CHINA NSFC – USA NSF Workshop on Sustainable Manufacturing

Multi Scale Sustainable Manufacturing: Approaches, Implementation and Application Perspectives
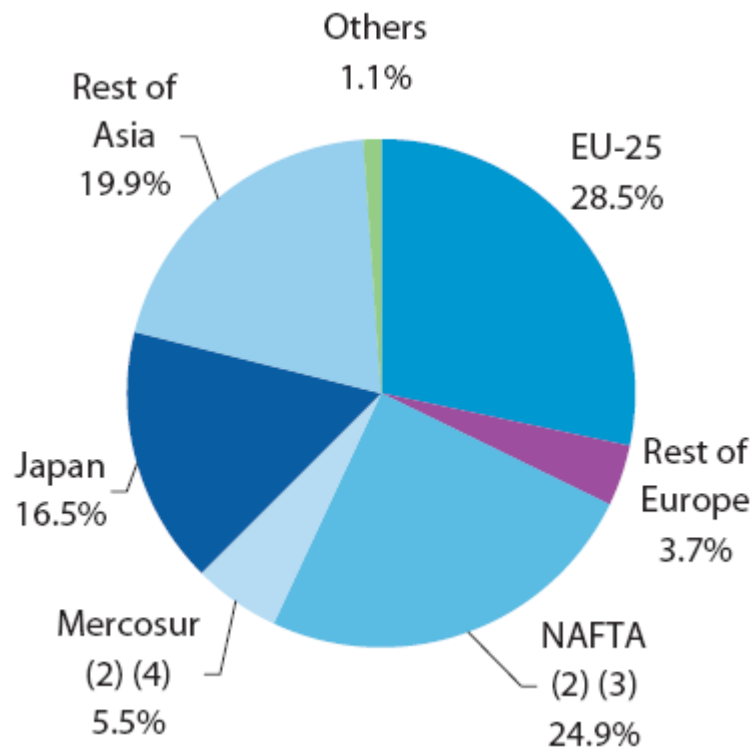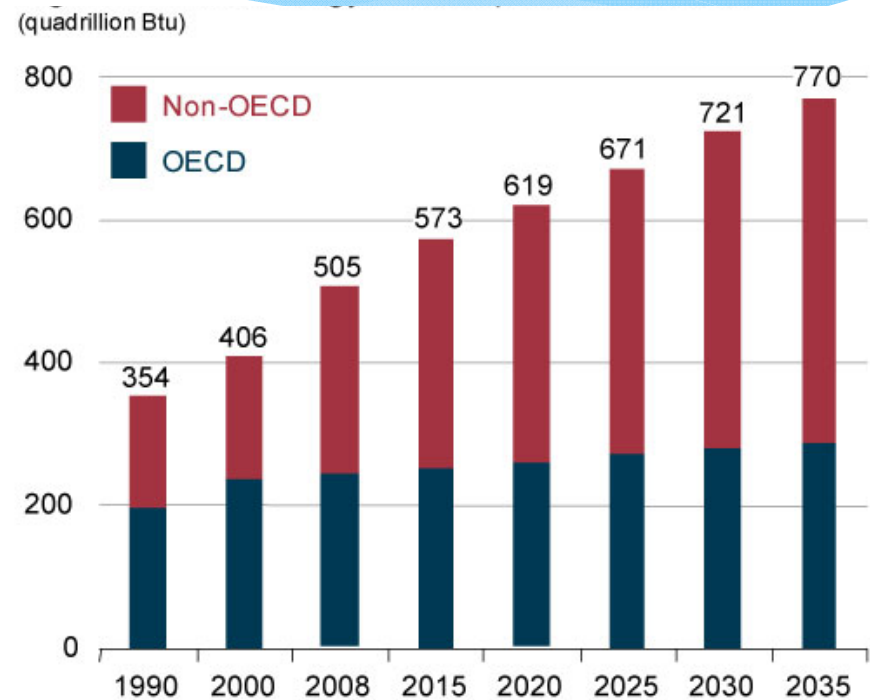
Professor Kai Cheng

