Chair of Energy Systems and Energy Economics
Prof. Dr.-Ing. H.-J. Wagner

Leopoldina
Nationale Akademie der Wissenschaften

Sustainability of Renewable Energies

Hermann-Josef Wagner

Institute for Energy Systems and Energy Economy
Ruhr-University Bochum, Germany

lee@lee.rub.de

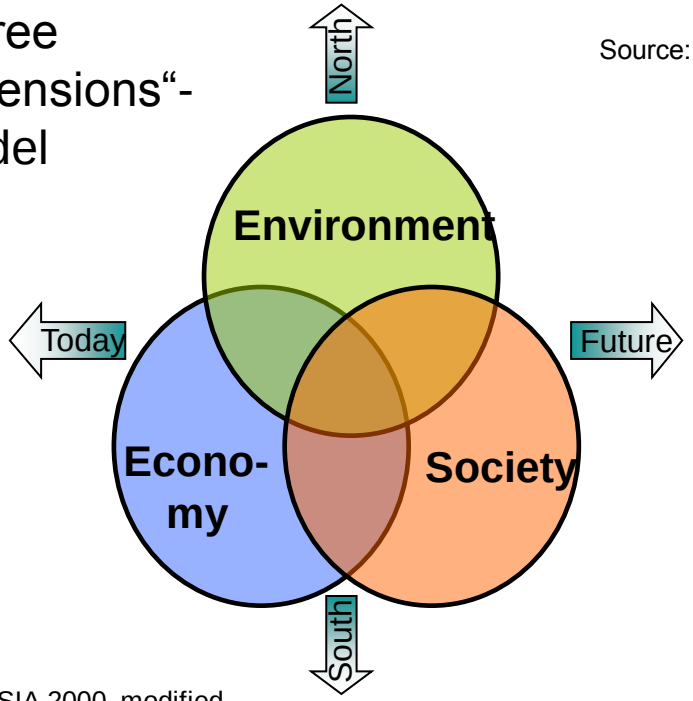
ASADI Conference :
Improving Acess to Energy in Sub-Saharan Africa
Cape Town, 9.-10. November 2010

Structure of my presentation

- **About sustainability**
- Status of renewable energy use
- Sustainability evaluation
- Conclusions and message

