5th International Workshop - Advances in Cleaner Production
São Paulo - Brazil - 20th to 22nd, May - 2015

Early Stage Investment and Cost Calculation Methodologies for NO_x Reduction Measures in Large Combustion Plants

MAYER, C., MUELLER, A.-K., FROEHLING, M., SCHULTMANN, F.
Karlsruhe Institute of Technology
GERMANY

Karlsruher Institut für Technologie

iip
Institute for Industrial Production

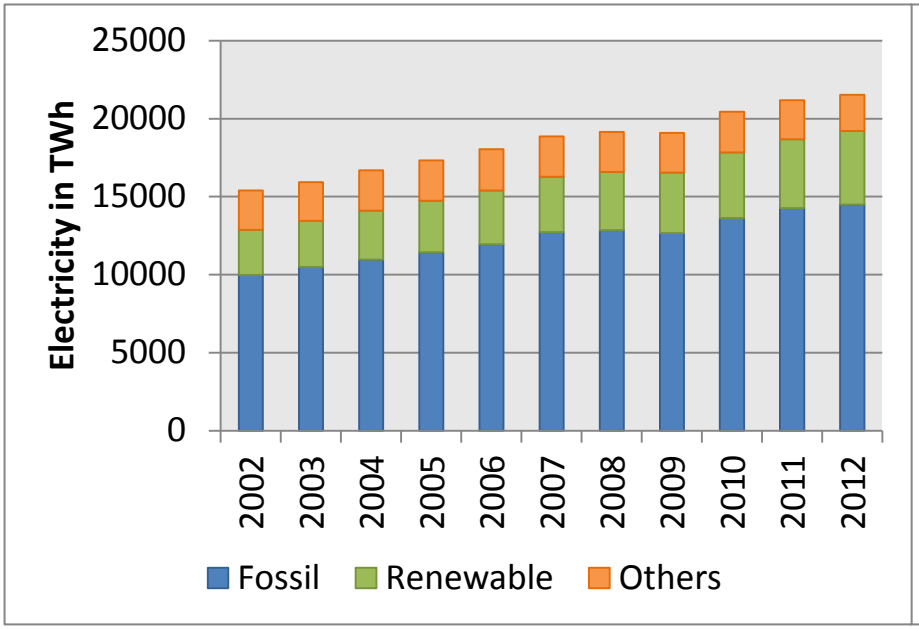
Academic Work

Agenda

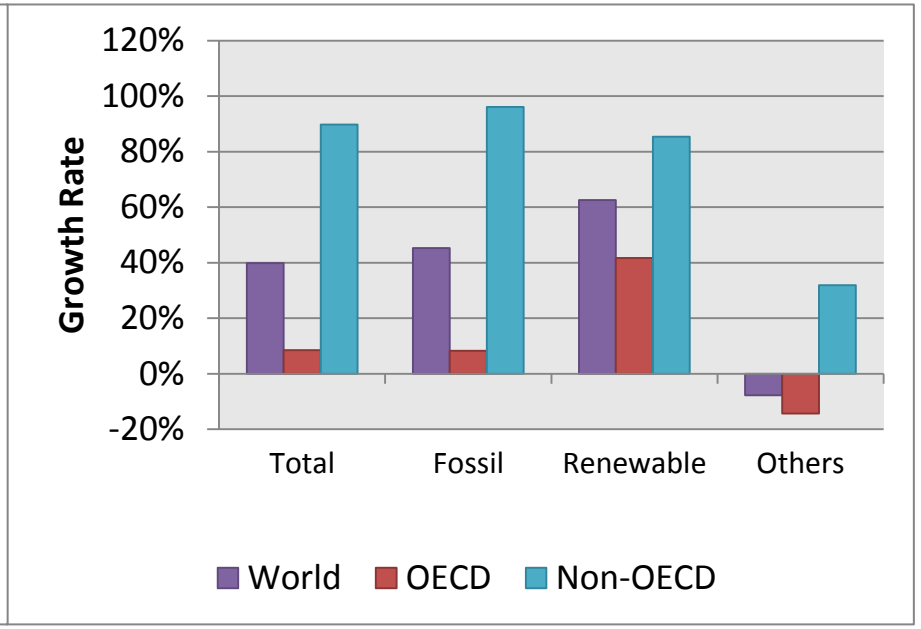
- Introduction and Background
- Investment and Cost Calculation
- Existing Methodologies
- Application
- Results
- Conclusion and Outlook