Harbin Institute of Technology

Wuhan, China, 13-15 March 2014

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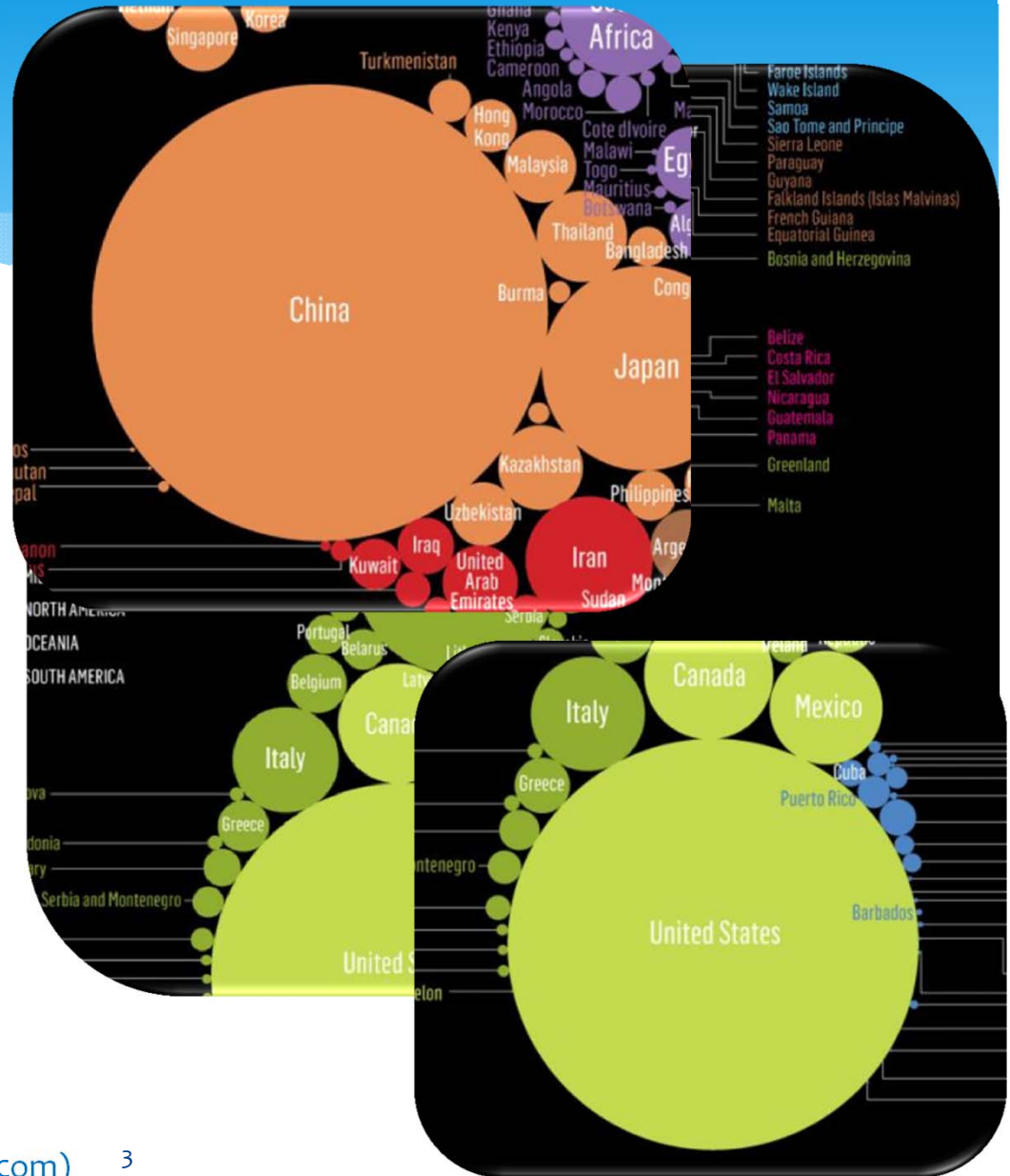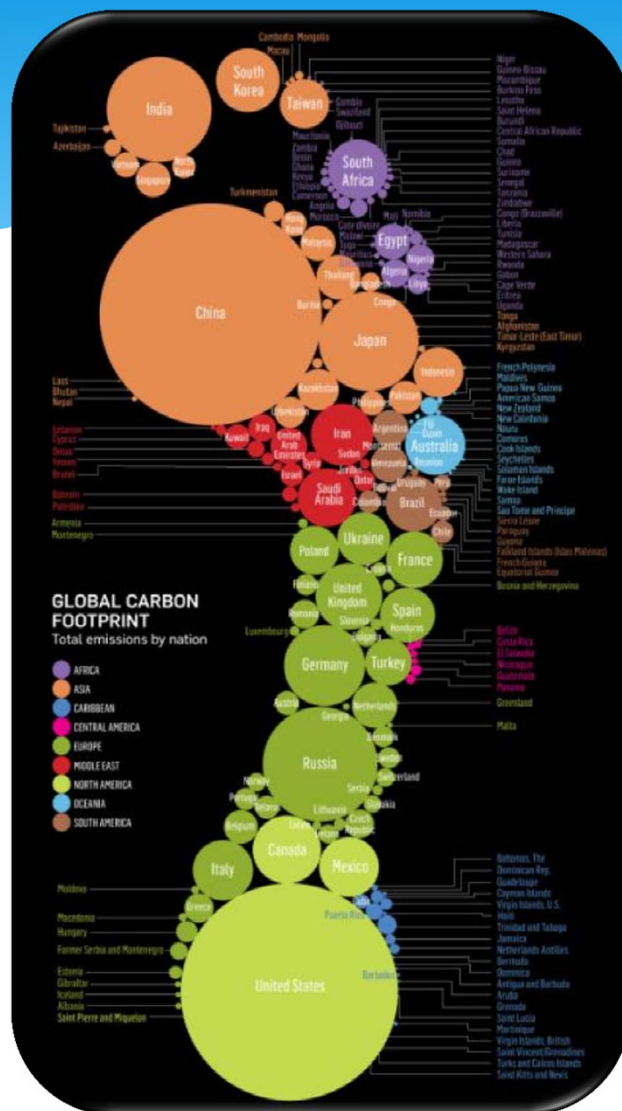# Typical Global Energy Consumption / Production Growth / CO2 Figures

