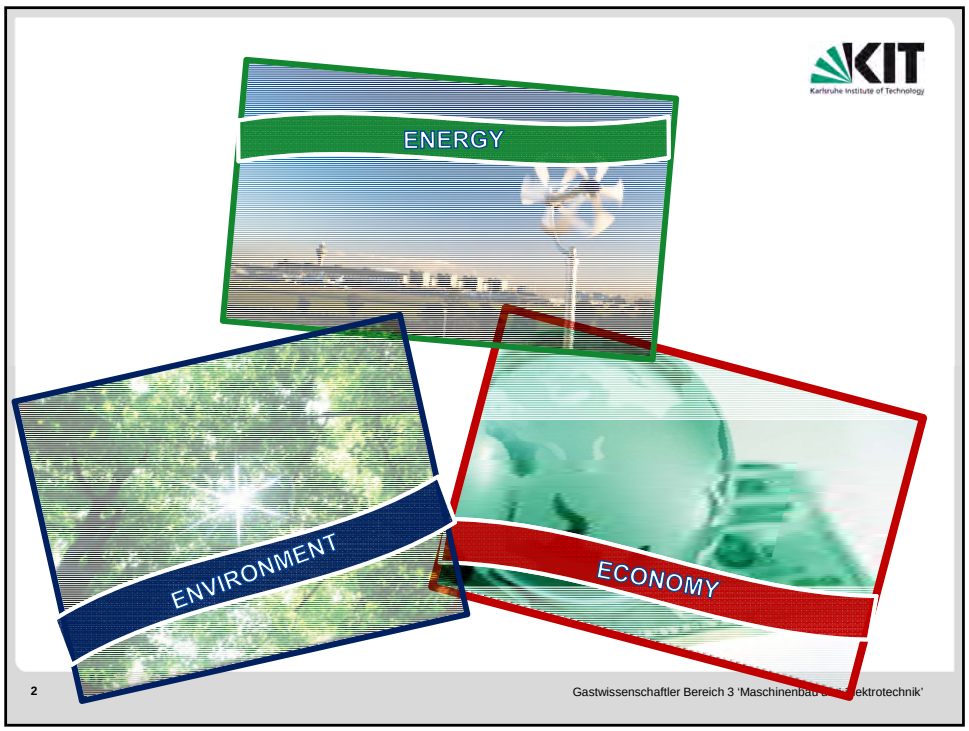
Karlsruhe Institute of Technology

Affordable Energy for Humanity

ITEP-Kolloquium
December 02, 2014, 9:00
KIT, Campus Nord, Bau 419, Raum 104 (Seminarraum)

Prof. Dr. Jathin Nathwani, Gastwissenschaftler, Bereich 3
Professor and Ontario Research Chair Sustainable Energy, Executive Director, Waterloo Institute for Sustainable Energy, University of Waterloo

