Dekati Ltd
Company and Products

Henna Isherwood
Director, Sales and Marketing
Dekati Ltd.
Background

- Company founded in 1994
- 14 private owners
- Technology spin-off from TUT Aerosol Physics Lab
- Core Competence and know-how
  - Fine particle sampling and measuring technologies
- 23 highly educated employees
  - More than 2/3 of staff BSc, MSc or PhD
- Exports ~ 90 % of sales

Dekati Ltd is located in Tampere, Finland.
Particle sizes and concentrations

Concentrations
- Background 1 µg/m³
- Indoor air 20
- Restaurant/bar 500
- Power plant stack 50 000
Applications

• Automotive exhaust emissions
• Blow-by emissions
• Combustion and energy – stack emissions
• Ambient – environmental fine particle monitoring
• Pharma – inhaled drug R&D
• Nanotechnology
Applications – last 15 years

Revenues/application

- Energy & Combustion
- Pharma
- Automotive
- Ambient air
- Misc./Industrial

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## Global Distribution and Agent Network

<table>
<thead>
<tr>
<th>Europe</th>
<th>Asia/Australia</th>
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<tbody>
<tr>
<td>Contrec Technologies Ltd.</td>
<td>SUI Flexisolve Technology Pte Ltd.</td>
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<tr>
<td>Ecomesure</td>
<td>France Ecotech Pty Ltd</td>
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<td>Enavsis - Petros patelis &amp; Sia O.E.</td>
<td>Greece Innovative Instrument Co., Ltd.</td>
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<td><strong>ExIS, Exhaust Instruments</strong></td>
<td><strong>SE, DK, NO Kanomax Japan Inc.</strong></td>
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<tr>
<td><strong>Scandinavia AB</strong></td>
<td><strong>Japan</strong></td>
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<tr>
<td>Ingenieros Asesores S.A.</td>
<td>Spain KINSCO Technology Parkor</td>
</tr>
<tr>
<td>MLU</td>
<td>Germany, Austria, Poland Oriental Renpro Technologies Co. Ltd.</td>
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<td>MS4 Analysentechnik GmbH</td>
<td>Germany Seacom Process Instruments S/B</td>
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<tr>
<td>Westtech Instruments Ltd</td>
<td>UK Tai E Trading Co. Ltd.</td>
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<tr>
<td>Umberta Sircana Conrado</td>
<td>Italy M&amp;G Analyser Systems Unispec Marketing Pvt. Ltd.</td>
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<tr>
<td>Envitec nv</td>
<td>Benelux North America Unispec Marketing Pvt. Ltd.</td>
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| North America                               | USA, Canada                                        |

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Dekati® Technology and Networks

- **In-house R&D**
  - Scientific and practical know-how about aerosol measurements and instrumentation
    - Design, mechanics, electronics, software
  - New products every year

- **Extensive R&D network**
  - TUT, LAT, FMI, VTT, Finnish Defence Forces
  - Ford Motor Co., Glaxo Smith Kline

- **Strong patent portfolio and management**
  - 14 patents granted or applied
  - Core patents – both method and equipment
Dekati Networks

• High visibility in legislative advisory groups & international projects
  – Automotive
    • Particulates (EU)
    • PMP / GRPE program (United Nations, global roof organization)
    • CRC E-66 (US EPA 2004), CRC Advanced Collaborative Emissions Study (ACES)
  – Ambient
    • ETV program (US EPA), ICAT (California / CARB)
    • VDI Fine Particle Measurement Guideline
    • CEN TC264/WG32
  – Emissions
    • PM10 ISO standard (ISO23210)
    • ISO TC146/C01/WG21 Sample conditioning for stationary source emissions
  – Nanotechnology
    • Nanodevice (EU)
Product Line

• Real-time instruments
  – ELPI™ & Outdoor ELPI™
  – DMM 230

• Sampling devices
  – Fine Particle Sampler FPS 4000
  – DEED, Dekati® Engine Exhaust Diluter
  – Dekati® Diluter
  – Dekati® Cyclone
  – Dekati® Thermodenuder
  – Dekati® Axial Diluter (DAD)

• Dekati® Impactors
  – Dekati® Low Pressure Impactor (DLPI)
  – Dekati® PM-10 Impactor
  – Dekati® Gravimetric Impactor (DGI)
Dekati® Gravimetric Impactors

- DLPI – Dekati® Low Pressure Impactor
- DGI – Dekati® Gravimetric Impactor
- Dekati® PM10 Impactor
Impactor Operating principle

