temperature, flue gas temperature, camera

Brand/Description	Description	Application/Dimensions
Mass Spectrometry	Process gas	H ₂ , N ₂ , O ₂ , CO, CO ₂ , CH ₄
Biobased Content		
14Campler (ISO 13833)	Proportional sampling of flue gas	% Biogenic
Biobased Carbon Content (CEN/TS 16640)	Biobased fuels and products	% Biogenic
Biobased Content (pr EN 16785)	Biobased fuels and products	% Biogenic
Corrosion & Electrochemical Testing		
IviumStat XR with bi-potential- stat option & 8-channel HiMux multiplexer (x2)	Electrochemical measurement equipment	Corrosion measurements and electrochemical characterisations of surfaces and/or sensor responses
Solartron ECI 1287 & Frequency response analyser 1255 (x2)	Electrochemical measurement equipment	Corrosion measurements and electrochemical characterisations of surfaces and/or sensor responses
Zahner IM6-EX impedance measurement unit & PP200 potentiostat	Impedance spectrometry	Corrosion measurements and electrochemical characterisations of surfaces and/or sensor responses
Physical Characterisation		
Netzsch DIL 402 C	Dilatometry (thermal expansion coefficient determination)	Temperature: up to 1650°C Atmospheres: standard: air, helium, Ar/5% H ₂ , oxygen. Other atmospheres on request Rate Controlled Sintering software Accuracy: 1.25 nm over 25 mm measuring length
Netzsch STA 409 PC	Simultaneous Thermal Analysis (STA)	DSC/TG (Differential Scanning Calorimetry/ Thermo- gravimetry) up to 1500°C Atmospheres: standard: air, helium, Ar/5%H ₂ , oxygen, humidified air
Netzsch DSC 204 F1 Phoenix	Differential Scanning Calorimetry (DSC)	DSC -180 to 700°C
Mettler Toledo TGA850	Thermogravimetric analyser (TGA)	Mass loss in air or nitrogen. The ignition temperatures of the materials (dust) can also be measured.
Midac M4000 + DTGC + MTC	Fourier Infrared Microscopy (FTIR)	Characterisation of organic materials by reflectance and transmittance based on molecular bonds
Mastersizer 2000	Particle size analyser	Determination of (spherical) particle size distribution between 20 nm and 1 mm. Method: dynamic light scattering
Sensys EVO TG-DSC analyser	Thermal Gravimetric Analysis (TGA) and DSC under controlled high pressure	Ambient to 830°C, pressure up to 400 bar and up to 600°C
Ami-200	BET, chemisorption, TPO, TPD, TPR	0.1 – 1.0 grams -100°C to +1200°C
GPO	Gas permeation	Helium, CO ₂ , CH ₄ , Nitrogen, Hydrogen Variation feed pressure ~10 barg Variation pressure difference Variation in temperature ~600°C
GSO	Gas separation	Test-gasmixtures feed from bottles No steam option H ₂ S, ammonia, etc. possible Variation feed pressure ~10 barg Variation pressure difference Variation in temperature ~600°C
Permporometry	Permporometry	3 bara 25-120°C Helium-water or helium-Hexane Accurate fluid feed by a Coriolis 0,4-20 gr/h

Brand/Description	Description	Application/Dimensions
Water flux Bubble point	Filter integrity	
Anton Paar Physica MCR 301	Rheology	Rheological behavior of liquids, gels, solids; -40°C -> 200°C; viscosity, shear stress, shear rate, G', G
Rubotherm	Gas adsorption	High pressure - high temperature gasadsorption, RT-800°C; 0-150 bar: H ₂ , CH ₄ , Ar, N ₂ , C _x H _y , NH ₃ , vapour
Quantachrome Autosorb iQ-C	Pore size analysis - gas adsorption	Pore size distribution, surface area, adsorption isotherm, chemisorption up to 1100°C, Temperature Programmed Desorption: NH ₃ , H ₂ , CO ₂ , Kr, vapor; gasdetectors: MS and TCD
Quantachrome He-pycnometer	Density	True density of porous solids and powders
Mettler PM400	Density	Density of solids by submersion
OmniStar Mass Spectrometer	Mobile Gas Analysis System	1-100 amu, stainless steel and quartz capillary, 200°C

Microscopy

Scanning Electron Microscopy

Hitachi SU70	SEM with EDX-WDX-EBSD: Field Emission Gun-Scanning Electron Microscope (Shottkey-FEG-SEM)	Magnification up to x500.000 Lateral resolution (practical): 1.0 nm at 15 kV/ 0.9nm at 30kV High signal/noise ratio at low keV, low and non-electrical conductive materials can be imaged without pre-coating Sample dimensions: upto ø100 mm and 50 mm height
Oxford-AZtech INCA	Materials chemical: <ul style="list-style-type: none"> • Energy Dispersive X-ray analyses (EDX) • Wavelength Dispersive X-ray analyses • Crystallographic examination: EBSD 	DX-Quantative Element analyses with an accuracy of ±0.5 wt% starting at sodium (Na) WDX-Quantative Element analyses down to Boor (B) using standards Automated analyses and particle recognition EBSD: analyses, characterisation and identification of crystallographic phases down to 50 nm in size Particles to be analysed can be down to 0.05 µm ₃ in size, depening on acc voltage
Hitachi S3700	SEM with EDX: W-emission variable pressure SEM with large chamber	Magnification up to x500.000 Lateral resolution (practical): 10nm at 3kV/3nm at 30kV Sample size up to 300 mm diameter and 110 mm height to be investigated Variable pressure: high vacuum to 270 Pa to investigate porous, dirty and non-conductive samples
Oxford-AZtech	Element analyses by Energy Dispersive X-ray analyses	EDX-Quantative Element analyses with an accuracy of ±0.5 wt% starting at sodium (Na) (also in low-vacuum mode)
Jeol/JSM-6010LA IntouchScope	SEM with EDX W-emission variable pressure	80x40x43 mm travel Res. 4 nm at 20KV High and low vacuum mode (100 Pa)