Global Car Production

(Source: VDA, http://www.vda.de)

World Energy Consumption, 1990-2035

[2] (Source: IEA, http://www.eia.gov/forecasts/ieo/index.cfm)

Global Carbon Footprint

(Source: Pacific Standard, http://www.psmag.com)   3
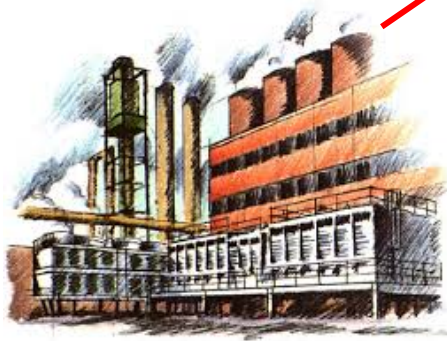
Manufacturing Supply Chains
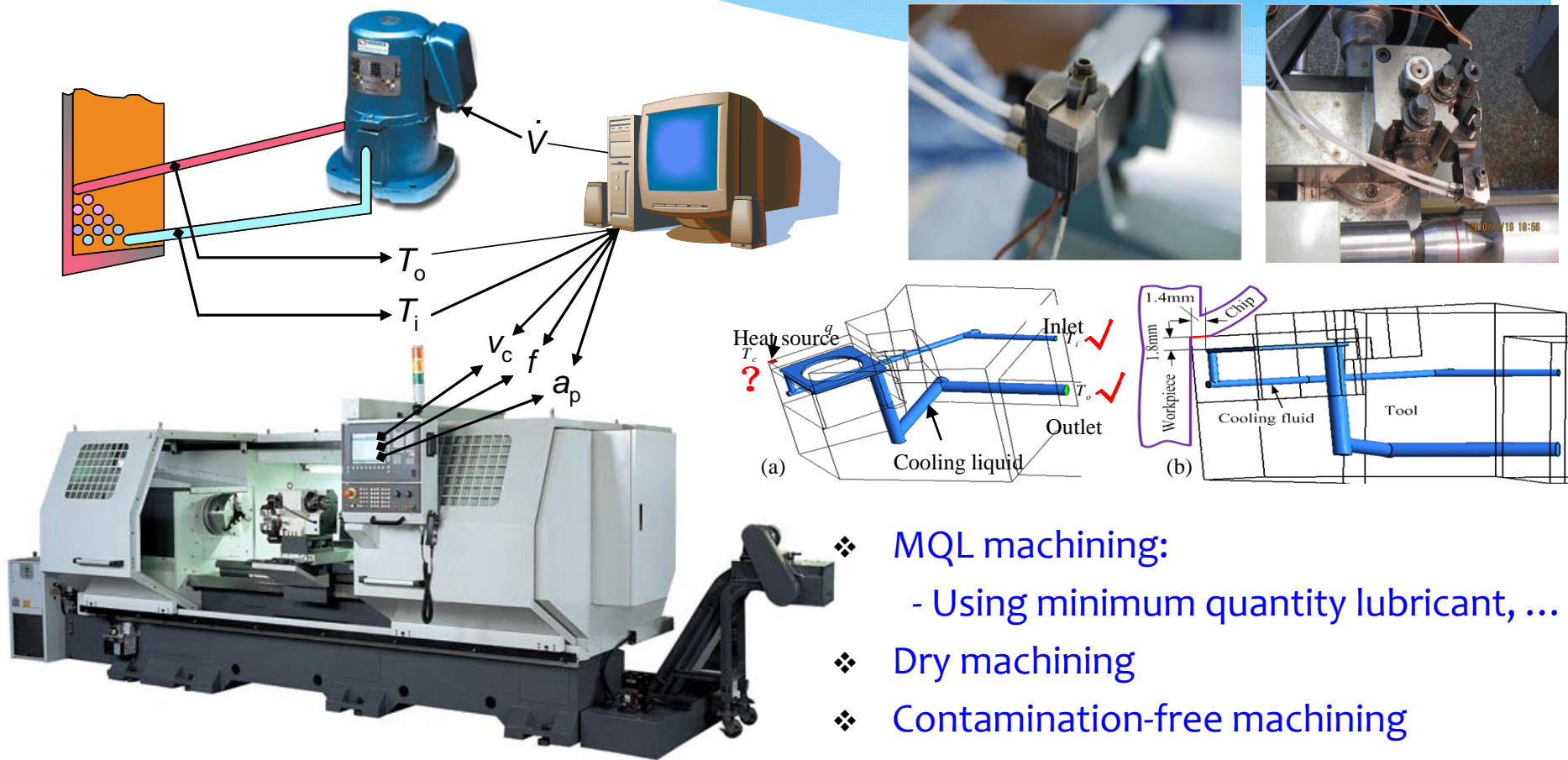
Factory

Workshop
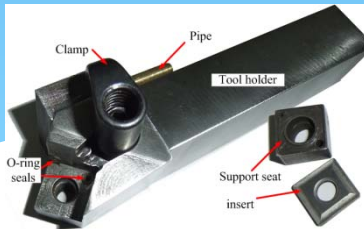
Machine

Tooling

- **Multiscale sustainable manufacturing**
- **Sustainable design index (SDI)**
- **Implementation and applications**
- **Approaches and generic issues: quantitative analysis, methods, ...**
- **......**

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(1) Smart cutting tool – internally cooled – plug-and-produce device