- Turn the gas flow sharply
- Particles with sufficient inertia cannot follow the flow
- Particles with small enough inertia remain in the flow
- Capture the particles escaping the flow
Cascade Impactor - example

Stage 1: >0.5 µm
Stage 2: >1 µm
Stage 3: >5 µm

Collection substrates

Flow
Nozzle Diameter $D_1$
Jet velocity $U$
Jet to plate distance

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DLPI impactor

- 13 stage cascade impactor
- 30nm -10μm
  - <30nm with filter stage
- Small deposit area, 25mm
- Good calibration info
- Option for ELPI upgrade
- Complete setups for
  - Automotive
  - Air quality
  - Combustion
  - Etc...
Dekati® PM-10 Impactor

• PM10, PM2.5 and PM1.0 mass concentrations
  – Ambient air
  – Indoor air
  – Stack sampling
  – Industrial hygiene

• Analysis
  – Gravimetric
  – Chemical
  – Physical

• Same construction as DLPI
• Fullfills ISO23210
• Complete setups available
Dekati® Gravimetric Impactor DGI

• Designed for automotive exhaust measurements
• D50: 2.5 – 1.0 – 0.5 – 0.2 µm + back-up filter
• 70 lpm nominal
  – adjustable 50-90lpm
• 47mm filters on impactor stages
• Can be operated in two modes
  – two stage DGI: two lowest impactor stages are replaced with a spacer
  – four stage DGI: five size fractions
ELPI™ Operating Principle

• Operation based on three main components:

  1. Impactor
     - Particle size fractionation
  2. Charger
     - Particle are charged before fractionating
  3. Electrometers
     - Current distribution - directly proportional to number distribution
     - Fast, sensitive

• ELPIVI Software for instrument control
Operating principle

Corona charger

+5 kV

400 V

Electrometers

Computer and control electronics

Vacuum pump

Impactor with insulators and contact needles

RS-232 serial

ASCII datafile

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Dekati
Excellence in Particle Measurements
ELPI™ offers

• Real time number size distribution and concentration measurement

• 7 nm - 10 μm with fs

• Particles are collected - enables subsequent chemical analysis

• Dynamic range, from outdoor air to power plant stack concentrations

• Can be used for charge size distribution measurements and as a gravimetric impactor
Outdoor Air ELPI™

- Same operating principle
- 30 lpm flow rate
- Stand-alone instrument
  - Automated operation
  - Power failure recovery
  - Data storage on a floppy disk/USB
- Humidity and temperature measurement
- Compatible with standard ELPI™
DMM-230 Dekati® Mass Monitor

• Based on the ELPI™ technology:
  – Particle charging in a diffusion charger
  – Particle size classification in a low-pressure impactor
  – Electrical detection of particles
  – Density measurement by comparing aerodynamic and mobility diameters (impactor vs. charger mobility analyzer)

Density calculation:
  - Mobility / aerodynamic sizes

Current to mass conversion
  - Total mass concentration

Multichannel electrometers
Aerodynamic size (Dpa) measurement

- Impactor classifies particles according their aerodynamic diameter
  - Correction of losses
  - Correction of mobility electrode collection
**Principle of density measurement**

- **Mobility size measurement**
  - Current distribution
  - Lognormal distribution
  - Current measured from TRAP
  - Total current measured from IMPACTOR

- **Aerodynamic size from the impactor**
  - Lognormal fit
  - dpa

- **Aerodynamic and mobility sizes, unit density**
  - The relation between aerodynamic and mobility sizes is the particle density
  - dp = dpm

- **Aerodynamic and mobility sizes, actual density**
  - Effective density is found after iteration

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Density profile

- Density as function of particle size: Diesel agglomerates

\[ \rho (g/cm^3) \text{ vs. } D_b (\mu m) \]

Virtanen et al SAE 2002-01-0056
DMM-230A Dekati® Mass Monitor

- For engine emission measurements
- Real-time mass concentration <1.2μm
- Real time number concentration
- MMD and GSD
- Results in good correlation with gravimetric measurements
- Simple to use
- Integration to test cells
Dekati® Sample Conditioning Instruments

- Dekati® Cyclones
- Dekati® Diluter
- Dekati® Axial Diluter -DAD
- FPS-4000 – Fine Particle Sampler
- DEED – Dekati® Engine Exhaust Diluter
- Dekati® Thermodenuder
Dekati® Cyclone SAC-65

- Pre-separator with 10μm cutpoint at 10lpm
- Stainless steel construction
- Designed according to EPA 201A
- Can be used in temperatures up to 600 °C
- Accessories include heaters for use outside stack
DAD-100 Dekati® Axial Diluter