Optical Macroscopy and Microscopy

Leica MeF-4	Optical microscope	Magnification up to x1500 Bright field Dark field Nomarski interference contrast Polarised light
Stream	Image analyses and storage	Image storage Image analyses Coupled to optical macroscope and microscope

Brand/Description	Description	Application/Dimensions
Sensofar Plμ2300 and Leica PLu Neox	Confocal microscopes	Confocal microscopy and interferometry Non Contact 3D profiling Sample surface area: 300x300 mm Z-resolution: Confocal mode 6 nm (2 nm reproducibility) Interferometry: 0.6 nm (0.2 nm reproducibility) Lateral resolution: 0.3 μm Automated analyses Data analyses Mountains 5.1 software (ISO DIS 25178)
Atomic Force Microscopy		
Park systems NX-10	Atomic Force Microscopy (AFM)	Contact and dynamic mode, EFM and conductive AFM Scan 100x100x15 μm (XYZ) res. 0.1 nm Max. sample size 50x50x20 mm Max. stage travel 20x20 mm res. 5 μm
Mechanical Characterisation		
Instron 4501-series 9 Instron 4502-series 9 Instron 4505-series 9	Tension/tensile testing Compression	Up to 100 kN Pull load (access to test load up to 2500 kN) Three and four point bending, Ring on Ring testing Room temperature up to 900°C
Wöhler machine	Rotating fatigue	Room temperature fatigue testing on standard test pieces. Testing of materials and coatings
Frank-Finotest 38542 Leica-Durimet	Hardness measurements	Macro-Vickers, up to 30 kg load Brinell, 1 mm ball up to 30 kg Micro-Vickers, down to 0.05 g Knoop hardness
Fatigue, Thermal cycling and proof testing		
Clive Hurley CH 500.40 Espec PL3-KPH Espec TSD-100 Binder MKF 115 Binder MK720	Climate Chambers	-40°C to 180°C, 20% - 98% RH, 2250 ltr -40°C to 150°C, 20% - 98% RH, 408 ltr -65°C to 0°C and 60% to 200°C, no RH, 100 ltr, 30 kg -40°C to 180°C, 10% - 98% RH -40°C to 180°C, no RH, 700 ltr
Fatigue and proof testing	Service offered by WMC (www.wmc.eu)	Up to 75m
Geometrical Control		
Mitutoyo Strato "Euro-C 9166" with QVP	3D mechanical probe contact measurements 2D optic Measurements	1600x900x600 mm U ₃ = 1.7 μm + 3l/1000 μm (VDI 2617)
Mitutoyo Quick Vision "QV202 Apex Pro3"	3D optic measurements	200x200x200 mm E _{xy} = 1.5 μm + 3.0 x 10 ⁻⁶ x l (l in meters) E _z = 3.0 μm + 4.0 x 10 ⁻⁶ x l
Mahr Perthometerconcept PCV (drag probe)	Contour measurements	Measuring 1-200 mm x 50 mm Resolution 0.15 or 0.30 μm
Mahr Perthometerconcept PRK "MFW 250" (drag probe)	Roughness measurements	Measuring range ± 500 μm
Mahr "Perthen Focodyn" Rodenstock RM600-3D (Laser)	Optical roughness and contour measurements	Measuring range ± 250 μm
Mahr Pherthometer LS10 (laser)	Optical roughness and contour measurements	Measuring range ± 250 μm Measuring distance 10 mm
Mitutoyo "LSM-1610"	Laserscan micrometer	Measuring width 50 mm Accuracy <3 μm
ULM 01-600 C	Universal length measuring machine	600 mm, E = 0.1 μm + 1.4 x 10 ⁻⁶ x l
Hewlett Packet	Laser interferometer	Length measurement with laser, also curves and surfaces
Pelt&Hooykaas	Surface plate (flat table)	Granite Klasse 1 - 2500 mm x 1250 mm
Mahr Digimar DX1	Height gauge (1D)	600 mm, E = 0.002 mm + 2.2 10 ⁻⁶ x l

Brand/Description	Description	Application/Dimensions
Talyrond 100	Roundness tester	Ø 200 mm
3D scanner	3D measurements	Scansize: 60-500 mm Resolution/Precision: Up to 0,1% of scan size (down to 0,06 mm)
Non-destructive Analyses		
Grindo Sonic	Non-destructive determination of E-module	Homogeneous metallic and ceramic materials Room temperature
Fischer Ferritescope-EN8D2-FE and MP3-GAB1.3 FED	Determination of ferrite content	Ferrite content up to 100% ferrite Can be modified for layer thickness measurements
Resato WPS65-1-R8/B/1/C	PED-High Pressure Testing	Pressuretest up till 450 bar
Pfeiffer Smart Test	Leak testing	He-leaktester tightness
Sample Preparation Facilities		
Struers Knuth rotor 2	Grinding	SiC grinding paper grit P150-P4000
Struers-Pedemax-2 Struers-PdM-Force Struers-Rotopol 3 + Rotoforce-4	Polishing	Multiple sample preparation 1 (25.4 mm) - 2 (50.8 mm) Specials are possible up to 100 mm Ø
Struers embedding press Struers embedding press UV-hardening-Kulzer Cold embedding masses	Embedding	Standard size 1 (25.4 mm) - 2 (50.8 mm) Embedding mass depending on sample size and material specials optional available
Struers Discotom-2 Struers Accutom 5 Retsch BB1 Siebtechnik Retsch ZM1 Retsch SM 300 Retsch SM 2000 Retsch SM 1 Condux HM23/20/N5-D Cissonius Dispermat	Cutting, Crushing, Milling	For cutting metallic, ceramic, biomass and fossil fuel, and plastic samples Precision cutting, µm precision Milling of materials in a slurry up to 10000rpm
MMM Venticell	Drying	Temperature up to 200°C, capacity up to 900 litres Self-heating behaviour
Retsch AS 200	Sieving	Vibratory sieve shaker
Hitachi IM4000	Ion Milling	For defect free sample preparation Cross section preparation thin layers, particles etc Post polishing of cross sections for removal of residual surface deformation Sample preparation for EBSD Investigation of thin (ductile) layers (below 1 µm down to 1 nm)
Ceramic and Metals Production		
<i>Powder Processing</i>		
CIP National Forge (EPSI)	Cold Isostatic Pressing	Max. 4000 bar, diameter 250 mm high 500 mm
Arburg 320C	Injection Moulder	Metals, Ceramics, 500 kN clamp force
Loomis extruder 232-40DT	Extruder (big model)	Extrusion of paste (3 liter)
Loomis extruder 232-16 DT-HS	Extruder (small model with heating)	Extrusion of paste and feedstock (350 ml) Ø 50x200 mm
Precipitation setup	Solids preparation by precipitation	Control of temperature and pH
Suspensions preparation	Attrition milling	Typically up to 500 gr material Alumina, zirconia, titania suspensions Boehmite synthesis