Sustainability approach and models

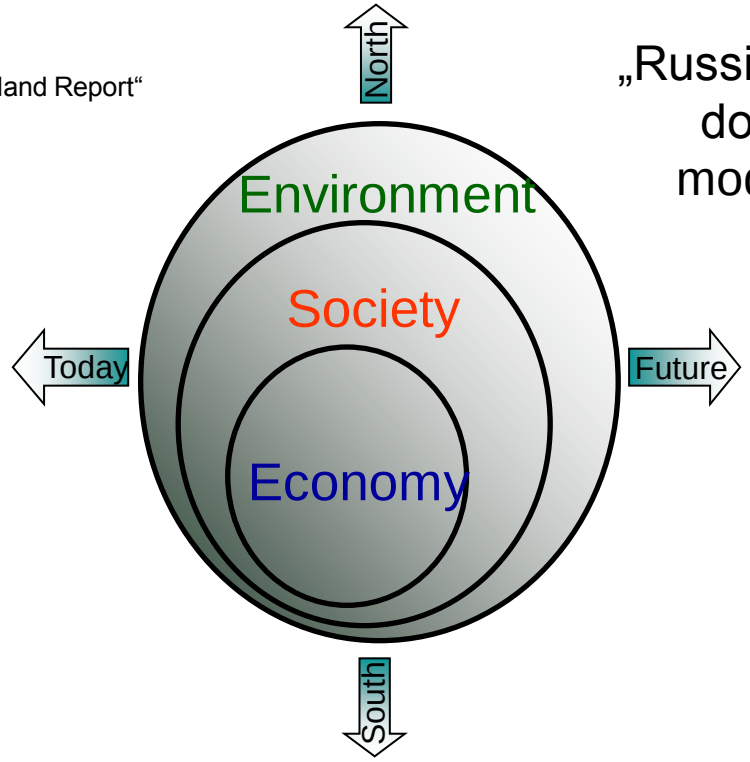
„Three dimensions“-model



source: SIA 2000, modified

Source: UN 1987 „Brundtland Report“

„Russian doll“-model

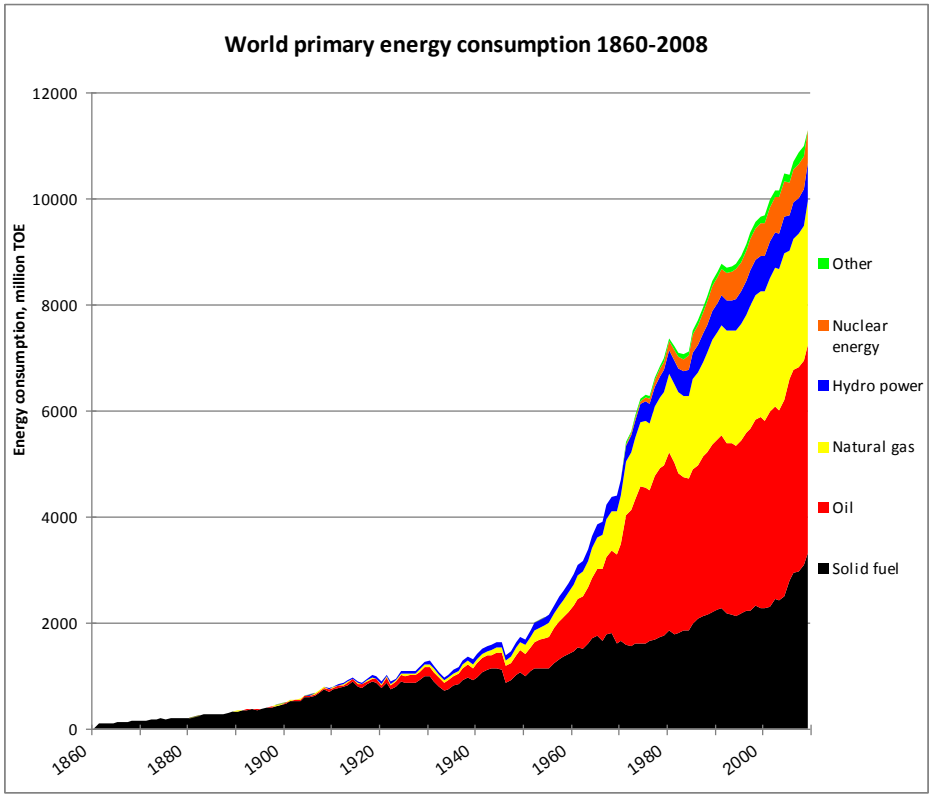


source: Levett 1999, modified

Structure of my presentation

- About sustainability
- **Status of renewable energy use**
- Sustainability evaluation
- Conclusions and message

The world is hungry on energy



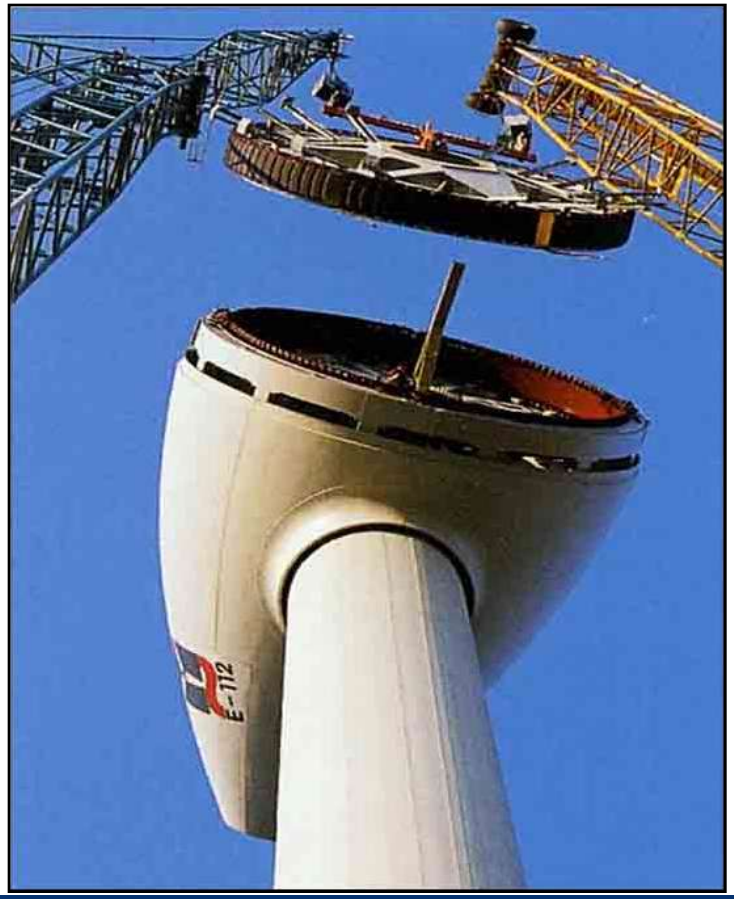
World primary energy consumption 2008:
~ 11 million TOE