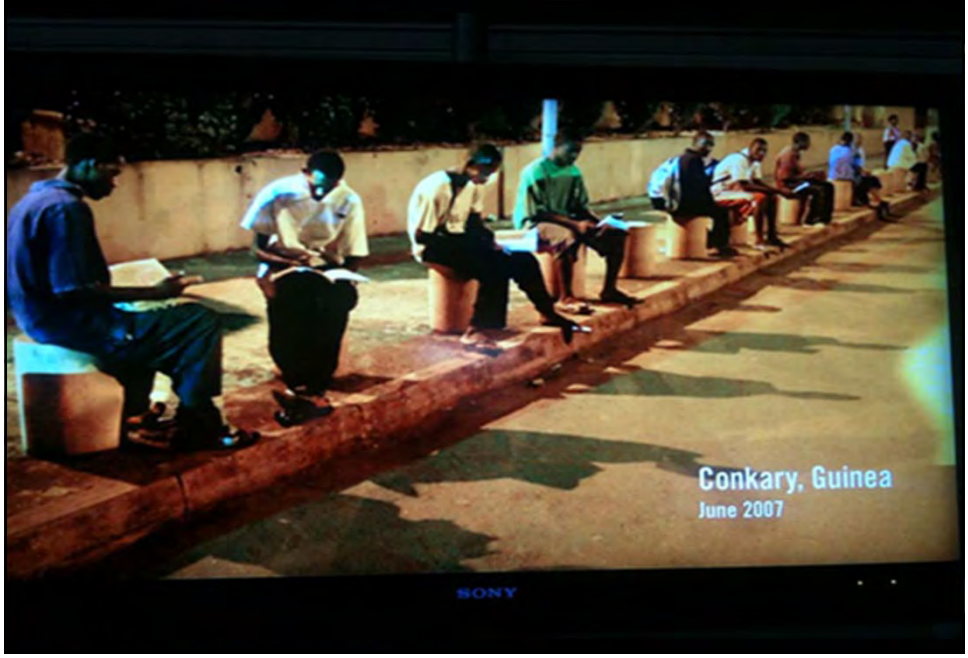


Key Themes

- **Energy and Climate**
- **Energy Ecosystem**
- **Affordable Energy for All (AE4A)**
- Intergenerational Burdens
- Technology Pathways for Resilience
- Dispersed Power