Brand/Description	Description	Application/Dimensions
Werner&Pleiderer LUK 8.o Klz	Kneader (big model)	Kneading of paste (8 liter)
Winkworth 2-Z	Kneader (small model)	Capacity 1 liter
Werner&Pleiderer LUK 025	Kneader (mini model)	Kneading of paste (250 ml)
Coating		
Membrane support layers	Ceramic coating	Controlled coating speed ~40 mm/sec Special coating room (low particle influence) Various diameters from 10 – 45 mm Various lengths from 120-1000 mm
Membrane layers	Ceramic coating	>100ml material Synthesis equipment High class Clean room Controlled coating speed ~40 [mm/sec] Various diameters from 10 – 45 [mm] Various lengths from 120-1000 [mm]
Electroless plating	Coating of noble metals	Tubular and (small) flat plate material Length (tubular) about 120 - 900 [mm] Various temperatures ~60°
Additive Manufacturing		
Admaflex	Metal & Ceramic printer	80 x 43 x 150 mm
SLM pilot equipment	Metal printer, Selective Laser Melting process; adapted for low stress processing	70 x 70 x 25 mm
Sintering & Heat Treatment		
Thermal Technology 1100 480 W ₃	High temperature sintering furnace	Max. 2200°C, Ar, H ₂ , N ₂ /H ₂ mixtures Diameter 80 mm, height 170 mm
Lömi type EDA-50	Debinding by liquid extraction	Max. 45 liter, max 200°C
Carbolite STF 16 /450	Sintering furnace (tube)	Max. 1550°C, Ar, N ₂ , N ₂ /H ₂ mixture, air Tube diameter 46 mm
Thermal Technology R-VCA 20L	Debinding furnace (chamber)	Max. 1400°C, Ar, N ₂ , N ₂ /H ₂ mixtures 25x26x30 cm
Smith ovens	Retort furnace - hardening	Up to 1200°C - ø 250x500 mm
Smith ovens	Circulation furnace	Up to 700°C - ø 350x400 mm
ECN build	Box furnace	Up to 1000°C - 25x30x12 cm Inert gasses or mixed with hydrogen
ECN build	Box furnace	Max. 1600°C, N ₂ , H ₂ , He
Naber N11HR	Sintering furnace	Hardening and other heat treatments Max. 1260°C in air 25x14x35 cm
Naber HT128, N60/H, N60/14H, HT08, HT64	Furnace	Ceramic 15x15x30 cm to 40x40x80 cm 8 to 128 liter Max. 1750°C in air
Linn 1600	Furnace	Ceramic Max. 1750°C in air and 1400°C in N ₂ , Ar or mixtures 25x30x30 cm
Hetherington	Vacuum/controlled atmosphere furnace	Vacuum down to 10-5 mbar Nitrogen, Hydrogen, Helium, Argon, Argon/ Hydrogen Up to 1850°C (short time)
Heraeus	Furnace	Max 1100°C in air
ECN build	Tube furnace	Max 900°C Air, N ₂ , CO, CO ₂ , CH ₄ , H ₂

Engineering

Brand/Description	Description	Application/Dimensions
Process Systems Engineering and Simulation		
MathWorks	Matlab, Simulink, Control System, Real Time Workshop, Simulink control, Stateflow, SF coder, xPC, xPC embedded, Matlab optimisation, Matlab PDE, Matlab Statistics	System modelling general
Aspen Tech	Aspen Plus, Aspen Dynamics, Aspen Custom Modeller, Aspen Icarus	Simulation chemical engineering
Comsol	Multiphysics (Femlab), incl. Chemical Engineering Module, Control Script	CFD, FEM, Reactor modelling
Mechanical Engineering		
PTC Creo	Direct	3D CAD
Database Management System	Model Manager	PDM
ANSYS	ANSYS Mechanical	FEM
AutoDesk	Acad (5x)	2D CAD
AutoDesk	Acad P&ID (3x)	Process and instrumentation diagram
MathSoft	MathCad	Modelling
Norbert Schmitz	SF Pressure Drop	Piping engineering
PV-Elite	PED Calculation ASME VIII	Pressure vessels
Software Engineering		
<i>Desktop development</i>		
Microsoft	VisualStudio .NET C#, VB	Desktop applications
Microsoft	WindowsCE, C++	Embedded applications
Borland	Delphi	Desktop applications
GNU	gcc, fortran	Scientific applications
<i>Libraries</i>		
ComponentOne	Studio	Charts/Graphics
Microsoft	WCF	Datacommunications, webservice
Microsoft	WPF	User Interface development
<i>Web development</i>		
Open Source	Typo3	Content Management System
Microsoft	Asp.Net Webforms	Webapplications
Microsoft	Asp.Net MVC	Webapplications
Open Source	Javascript/Jquery/ etc.	Webapplications (client side)
<i>Databases</i>		
Microsoft	SQL Server	Structured data storage and retrieval
Open Source	MySQL	Structured data storage and retrieval
Open Source	PostgreSQL	Structured data storage and retrieval