Contribution of selected countries and country groups to the world primary energy consumption

USA	20 %
EU – 27	15 %
– Germany	3 %
China	18 %
Japan	4 %
African Countries	3 %

Source: various statistics, recent years: BP-Statistics

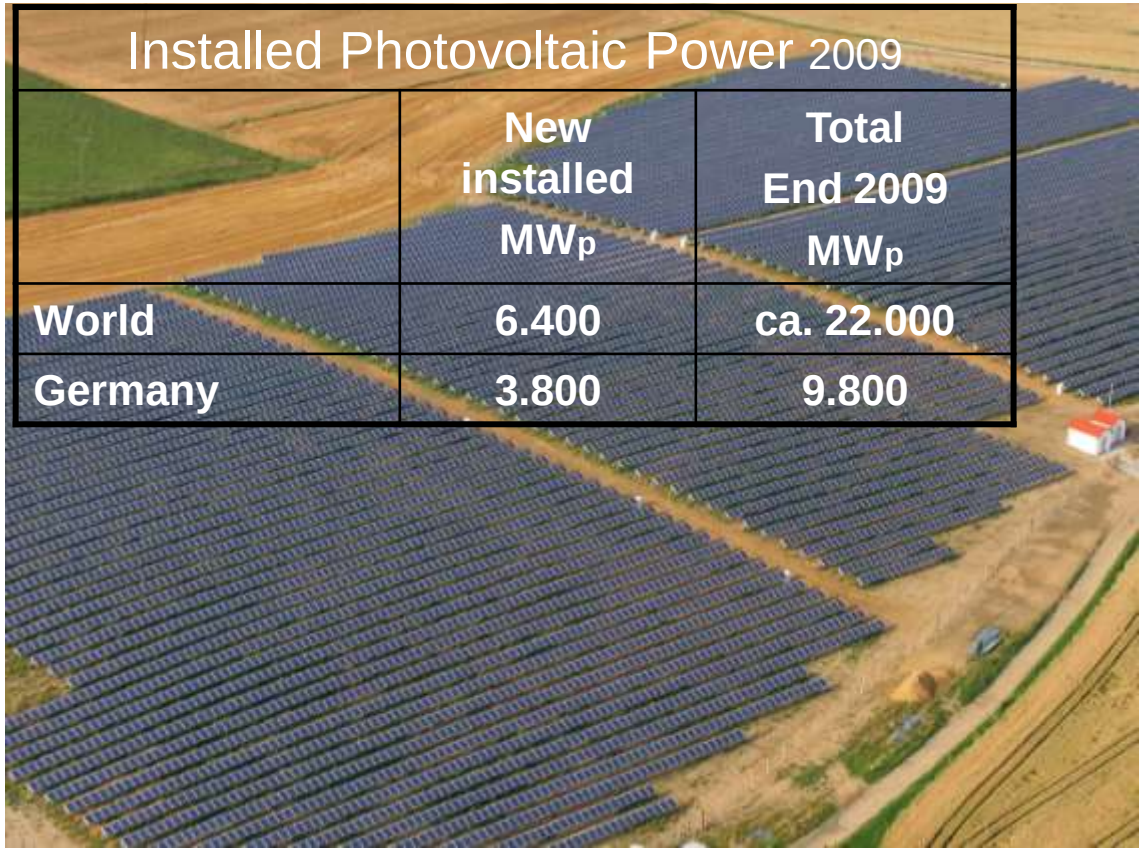
Electricity from wind energy



Status of installed wind power		
	Rated Capacity 1.1.2010 [MW]	Share worldwide [%]
USA	35,200	22
Germany	25,800	16
China	25,100	16
Spain	19,100	12
India	10,900	7
Italy	4,900	3
France	4,500	3
UK	4,000	3
Portugal	3,500	2
Denmark	3,500	2
Remaining countries	21,400	14
Total	**157,900**	**100**