Karlsruher Institut für Technologie

Worldwide Electricity Generation



Worldwide annual electricity net generation (divided by fuel, 2002-2012)



Ten years percentual growth rates of the worldwide electricity net generation (divided by fuel and region, 2002-2012)

Reference: *US EIA, International Energy Statistics, 2015*

Introduction and Scope

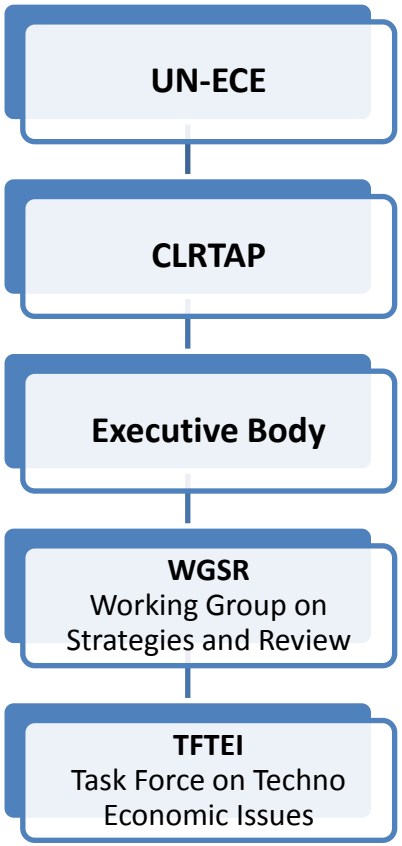
- The worldwide electricity demand is rising, fossil fuels are still playing an important role
- Especially in the Non-OECD Countries, the electricity generation from fossil fuels is growing massively, often without any emission reduction measures

⇒ These countries have a huge abatement potential and policies need to be supported with cost and investment estimation tools/methods

Scope of this presentation:

- Presenting and comparing two specific methodologies:
  - US EPA cost calculation manual
  - TFTEI investment and cost calculation tool
- Showing advantages and disadvantages of the existing methods
- Ideas for further improvements

The Work of TFTEI under the CLRTAP



Scope (in this context):

- Cost and investment calculation methodologies
- Secondary NO_x emission reduction measures (SCR, SNCR)
- Fossil fuels (coal, oil, gas)
- Large combustion plants (LCP > $50MW_{th}$)

Organizational background of the work:

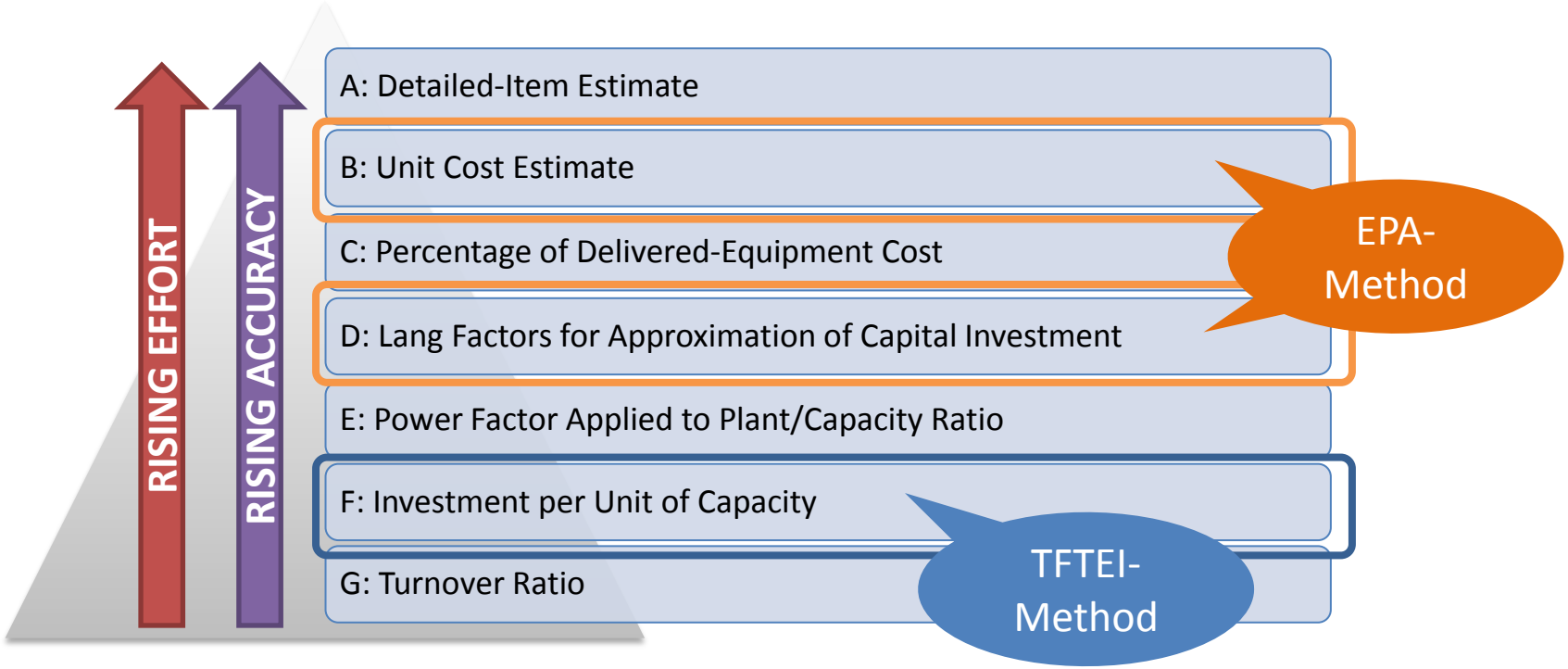
- TFTEI (former EGTEI) Technical Secretariat
- Financed by France and Italy

CITEPA

Karlsruher Institut für Technologie

Karlsruher Institut für Technologie

Investment and Cost Calculation



Reference:
Peters et al.: Plant Design and Economics for Chemical Engineers, 2003

Karlsruher Institut für Technologie

Investment and Cost Calculation

$$K^{ERM} = K_I^{ERM} + K_{ME}^{ERM} + K_{Process}^{ERM} + K_{Other}^{ERM} \quad [MU/a]$$

Investment related costs | **Operating costs**

K^{ERM} : Annual total costs for the evaluated emission reduction measure (ERM)