Brand/Description	Description	Application/Dimensions
Proces control development		
Elutions	Wizcon SCADA/control Maestro	Process control
Beckhoff	TwinCat SoftPLC	Process control
Embedded system tools		
MicroChip	PIC processors (DSPIC/PIC16/PIC18/PIC24)	C/C++
Keil GMBH	Intel 8051-series	C
Microsoft	Embedded XP	C, C#, ASP.NET
Microsoft	Platform Builder Windows CE	Embedded system development
Altera	FPGA's	VHDL/schematic design
Texas Instruments	MSC1210	C/C++
Texas Instruments	MSP430	C/C++
Atmel	AVR/ARM	C/C++/Basic
Documentation		
Adobe	Photoshop, Premiere, Acrobat, Illustrator	
Open source	LATEX 2	Image manipulation/Desktop publishing
Electrical Engineering		
Power Quality Measurement		
PM 300 Voltech	Harmonic analyser	Residual mains/grid utility
Nanovip	Power monitor	Distribution stations & cabinets 400-750VAC @ 200-1000A
Tektronix MDO3024 Tektronix TDS 3014 Tektronix 2221A Tektronix 2225 Tektronix AM503B (amplifier) Tektronix A6302 (probe) Tektronix A6303 (probe)	Mixed signal oscilloscope Memory oscilloscope Wideband Current Probes + Amplifier	Laboratory test / Development DC Bushbars Power convertors Rectifiers Power transformers Current probe Current probe
Tektronix P5200	3x Differential Probes	Grid coupled 3-phase measurements
Instrumentation		
Burster 4420/4421 /4485	Signal conversion generator/calibrator	Calibration of sensors and instruments
Digistant 4421 Knick Voltage source 14621 Knick Voltage reference 273591	Calibration of field instruments	Transducers: flow, pressure, force, temperature, humidity, conductivity, volts, amps, power etc.
Hewlett Packard 34970A Datalogger & Software	Trending & signal monitoring	Transducer outputs
Insulation testing		
PAT tester Nieaff Smitt	Inspection & test of electric equipment acc. to NEN 3140	Electric tools: household & industrial according to NEN-EN 3140
Combitester Gossen M5020	Earth & circuit tester	Grid utility & experimental applications
Power performance tests		
Digatron EVT 350-300	Power source/sinking	DUT 0-300V @ 350A bidirectional
Digatron EVT 410-540	Power source/sinking	DUT 10-540V @ 400A bidirectional

Brand/Description	Description	Application/Dimensions
Delta SMD 120-4x25 (1)master @ (3)slaves	Power supply	DUT 0-120V @ 100A unidirectional
Delta E300-0.1-L	Power supply	DUT 0-300V @ 0,1A unidirectional

Computer & Communication Testing

Logic analyser	CPU and periferie testing	Computer equipment
Data analyser Serial data	Testing physical link layer	Communications, protocol

Hardware

Hewlett Packard 2849-Go7566	Sweep generator	Laboratory test: EUT & DUT
Hewlett Packard 54645D Tektronix TDS3032	Oscilloscope	Laboratory test: EUT & DUT
Fluke 87 III, Keithley 0626177, 2000, 2700, 7700	Digital Multimeter	Laboratory test: EUT & DUT
Hewlett Packard 3416A, 53131A (1Ghz)	Frequency counter	Laboratory test
Hewlett Packard 33120A	Arbitrary Waveform Generator	Laboratory test
Chauvin Arnoug E3n		Field/lab test
Agilent/HP 34970A	Data Aquisition/Switch	Lab test
Hocherl & Hackl PL306, PL306A	Electronic load	Cell test
Spitzenberger & Spies PAS5000 NT5000 Spycore	Netsimulator	1 phase test 5000W
Norma D6000 Norma D6100 Yokogawa PZ4000 Yokogawa WT110 Voltech PM300	Power analyser	Three phase, Harm analysis Three phase Three phase, Harm analysis Single phase Three phase NEN 3140 testing
Delta SM 300-10D Delta SM 120-25 D Delta SM 15-200 D Delta SM 7020-D Delta 1200 S 48 Agilent/HP 6642A Agilent E4350A Agilent E4350B Kepco BOP 36-6M Kepco BOP 100-4M	Power supply	Current, SAS and bipolar
Teseq NSG 3040 Teseq NSG 437 HAMEG HMS1010 HAMEG HZ560 Advantest TR 17207 FCC F-33-2 Schaffner CDN 8014 Thurlby Thandar 1phase 16 amp Swarzbeck, NSLK 8128	EMC Testing Equipment	EMC Test system ESD Simulator Spectrum analyser to 1 GHz Transient limiter Search coil RF current probe 1kHz to 250 MHz Capacitive Coupling Clamp EMC Line impedance (LISN)