Source: Global Wind Energy Council www.gwec.net

Photovoltaics – expensive but increasing



Installed Photovoltaic Power 2009

	New installed MW_p	Total End 2009 MW_p
World	6.400	ca. 22.000
Germany	3.800	9.800

At the beginning: Solarthermal power electricity generation

Parabol concentrator solar power station in Spain (Andasol 1, 5 MW)

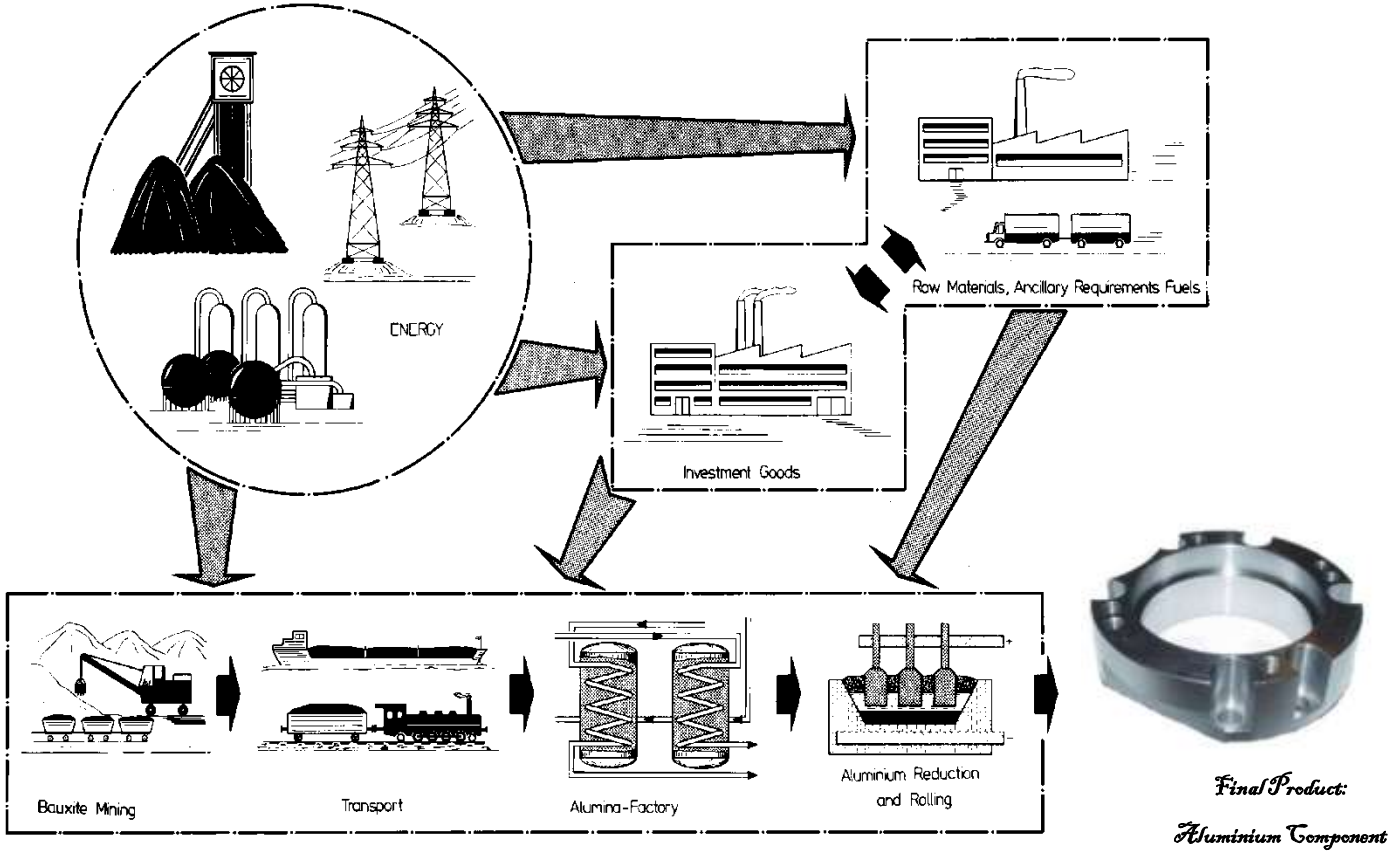
Solarthermal power station in California – a vision for Africa