(a) Heat source T_c, Cooling liquid, Inlet T_i, Outlet T_o

(b) 1.4mm, 1.8mm, Chip, Workpiece, Cooling fluid, Tool

$\dot{V}$, T_o, T_i, v_c, f, a_p

❖ MQL machining:
   - Using minimum quantity lubricant, …

❖ Dry machining

❖ Contamination-free machining

❖ Energy/Resource efficient machining

(1) Smart cutting tool with wireless data transmission – plug-and-produce device
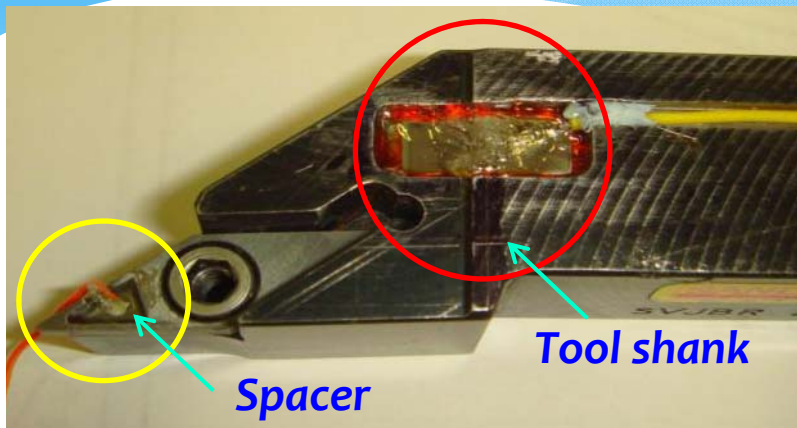
Spacer

Tool shank

- Piezoelectric ceramics – one is on spacer and the other on tool shank
- Wireless data transmission
- Battery required (hidden inside tool shank)
- Indirect force measurement method – Strain/force

Transmitter

Battery (hidden inside tool shank)
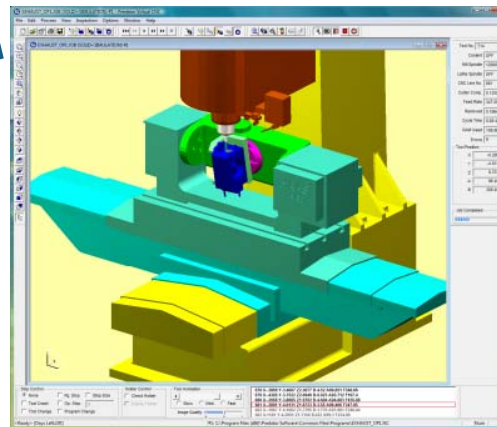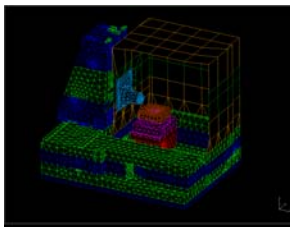