Realisation & Manufacturing

Brand/Description	Description	Application/Dimensions
CNC Turning		
Boehringler	DUS 560 ti-2000	∅ 520x2000 mm
Montforts	RNC-3	∅ 180x500 mm
Schaublin	125 CCN	∅ 200x450 mm
Hwachon	Hi Eco10	∅ 200x500 mm
CNC Milling		
Hermle (x2)	C400U 5-axis simultaneously	850x700x500 mm x360° x (-91°+139°)
Mikron	VCE 1600 4-axis	1625x812x762 mm
Mikron	VCP 600 3-axis	600x400x350 mm
Fehlmann (x2)	PicoMax 54 3-axis (linear or rotation)	500x260x490 mm
Wire Cut Electro Discharge Machining		
Sodick (x2)	AQ 750 LH	750x600x600 mm
Sodick	AQ 300 L	300x200x200 mm
Die-sinking Electro Discharge Machining		
Sodick	KIC	200x300x300 mm
Grinding & Honing		
Studer	S20-2	400 mm b.c.* and 100 mm c.h.**
Studer	S30	700 mm b.c. and 125 mm c.h.
Jung	JA600 CNC-E	600x250x240 mm
Sunnen	M B1803	∅ 2 x ∅ 60, length 500 mm
Lasers and opticals		
Baasel BLS610	Qs Nd:YAG-marking/engraving laser	Marking 150x150x200x200 mm
Lasag KLS 246-102 (040+046)	Nd:YAG-cutting laser 1064 nm	Cutting 600x400x300 mm
Lasag SLS 200C60	Nd:YAG-welding laser 1064 nm, fiber 400 µm	Welding 600x400x300 mm
Lasag SLS C16-046	Nd:YAG-welding laser 1064 nm, fiber 100 µm	Welding 600x400x300 mm
Rofin 20 E	Diode pumped, 355 nm and 1064 nm	Marking & Ablation 600x400x300 mm
SPI G3	Pulsed Fiber MoPa, 1064 nm	Marking & Ablation 300x300 mm
Synrad	Sealed CO ₂ laser, 10600 nm	Cutting 440x440 mm
SPI	CW Fiber, 1070 nm	Marking 440x440 mm
SPI	CW Fiber, 1565 nm	Marking & Ablation 440x440 mm
Trumpf HL204P	Nd:YAG-welding laser 1064 nm, 4 x fiber 400 µm	Welding 440x440 mm
IPG	Fiber laser, 1060 nm, short pulse	Ablation 100x100 mm

Brand/Description	Description	Application/Dimensions
IPG	Fiber laser, 530 nm, short pulse	Ablation 100x100 mm
Light Conversion, Pharos	fs-ps laser: 1060 nm, 530 nm and 340 nm Adjustable pulse length	Ablation 1200x800x200 mm
Light Conversion, Pharos	fs-fps laser: 1060 nm, 530 nm and 340 nm Adjustable pulse length	Ablation 600x400x300 mm
Eolite, Boreas	ns laser: 532 nm and 355 nm	Ablation 250x250x25 mm

Sheet metal and tube bending

SAFAN	E-BRAKE B80-2550	80 ton - 2,550 m
JUTEC	Pipe bending	Ø 40 x 2 stainless steel

Welding & joining

Induction welding	Inert Atmosphere	Up to 1200°C, stainless steel and high temperature alloys
Hobart Cyber-Wave 300 (x2)	TIG	From aluminium up till high temperature (WPQ) Welder Performance Qualification alloys (PQR) Procedure Qualification Record and (WPS) Welding Procedure Specifications for stainless steel, duplex and high Ni alloys
L-TEC Synergipuls 505	MIGTIG	
Plasmafix 50E	Micro Plasma Welding	
Centaur III 150 PTW-1	Orbital Welding	

Wind

List of ISO17025 accredited analyses available at <https://www.rva.nl/scopes/details/L324>

Brand/Type	Description	Application/Dimensions
Wind Test Site		
R&D Wind Farm	Nordex N80 (x5) to be used for R&D	Rated capacity 2.5 MW Hub height 80m Rotor diameter 80m
Prototype Test Locations (x6)	Test locations for wind turbine prototypes	Power up to 12 MWe per prototype Hub height up to 150m Rotor diameter up to 175m 10 kV grid connection Data communication infrastructure
Meteo Towers (x5)	Wind condition monitoring	Wind speed Wind direction Air temperature Air pressure Relative humidity Turbulence Atmospheric stability Sonic anemometers
Wind Turbine Measurements		
Power curve	In accordance with: IEC 61400-12-1 MEASNET Power Performance measurement procedure	
Energy production	FGW TR2 rev.16, 2010-01	
Power coefficient	FGW TR5 rev. 4, 2008-06	
Mechanical loads	In accordance with IEC 61400-13	
Wind conditions	In accordance with IEC 61400-12-1	

Solar

Brand/Type	Description	Application/Dimensions
Generic		
Filmetrics	Angle dependent R	280-1100 nm, flat, thin (<0.3 mm) sample
CV-MOS	Fixed charges and interface states	
DekTak	Profilometer	
Ellipsometer (Sentech)	Optical constants (k,n) of layers	280-1700 nm
Emission	indicative only	400-1600 nm
FLIR	Infrared Camera	Object temperature range -20 to +150°C 0 to +650°C
FTIR	Measurement of atomic bonds	400-4000 cm ⁻¹
Kelvin Probe	Workfunction (conductive), surface potential (isolating)	
Reflectance	integrating sphere	400-1600 nm, sample < 20 cm
Resistomat	accurate determination of electrical resistances	>1 mOhm
Ocean Optics	Fiber Spectrometer	calibrated power 250-600 nm
Transmission VIS-IR	integrating sphere	400-1600 nm, sample < 20 cm
Transmission UV-VIS		280-1100 nm
Semiconductor specific		
Doped layer characterisation	Hall, Sheet resistance, ECV	
Metal line resistance	B2B, TLM, Corescan	
Minority carrier lifetimes	QSSPC, uPCD, luminescence, DLIT	~300 K
Solar simulator	WACOM, Neonsee, Atlas, Pasan, Halm, Eternal Sun, Spire	Solar cells
Spectral responses	SR, LBIC	Solar cells
Modelling tools		
Silvaco Atlas	Atlas is a 2D and 3D device simulator that performs DC, AC, and transient analysis for silicon, binary, ternary, and quaternary material-based devices. Atlas enables the characterisation and optimisation of semiconductor devices for a wide range of technologies	All kind of semiconductor technologies. Most experience on solar cells
Scout/Code	Optical simulation software	Coating design, light trapping, light transmission
Ray-tracing	Optical simulation based on ray-tracing	For size scale larger than the wavelength of the light. Coatings, structured surfaces.
Module testing		
MLPM proeftuin	3x 1.5 kWp PV-system with power analyser	Testing of micro-converters, power optimizers, and for shadow-related losses
BIPV proeftuin "SolarBEAT"	6x BIPV house, each with 30 m2 roof/façade surface	Infrastructure for electrical tests Infrastructure for thermal tests (heat flux, flow rates, temperatures) Weather station