K_I^{ERM} : Costs related to investments

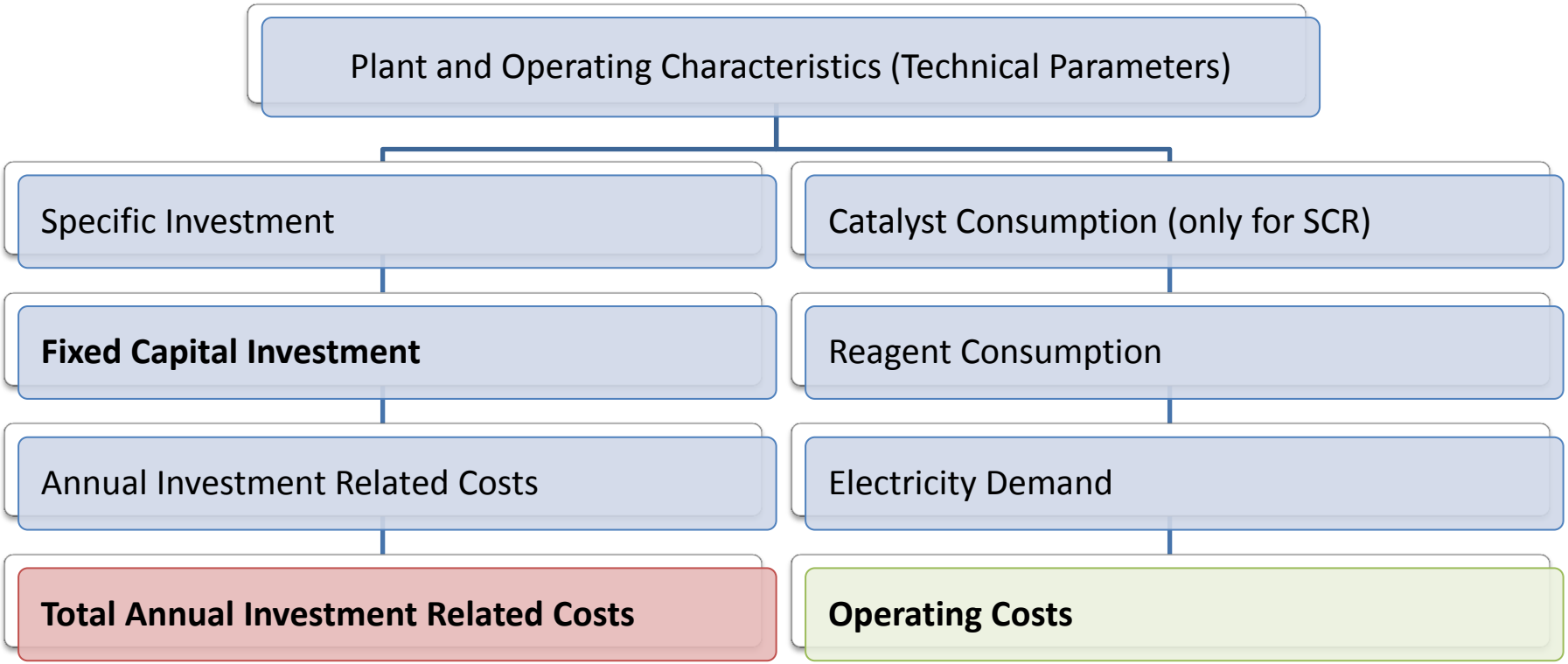
K_{ME}^{ERM} : Costs for inputs and outputs induced by material and/or energy flows

$K_{Process}^{ERM}$: Process costs for relevant unit operations

K_{Other}^{ERM} : Other decision relevant costs

References:
Rentz: Techno-Economy of Industrial Emission Reducion Measures, 1979
Schultmann, et al.: A Methodological Approach for the Economic Assessment of Best Available Techniques. 2001
Spengler: Industrial materials flow management. 1998
VDI Guideline 3800: Determination of the cost of emission control activities, 1979

Existing Methodologies I – TFTEI



Reference:
TFTEI: Estimation of Costs of Reduction Techniques for LCP – Methodology, 2015

Karlsruher Institut für Technologie

The TFTEI Excel-Tool

	NO_x	SO_2	Dust
Natural Gas	Natural Gas - NOx incl. Primary Measures SCR SNCR		
Liquid Fuels	Liquid - NOx incl. Primary Measures SCR SNCR	Liquid - SO2 incl. Fuel Substitution LSFO Flue Gas Desulfurization LSD Flue Gas Desulfurization DSI Flue Gas Desulfurization with Fabric Filter	Liquid - Dust incl. ESP
Solid Fuels (coal and bio-mass)	Solid - NOx incl. Primary Measures SCR SNCR	Solid - SO2 incl. Fuel Substitution LSFO Flue Gas Desulfurization LSD Flue Gas Desulfurization DSI Flue Gas Desulfurization with Fabric Filter	Solid - Dust incl. ESP PJFF

Screenshot of the front page of the TFTEI cost calculation tool

to be published on the new TFTEI website in June 2015

Existing Methodologies II – US EPA

- Plant and Operating Characteristics
- Catalyst Volume*
- Reactor Dimensions*
- Reagent Consumption and Tank Size
- Power Consumption
- Catalyst Replacement*
- Calculation of Total Investment and Operating Costs