Receiver

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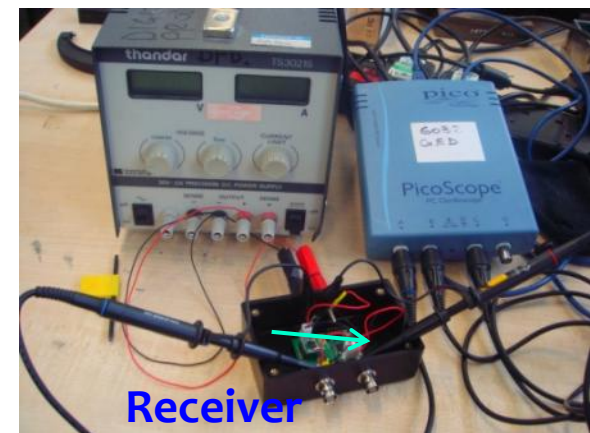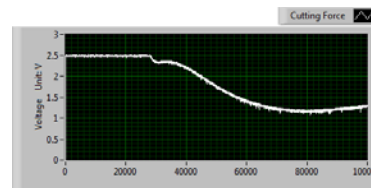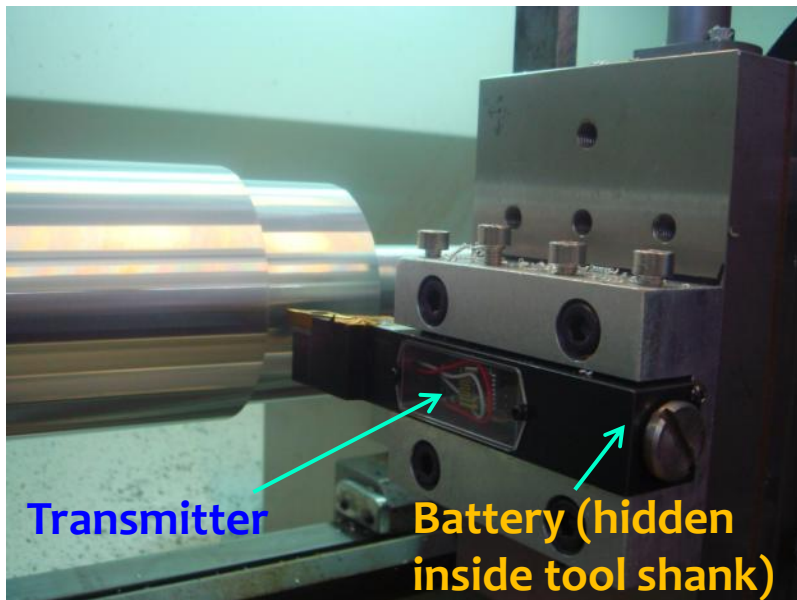
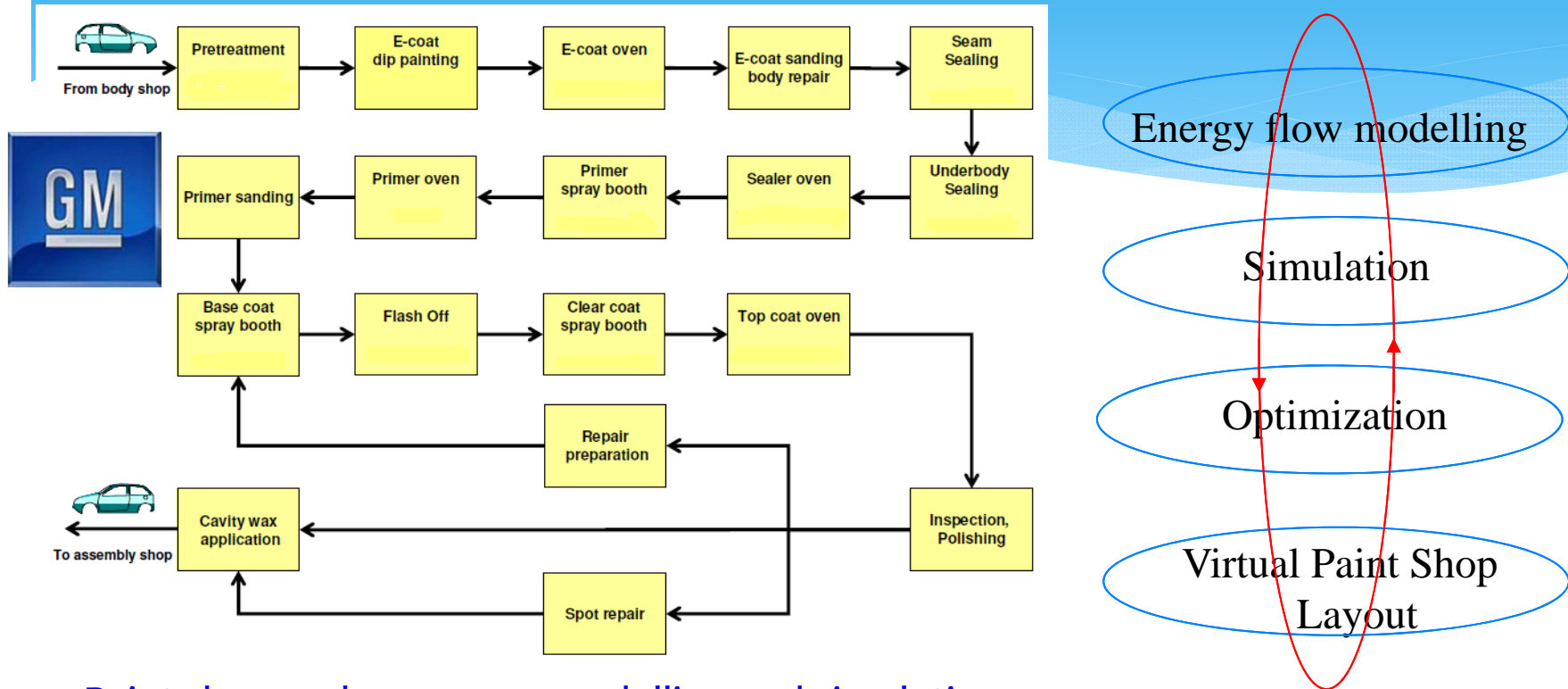# (2) Design and development of energy-smart CNC machine tools