World at Night

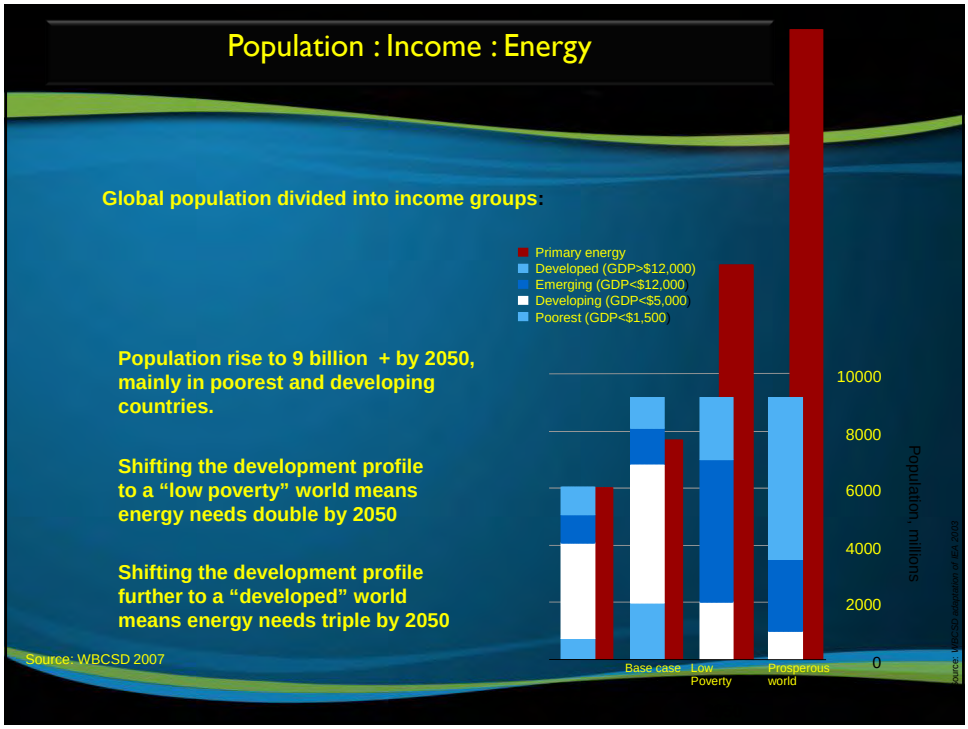
Homework Under Streetlight

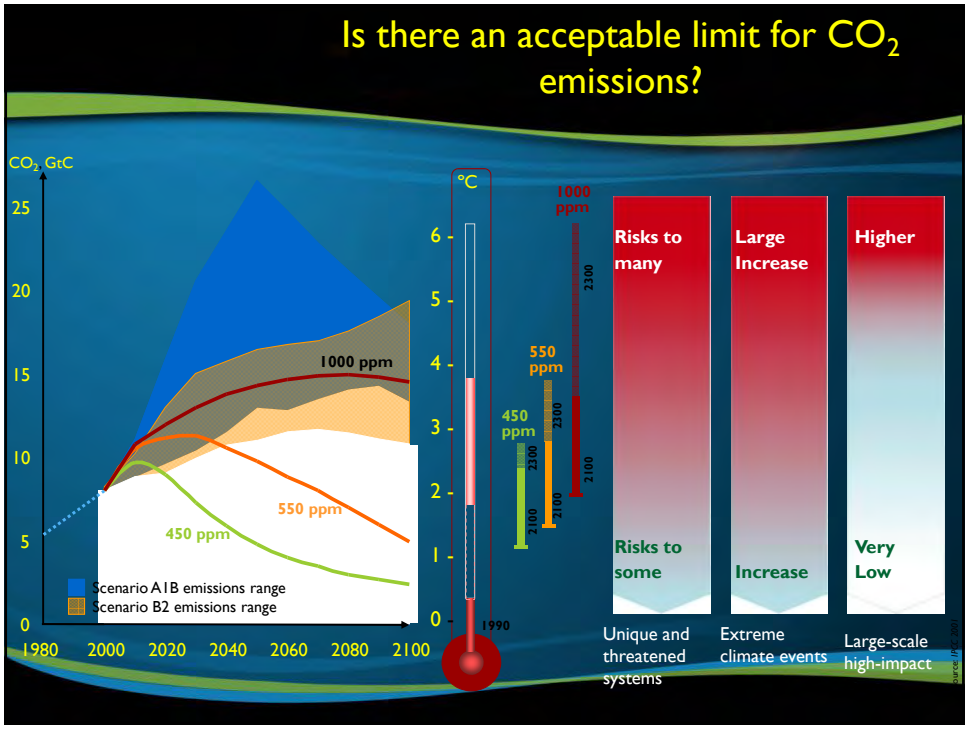


Global Energy Challenge

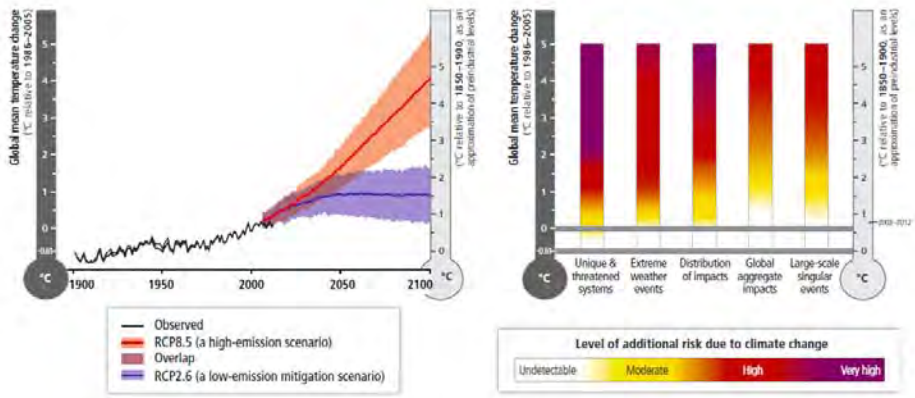
85/15

All new growth to be met by non-carbon sources


Population : Income : Energy
Global population divided into income groups:
Primary energy
Developed (GDP>$12,000)
Emerging (GDP<$12,000)
Developing (GDP<$5,000)
Poorest (GDP<$1,500
Population rise to 9 billion + by 2050, mainly in poorest and developing countries.
Shifting the development profile to a "low poverty" world means energy needs double by 2050
Shifting the development profile further to a "developed" world means energy needs triple by 2050
Source: WBCSD 2007
10000
8000
6000
4000
2000
0
Population, millions
Base case
Low Poverty
Prosperous world