Source: Schlaich Bergermann und Partner

Structure of my presentation

- About sustainability
- Status of renewable energy use
- **Sustainability evaluation**
- Conclusions and message

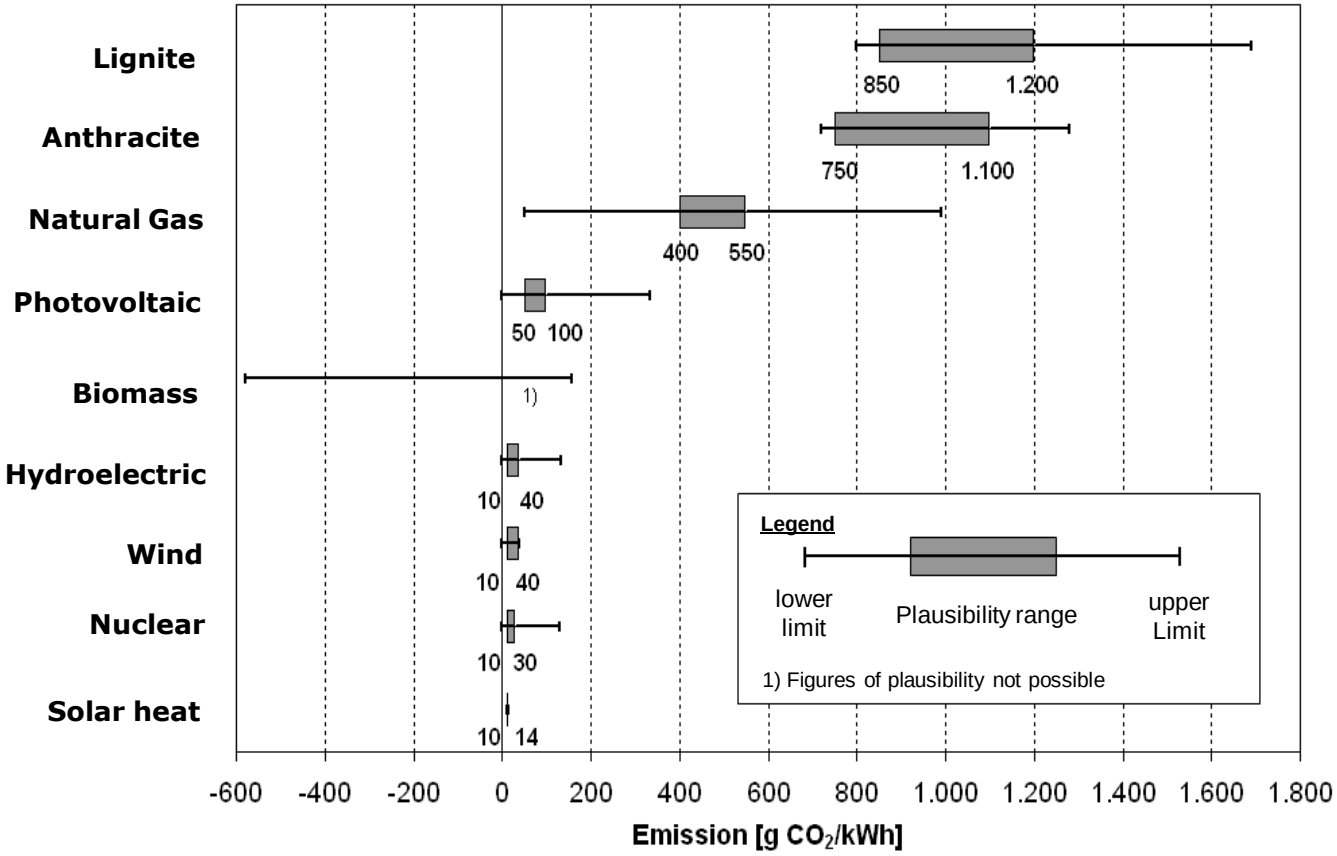
Life cycle assessment: production-use-recycling