- ERWC modelling and quantitative analysis

- ● Time
- ● Material removal rate
- ● Surface roughness
- ● Energy consumption
- ● Lubrication efficiency
- ● Carbon footprint
- ● ……

(3) Quantitative analysis on energy consumption and CO2 footprint at the automotive paints shop

- ❖ Paint shop and processes modelling and simulation

  (1) processes mapping using IDEF0 (2) developing simulations with Arena programming

- ❖ Simulation-based analysis and optimization of the 'virtual paint shop' against GM production requirements

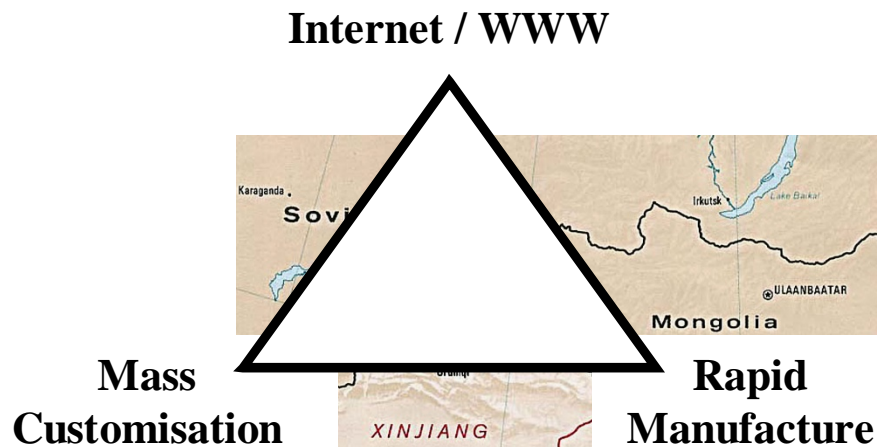# (4) Development of the energy management system for an automotive factory

HVAC

Energy management system

Weather Data

- **Workflow**
- **Quality assurance/data**
- **Energy flow**
- **Underlying correlations**
- **......**

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(5) Point-of-Use (POU) manufacturing systems with application to 'food' manufacturing

POU Manufacturing Systems

Internet / WWW

Mass Customisation

Rapid Manufacture

* Outsourcing
* Outlet setup
* Factory 'box'
* New opportunities, ...

Unilever

Scientific and Technological Challenges

<u>Scientific challenges:</u>

- Quantitative analysis, ERMC modelling, …
- Multiscale, multi-dimension, complex nature, …

- ……

<u>Technological challenges:</u>

- 'Standards', …
- Sustainable design index (SDI), …

- ……

<u>Industrial significance:</u>

- Competitiveness resulted from sustainable manufacturing, …
- Sustainable manufacturing is a 'technology' and beyond, …

Thank you for listening.

Any questions?