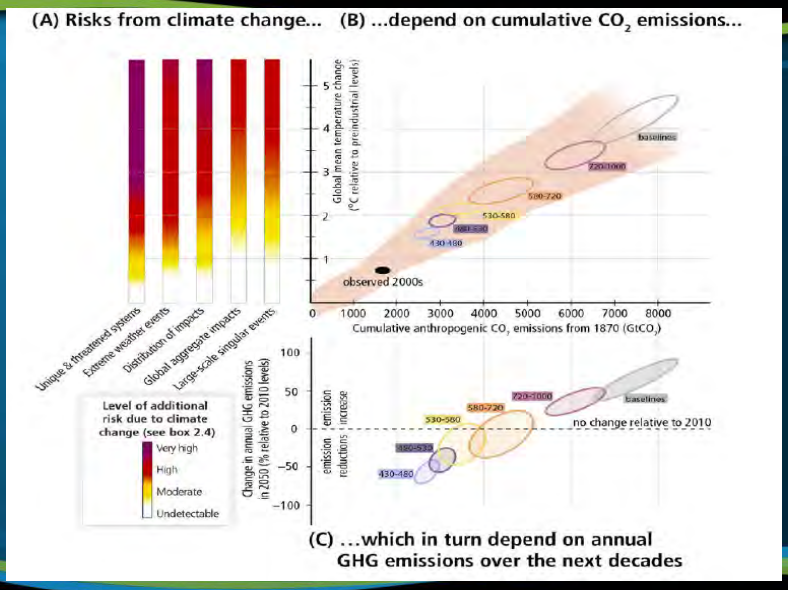

Is there an acceptable limit for CO_2 emissions?
CO_2, GtC
25
20
15
10
5
0
1980
2000
2020
2040
2060
2080
2100
1000 ppm
550 ppm
450 ppm
Scenario A1B emissions range
Scenario B2 emissions range
°C
6
5
4
3
2
1
0
1990
1000 ppm
2300
2100
550 ppm
2300
2100
450 ppm
2300
2100
Risks to many
Risks to some
Large Increase
Increase
Higher
Very Low
Unique and threatened systems
Extreme climate events
Large-scale high-impact

IPCC : The Most Recent View



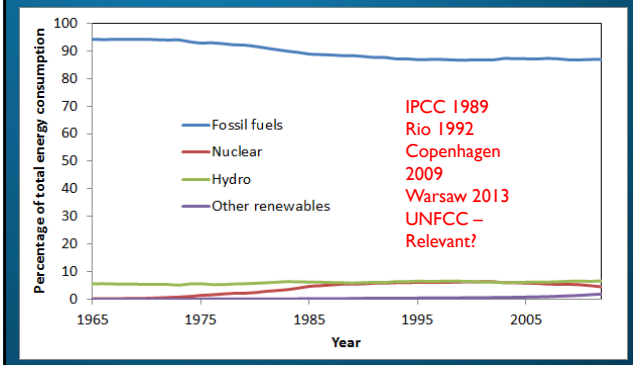
Source: IPCC Synthesis Report (2014)

Emission Profile: Risk Profiles



Source: IPCC Synthesis Report (2014)

Poor Results So Far: Fossil fuels continue dominance

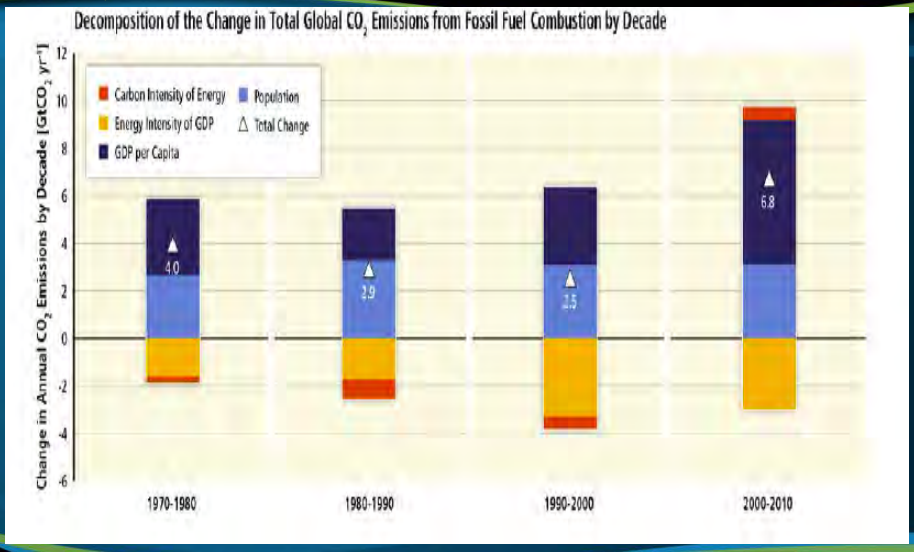


IPCC 1989
Rio 1992
Copenhagen 2009
Warsaw 2013
UNFCC – Relevant?