Thermal Conversion, Storage & Exchange

Brand/Type	Description	Application/Dimensions work piece
Characterisation and pre-treatment		
Hartmann tube	Minimum Ignition Energy (MIE) according to EN 13821 Minimum Explosive Concentration Maximum Flame Velocities	Explosivity of dust, gas, vapors, or hybrid mixture samples. Influence of moisture content, particle size and shape, operation temperature, oxygen concentration, atmosphere
Andritz	Tumbler	Equipment to determine the amount of dust created in the handling of pellets. The pellets are contained in a box, which is turned a fixed number of times and the amount of dust created is determined relative to the mass of the sample. Tests are performed according to the NEN-EN 15210-1 standard
Struers	Prontopress	Equipment to produce single pellets with a diameter of 17 mm, a maximum pressure of 1750 bars and temperature of 200°C
Höcker PolyTechnik BrikStar CS 4-12R	Briquetting press	Equipment to produce briquettes of 50 mm diameter. The maximum throughput is 50 kg/hr.
Cold Flow	Pneumatic Transport Behaviour	Pneumatic behaviour in dilute phase and dense phase. The transport line has around 5 m of total length, an inner diameter of 28 mm and 3 bends. The maximum velocity that can be achieved with the carrier gas is 22 m/s. The maximum pressure gradient allowed is 400 mbar
Dye press	Used to produce pellets to asses properties	Disks up to 5 cm of pressable materials
Lab centrifuges	Lab centrifuge to determine optimal conditions and small samples.	1.5 to 750 mL per sample, max 3l/run. Used to set parameters for semi-continuous centrifuge
Industrial washing machine	Fully programmable washing machine for experiments. Water can be gathered for analysis or products.	Up to 95°C, volume of drum is 70 liter
Incubators	Up to 80°C shaken incubation	small samples 25 mL each, 10-15 samples
Freeze dryer	Drying samples by freezing	Up to 1 kg, operating temperature approximately 0°C
Sterilisation apparatus	121°C sterilisation chamber	Chamber volume is 20 liter
Controlled environment refrigerator	Controlled environment and temperature to assess storage concepts of wet biomass	4-15°C, up to 15x 1L bottles or larger flasks if reconfigured
Evodos continuous centrifuge	Fed batch Evodos centrifuge	10 kg. size samples. Maximum flow through is 600 l/hr
Conversion		
WOB Lab-scale Reactor for Gasification, Pyrolysis, Combustion	Multi-purpose reactor for bubbling fluidised bed (BFB) gasification, combustion and pyrolysis of approximately 0.5 kg/h fuel. It is a very flexible and reliable reactor and is used for many types of research	The reactor can be electrically heated to the preferred temperature with a maximum of 1000°C. Online gas emission analyses can be done and also analysis of the cyclone ash and dust samples collected. The WOB is also used for agglomeration research purposes
Batch torrefaction reactor	Torrefaction	Temperature treatment of up to 5 kilos of a material like biomass to a temperature up to 300°C in nitrogen. Materials can also be tested on their self-heating behaviour
Pilot torrefaction reactor	Torrefaction	Temperature treatment of up to tonnes of a material like biomass to a temperature treatment up to 300°C in nitrogen