*SCR only

Reference:
US EPA: Air Pollution Control Cost Manual, 2002

Application

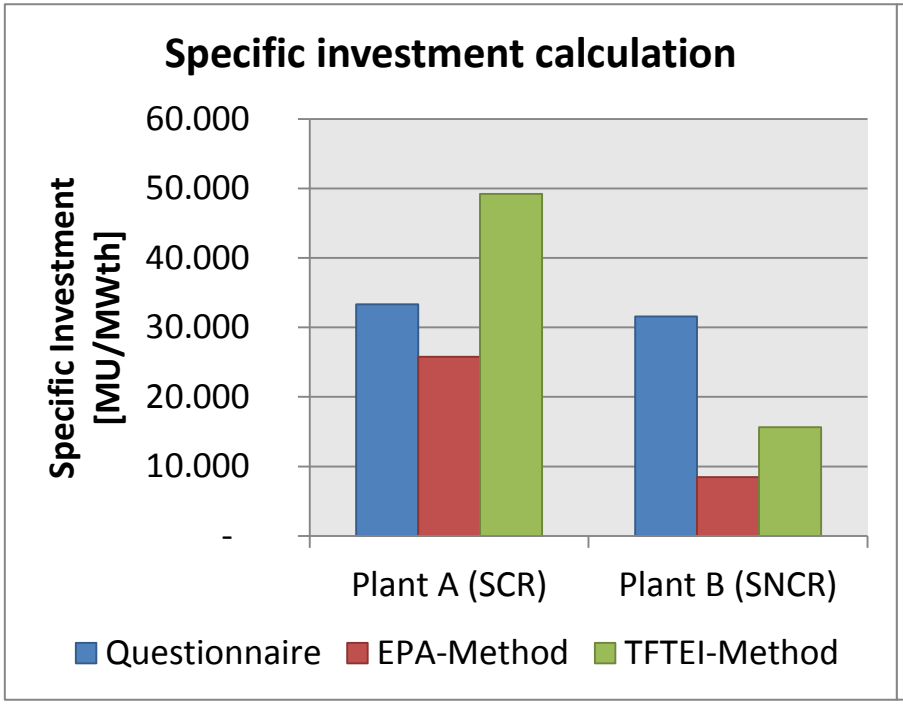
To compare the two methodologies, a case study has been conducted with two exemplary plants:

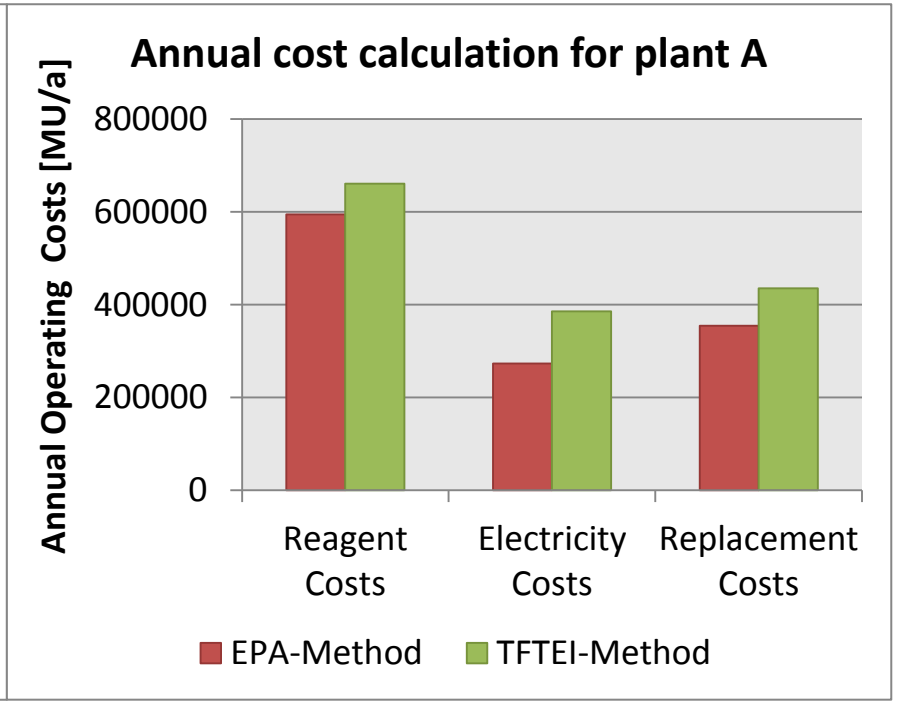
Plant A	Plant B
Coal fired	Coal fired
1500 MW_{th}	620 MW_{th}
Equipped with SCR	Equipped with SNCR