85=85

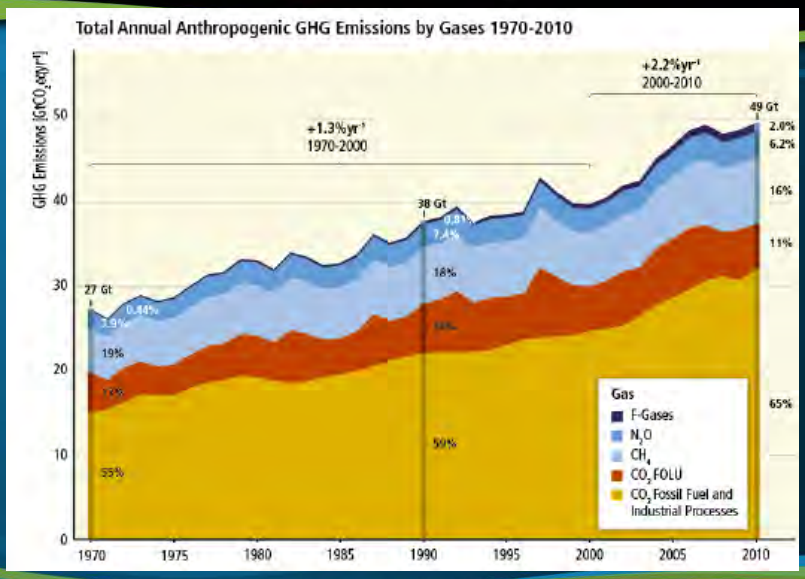
Annual Emissions Decade by Decade:

,



Source: IPCC Synthesis Report (2014)

Emissions are on the rise

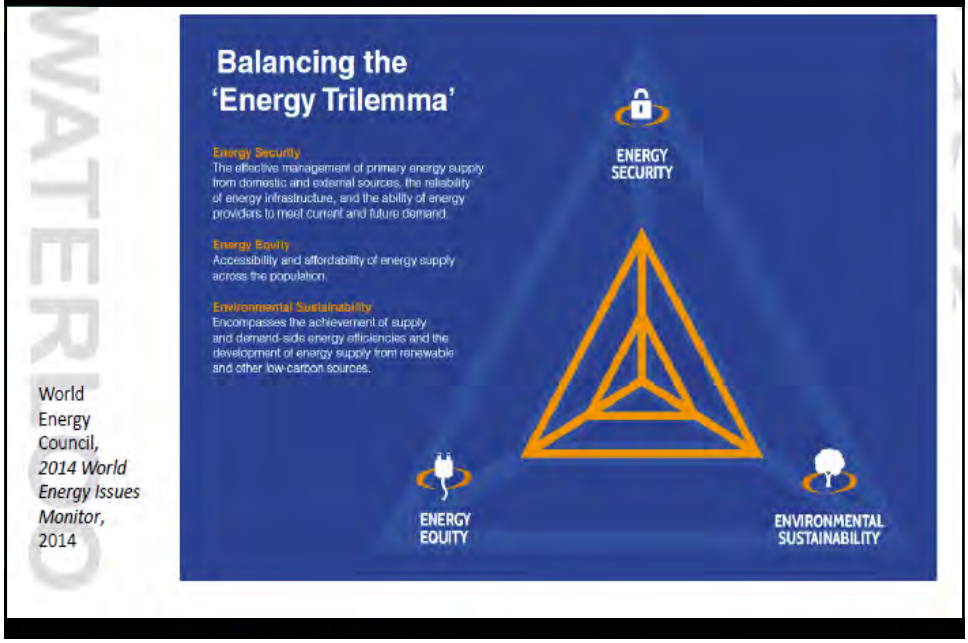


Source: IPCC Synthesis Report (2014)