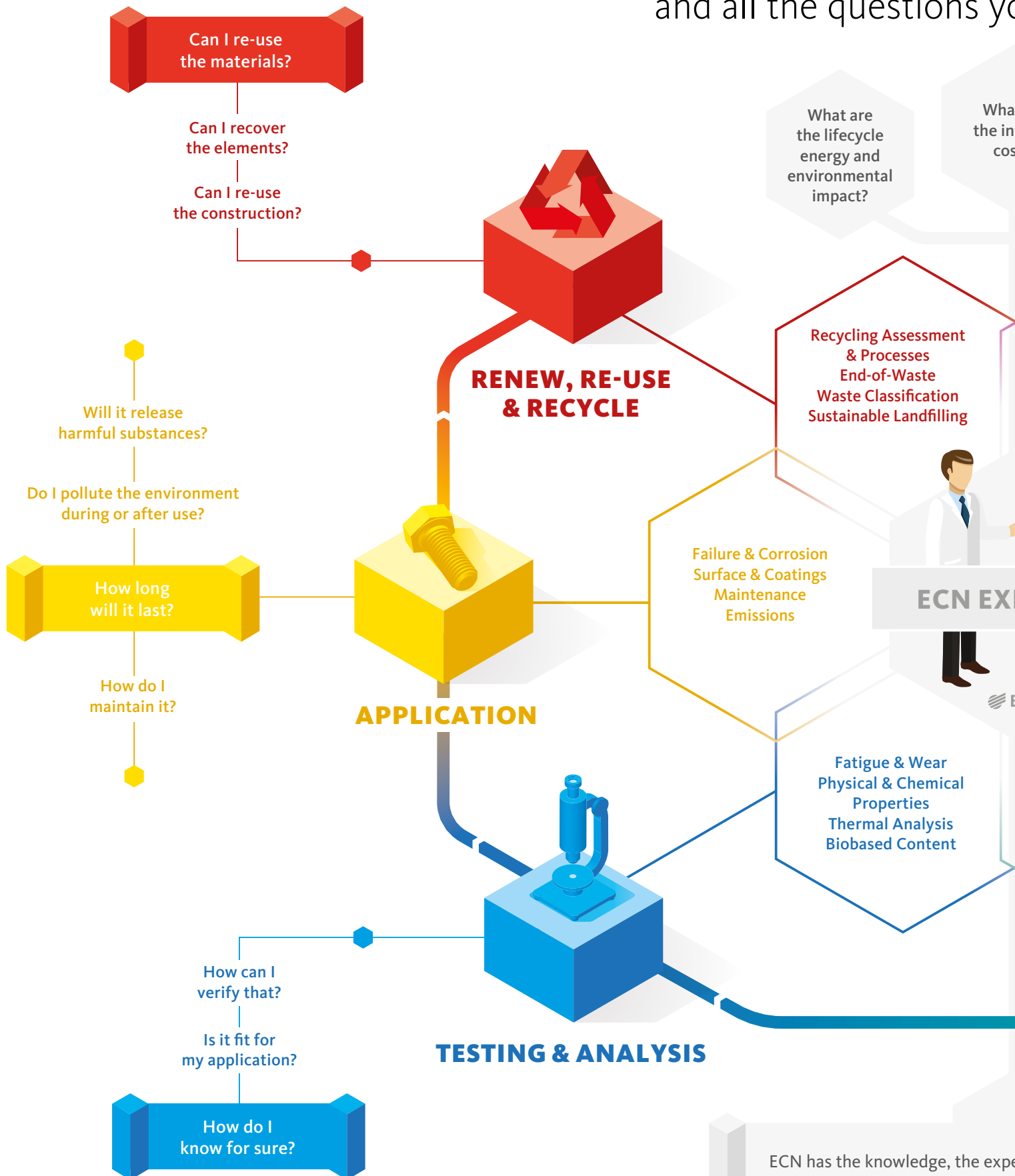
Brand/Type	Description	Application/Dimensions work piece
Thermal storage and exchange		
Mobile windtunnel	Wind tunnel for testing of heat exchanger concepts. Gives insight in the performance relative to the other concepts or calculated design values. The wind tunnel unit is equipped with a controllable speed fan. With the help of various air ducts and grid / mesh profiles the desired flow profile can be achieved. The air can be heated as desired with a liquid-air heat exchanger	3 to 5 meters in length with square flow pattern of 120 x 120 mm. Medium is thermal oil (up to $\pm 200^{\circ}\text{C}$)
ROSATI sorption cycle lineup	On scale, with small heat exchanger, measuring the adsorption and desorption rate. The pressure level in the reactor and the temperature level of the heat transfer medium can be set independently of each other. <ul style="list-style-type: none"> • Characterisation of heat and mass transfer limitations. • Testing of reactor concepts consisting of both a heat exchanger and a sorbent. • A visual indication of the sorbent behavior. • Performing endurance tests in order to determine fatigue performance of the sorbent 	The present reactor volume is ± 1 liter. Temperature up to 200°C (thermal oil). Pressure up to 25 bara
Heat supply and discharge unit including measurement unit	Heat supplying and discharging infrastructure to exchange heat at four different temperature levels. Both the temperature level and the flow rate are fully adjustable. In the separate measurement unit the thermal power is determined by precise measurement of the flow rate (Coriolis flow sensor) and temperature	Capacity 5-20 kWth. Water (up to 95°C) or oil (up to $+ -200^{\circ}\text{C}$) can be used as medium. The to be linked systems can differ in size
Vacuum vessel measuring unit	The vacuum vessel is a set-up for measuring the warm-up pattern of heat exchangers in an environment without heat loss	50x50 cm cylindrical ± 1 millibar vacuum
Flow and temperature calibration unit	Calibration setup for sensors. This small mobile arrangement is able to check flow rates and temperatures of sensors built into their installation	The mobile unit can be used in various ways. <ol style="list-style-type: none"> 1. Temperature Calibration by placing the sensors in water combined with a highly accurate reference thermometer. Possible in a range from -40 to $+200^{\circ}\text{C}$. 2. Calibration of flow sensors with a Coriolis flowmeter. 3. Thermal power measurement in the range of 2 kW to 1 kW heating cooling
Vacuum pump with cold trap	Combination of vacuum pump with a cold trap in one setup. Along with a precision electronic pressure sensor and a wide range of vacuum components, this unit can be rapidly deployed in various test configurations	The vacuum range is $3 \cdot 10^{-3}$ hPa at a pumping rate of 9 m ³ /h
Vacuum filtration unit	Isolation of solid materials	Up to 15 L per batch