Choice of indicators

Energy security related risks	➢ Covering supply, technical and economical related risks ➢ Aggregation via measure for concentration tendencies
Cumulated Energy Demand	➢ According to VDI guideline 4600: totality of energetic expenditures ➢ Distinction of sustainable / non-sustainable energy expenditures
Energy Costs	➢ Calculation with annuity method according to VDI guideline 2067 ➢ A 5% discount rate was used.
Gross Employment Effects	➢ Induced by installation of 1.000 MW capacity of a specific technology ➢ Comparison of two scenarios: „business as usual“ vs. „installation“
Usage of Air Resources	➢ Critical air volume that is necessary to attenuate emissions accurate to limits that are defined and regulated by law
Usage of Water Resources	➢ Critical water volume that is necessary to attenuate water based pollutants accurate to limits that are defined and regulated by law
Land Use	➢ Direct land use by energy system and infrastructure ➢ Indirect land use due to visual disturbance of the environment (= buffer area trading off the visual impact)

CO_2- emission of electricity generation in consideration of the whole chain - Comparison of different studies

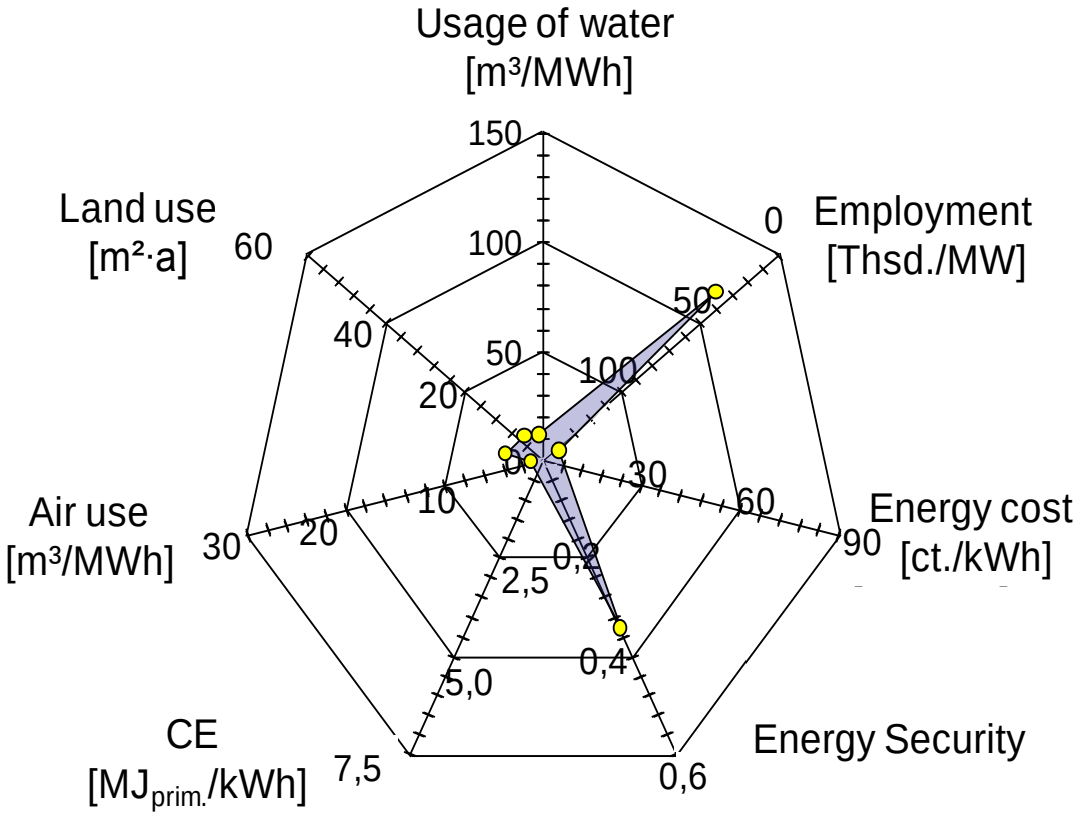


Description of reference systems