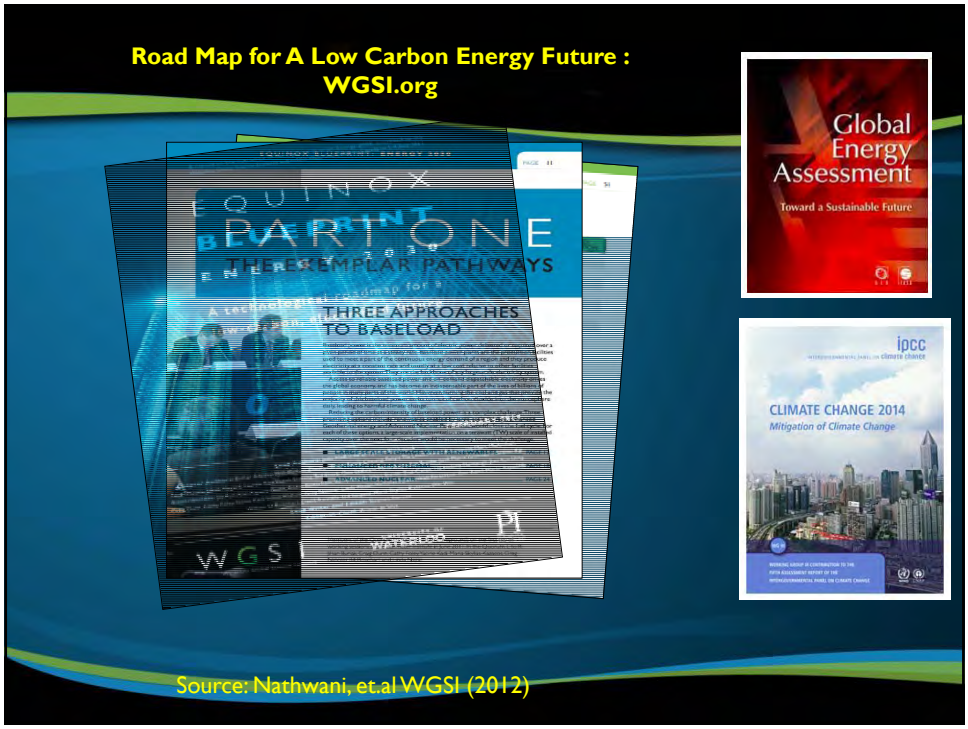
Global Energy Transition Needed – But How?

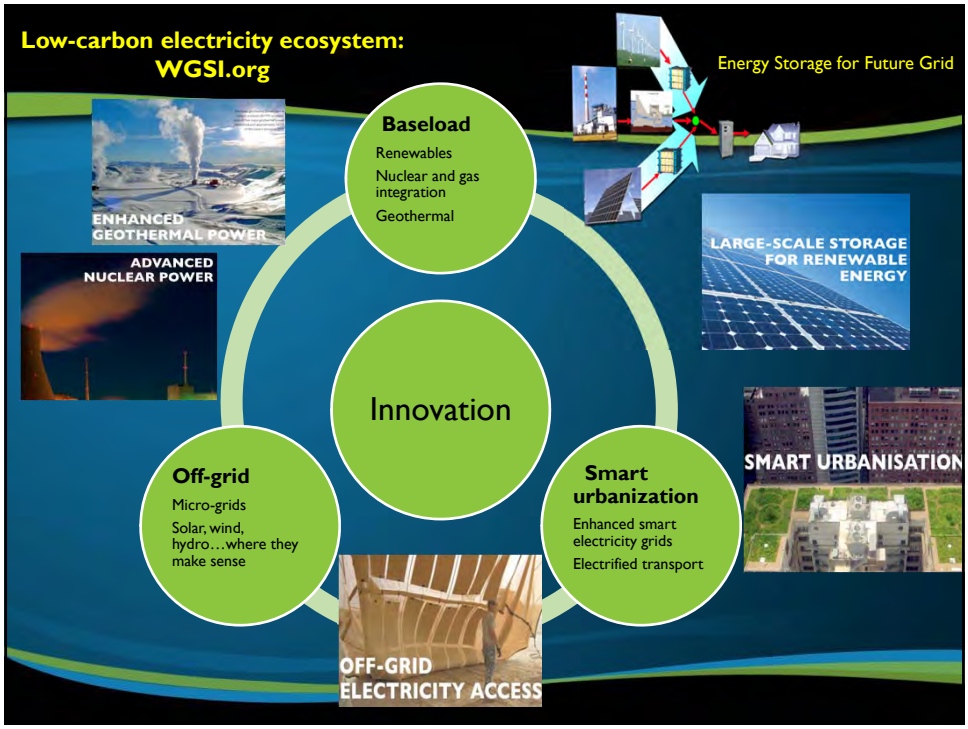
UNFCC?