Separation & (Electro) chemical Conversion

Brand/Type	Description	Application/Dimensions work piece
Separation and chemical conversion		
Microflow reactors	A series of small scale equipment for gas phase sorbent and catalysis research	Typical flow range 30-200 ml/min. Sample volume 50-5000 mg. Various analysis equipment for off gas analysis. Feed gasses CO, CO ₂ , H ₂ , H ₂ , N ₂ , NO _x , NH ₃ , H ₂ S and more. It is also possible to add (organic) contaminants. Atmospheric pressure
Parallel flow reactors	A 6 reactor system for small scale gas phase sorbent and catalysis research	Typical flow range 30-200 ml/min. Sample volume 50-5000 mg. Various analysis equipment for off gas analysis. Feed gasses CO, CO ₂ , H ₂ , H ₂ , N ₂ , NO _x , NH ₃ , H ₂ S and more. It is also possible to add (organic) contaminants. Pressure up to 5 bar
Picoclave	Small scale autoclave for mixing and reaction of slurries at elevated pressure	Various feed gasses possible, ie. CO ₂ , N ₂ . Pressure based on vapour pressure of the liquid. Temperature up-to 250C
HYSUM1/2	Reactor testsv	Flexible in module types Test-gasmixtures feed made by a booster Steam option available H ₂ S, ammonia, etc. possible (safety measured infra) Variation feed pressure ~70 barg Variation pressure difference Variation in temperature ~600°C With catalyst
CRS	This installation is computer controlled continuous flow reactors designed for testing gas-liquid and liquid-liquid reactions. Reactor options are with/ without coated capillary (tube) wall in liquid phase	Used for testing Oxidation, Hydrogenation, Hydrolysis, Extraction and reactive extraction process using Taylor flow. Max conditions : 40 bar pressure and 300°C Temperature
CaTe	This installation is computer controlled continuous flow reactors designed for testing gas-liquid and liquid-liquid reactions. Reactor options are with packed bed	Used for testing Oxidation, Hydrolysis, Extraction and cracking process. Max conditions: pressure 100 bar and 450°C temperature.
DTU	This installation is computer controlled continuous flow installation used for flow visualisation in the structured packings	Flow visualisation
HIDiC	The heat integrated distillation column installation is used to address the issue of flow distribution, heat and mass transport	Distillation, absorption, structured packing testing for heat and mass transfer
Rotatieverdamer	Controlled mixing and drying of slurries (aqueous or organic) by means of vacuum and temperature.	Vacuum to 2mbar, Maximum temperature 180°C, rotation: 20-280rpm
Multiclave	Autoclave units, for carrying out 6 parallel thermochemical experiments. Contents can be stirred	6 parallel screening experiments. 70 mL max, 2 temperatures up to 250°C and 100 bar, no pressure control
Autoclave	Autoclave unit for carrying out thermochemical experiments. There are three reactor vessels available, respectively	0.5 - 20 L autoclaves, 250°C, 55 to 90 bar, 2000 rpm stirring
Soxhlet extraction apparatus	Experimental extraction of products with solvents (or water)	up to 10 grams
Kugelrohr distillation apparatus	Experimental distillation of small sensitive samples under high vacuum. Pressure dependent on conditions and sample	Max 50 mL sample, temperature range 40-300°C Pressure range 1E-5 - 1 bar
Electrochemical conversion		
EA PS-9040 120A	Power supply	0-40 V 0-120 A power units for electrolysis or electrowinning. Monitoring of potential, acidity and electrolyte flow

Material

and all the questions you

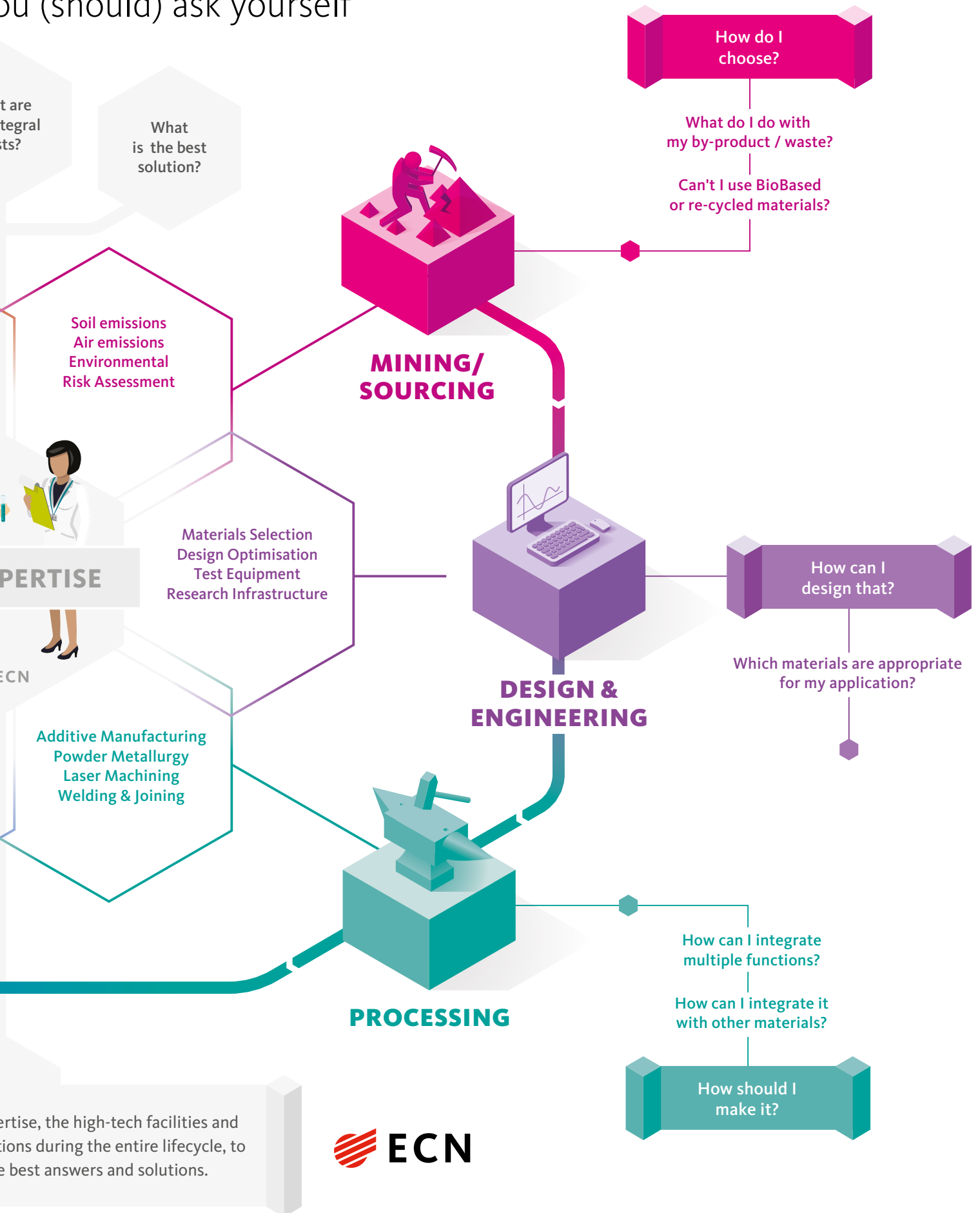


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ECN has the knowledge, the experience, the network to ask the right questions, test, analyse, and provide the

Materials

What (should) you ask yourself





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