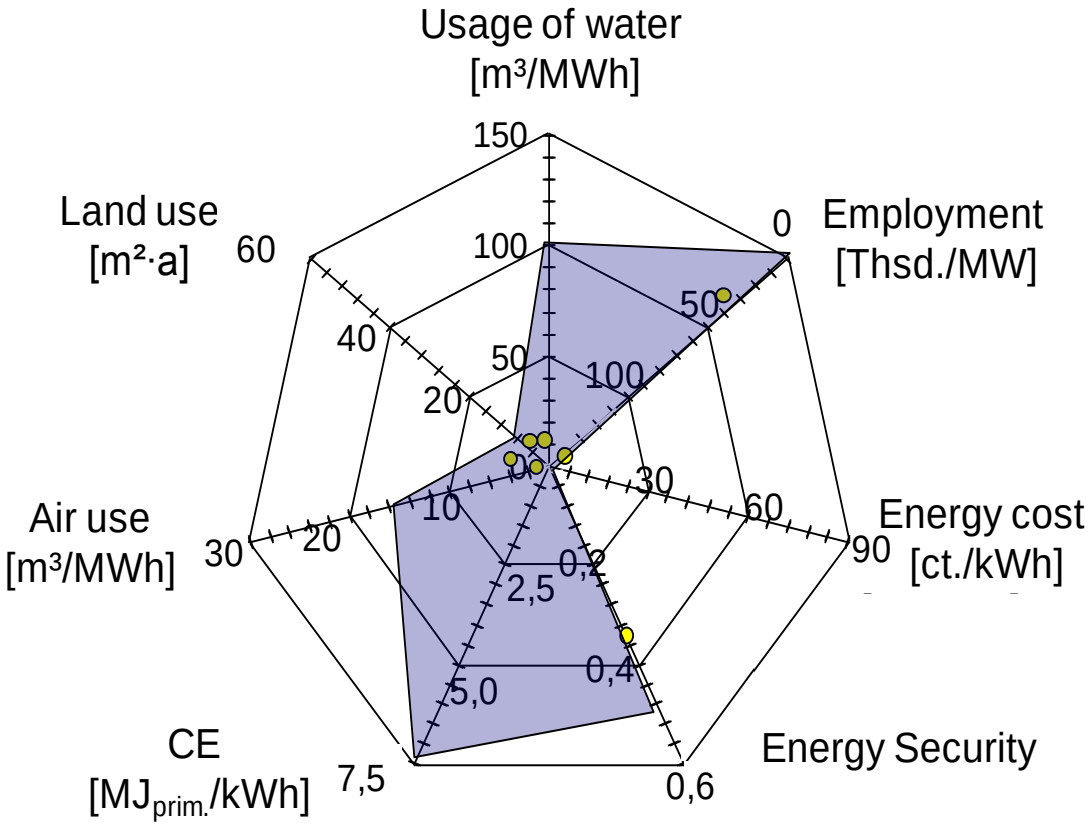
Reference System Specification	Wind	GCC plant NG fired
Installed capacity [MW]	1.5	353.0
Expected lifetime: System (IS*) [a]	20 / (40)	30 / (40)
System efficiency [%]	53.6	58.0
Solar irradiation [W/m^2]	-	-
Wind speed [m/s]	6.5	-
Capacity factor [%]	25.1	79.9
Investment costs (IVC) [€/kW]	1,250	1,330
Operational costs p. a. [% of IVC]	6.0	3.3

*IS: Infrastructure

Sustainability evaluation of a 1,5 MW onshore wind converter (Wind-1) without backup power station



Sustainability evaluation of a 350 MW GCC power station



Structure of my presentation

- About sustainability
- Status of renewable energy use
- Sustainability evaluation
- **Conclusions and message**

Conclusions and message

- The world is not on a sustainable way
- Renewables contribute to a sustainable development
- Renewables are material intensive → ecobalances inform about sustainability
- Africa needs energy
- Africa has a hight renewable potential - and free areas (deserts)
- Lets make a barter - solar technology versus sun electricity and less emissions
- Scientific cooperation must smooth actions in policy

Chair of Energy Systems
and Energy Economics
Prof. Dr.-Ing. H.-J. Wagner

Leopoldina
Nationale Akademie
der Wissenschaften

Thank you for your attention

www.lee.rub.de