The technical and economic data for both plants has been collected in a survey executed by EGTEI in 2012.

Karlsruher Institut für Technologie

Quantitative Results





⇒ Big deviations between the methods, but within a rather steady proportion
⇒ Updating of cost factors necessary/recommendable to calibrate the EPA method
⇒ Small data base

Qualitative Results

	EPA	TFTEI
Advantages	Lower dependence on single parameters	Literature based reference data
	No experience with existing plants necessary (no assumption of specific investments)	Higher transparency (no empirically determined factors), less complex calculations
	More precise technical process reproduction in the economical equations	Higher flexibility through specific investment adaptation
	Documentation and calculation example available	Less input parameters necessary
Disadvantages	Many technical parameters necessary	Strong dependence on specific investments
	No individual influence parameter (e.g. specific investment) that takes the complexity/ circumstances of the system into account	Neglect of technical configuration (e.g. water consumption, tank size, size of the reactor, etc.)
	Few information on origin of cost factors	Less detailed consideration of economic factors (contingencies, engineering, etc.)

Conclusion and Outlook

- No „good or bad“ decision possible
- Improvement of database necessary to calibrate the EPA method
- Offering both methods or a combination might be reasonable (taking the availability of data into account)

Further aspects of interest:

⇒ Analysing the data quality and the impact of possible uncertainties/ inaccuracies

⇒ Developing an optimization model to define ideal investment strategies

⇒ Investigating dynamic aspects (what is the best time for an investment)

References

- Peters, M., Timmerhaus, K., West, R., 2003. Plant Design and Economics for Chemical Engineers. 5. McGraw-Hill Education, New York.
- Rentz, O., 1979. Techno-Economy of Industrial Emission Reducion Measures. Techno-Ökonomie betrieblicher Emissionsminderungsmassnahmen (in German), Erich Schmidt Verlag, Berlin.
- Schultmann, F., Jochum, R., Rentz, O., 2001. A Methodological Approach for the Economic Assessment of Best Available Techniques. The International Journal of Life Cycle Assessment. Volume 6, Issue 1, 19-27.
- Spengler, T., 1998. Industrial materials flow management - economic planning and control of materials and energy flows in manufacturing plants. Industrielles Stoffstrommanagement - Betriebswirtschaftliche Planung und Steuerung von Stoff- und Energieströmen in Produktionsunternehmen (in German). Erich Schmidt Verlag, Berlin.
- TFTEI, 2015. Estimation of Costs of Reduction Techniques for LCP – Methodology. TFTEI technical secretariat.
- US EIA, 2015. International Energy Statistics, United States Energy Information Administration. http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=2&aid=12&cid=regions&syid=2002&eyid=2012&unit=BKWH, last accessed February 2015.
- US EPA, 2002. Air Pollution Control Cost Manual. 6. EPA/452/B-02-001, United States Environmental Protection Agency.
- VDI Richtline 3800, 1979. Determination of the cost of emission control activities. Kostenermittlung für Anlagen und Maßnahmen zur Emissionsminderung (in German). VDI-Handbuch Reinhaltung der Luft 6, Düsseldorf.

Thank you very much for your attention!

MAYER, C., MUELLER, A.-K., FROEHLING, M., SCHULTMANN, F.
Karlsruhe Institute of Technology

carmen.mayer@kit.edu
http://www.iip.kit.edu/

Karlsruher Institut für Technologie

iip
Institute for Industrial Production