• Simple dilution tool for any aerosol sample
  – Low consumption of dilution medium
• Measurement instrument inlet flow needs to be known
  – No problem with Dekati products
• Adjustable, but constant dilution ratio
• Calculation sheet provided with instrument
DAD-100 operation principle

Pressurised and purified dilution air

High precision needle valve

Undiluted aerosol

Diluted aerosol drawn out by the measurement instrument

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Dekati® Diluter

• Ejector diluter DR ~8
• Stainless steel construction
  – Can be heated up 450 °C
• Full setups available for combustion and automotive exhaust measurements
  – Double diluter setup for volatile matter removal
• Simple to use
Dekati® Diluter

- Low pressure caused by dilution air flow in the nozzle sucks the sample from the inlet
- Mixing in the mixing chamber
- Coaxial dilution, low losses
Dekati® Double Diluter Setup

Tailpipe:
- High concentration
- High temperature
- High vapour pressure

Hot Dilution
- Concentration decrease
- Vapour pressure decrease
- Temperature preserved

Cold Dilution:
- Concentration decrease
- Low vapour pressure => safe temperature decrease
DEED – Dekati® Engine Exhaust Diluter

- Complete compliance to PMP specifications
- Affordable
- Simple user interface
- Dilution ratio always constant, repeatability and reproducibility extremely high
- Can be used with ANY particle number or mass measurement device
- AK-protocol available
DEED Operation
FPS-4000 Dekati® Fine Particle Sampler

- Two-stage dilution system
- Controllable
  - Dilution temperature – cold/hot
  - Dilution ratio
  - Residence time
- Measurements from low/high
  - Temperature 0-600°C
  - Pressure 750-2000 mbar abs
- Continuous dilution ratio calculation
  - +/- 10% reading
- Integration to data logging systems
FPS operation principle

• Primary dilution
  - perforated tube dilution
  - Cold or hot primary dilution
  - Controlled dilution ratio

• Secondary dilution
  - Ejector type diluter acts as pump
  - Cooling of sample
  - Controlled dilution ratio
Dekati® Thermodenuder

• Heats exhaust gases up to 250°C
  – Most volatile components evaporate in vehicle exhaust
• Removes VOC with fibrous active carbon

• High volume flow rate, 10-20 LPM
• Easy-to-use
  – Connect cooling medium
  – Turn heater on
  – Active carbon as cartridges – easy exchange

• Correction algorithm for losses available
Dekati® Thermodenuder Operation
Dekati® Dryer

- Permapure Nafion® dryer designed for PM measurements
- Minimal particle losses
- 10 or 30 lpm sample flow
Selected customer references

Automotive
- Ford Motor Company US/UK
- Nissan Motor Co. Ltd. JP
- Toyota JP
- Renault CTL
- Peugeot, FR
- General Motors Corporation, USA
- Isuzu Motors Co. Ltd.
- Nisseei Mitsubishi Co
- Porsche AG
- Volkswagen AG
- Audi AG
- Caterpillar, US
- Cummins, US
- Castrol Oils, UK
- Mobil Technology Company, USA
- Indian Oil Company
- Millbrook Proving Ground Ltd, UK
- EMPA, Switzerland
- ETH, Switzerland
- Aristotle University Thessaloniki, Greece
- University of Minnesota, USA

Ambient
- Xinjiang Environment Monitoring Station, China
- Southwest Research Institute, USA
- Environment Protection Agency EPA, USA
- Ecole des Mines, France
- CERTAM, France
- Max Planck Institute, Germany
- GSF, Germany
- Beijing Environmental Protection Bureau, China
- Finnish meteorological institute, Finland
- Fraunhofer Institute
- CIEMAT, Spain
- National Taiwan University, Taiwan

Pharmaceutical
- Battelle Northwest, USA
- Astra Draco AB, Sweden
- University of Sydney, Australia
- Glaxo-Smith Kline
- Virginia Commonwealth University, USA
- Boehringer Ingelheim Pharma GmbH & Co. KG, Germany

Energy&Combustion
- Korea Institute of Energy
- Japan Atomic Energy Research Institute
- Power Reactor and Nuclear Fuel Development Corp.
- USAF Wright Patterson Air Force Base, USA
- Tsinghua University, China
- Corus Narrow Strip, UK
- ENEA, Italy

Other
- Japan Tobacco Inc.
- Philip Morris, USA
- Finnish Defence Forces TRC, FI
- TNO, Netherlands
- Tokyo Filter Co, JP
- VTT Chemical Technology, Finland
- Italcementi Group Spa, Italy
- US Army

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Thank you for your attention
- Questions?

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