Balance – is necessary but difficult to achieve

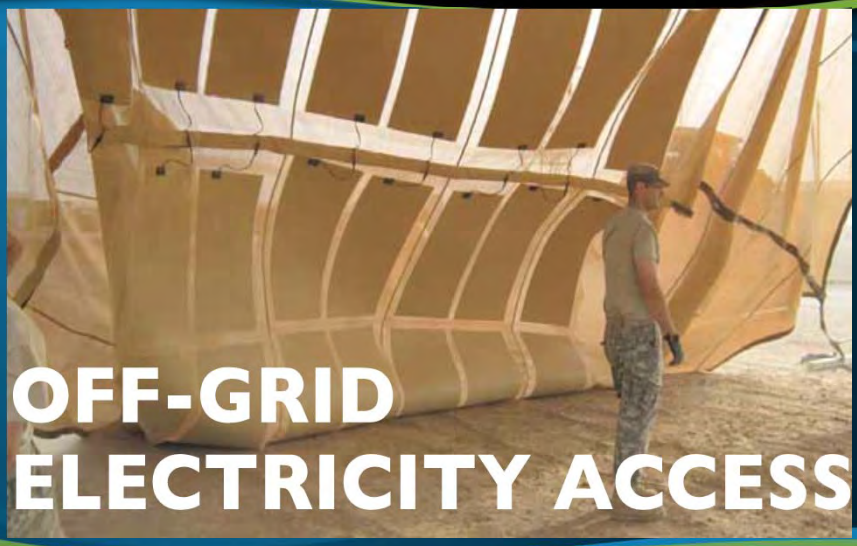


World Energy Council, *2014 World Energy Issues Monitor*, 2014

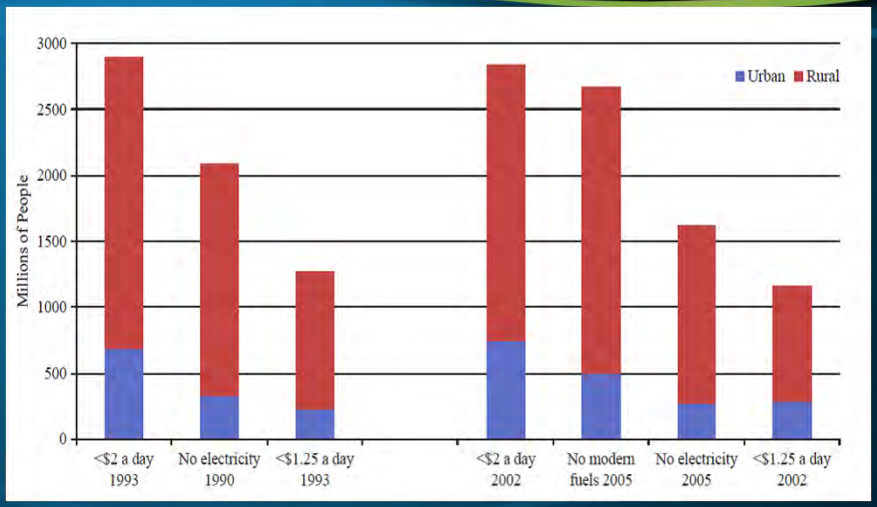

Road Map for A Low Carbon Energy Future :
WGSI.org
EQUINOX
BLUEPRINT
PART ONE
THREE EXEMPLAR PATHWAYS
THREE APPROACHES TO BASELOAD
WGS
PI
Global Energy Assessment
Toward a Sustainable Future
ipcc
CLIMATE CHANGE 2014
Mitigation of Climate Change
Source: Nathwani, et.al WGSI (2012)


Low-carbon electricity ecosystem:
WGSI.org
Energy Storage for Future Grid
ENHANCED GEOTHERMAL POWER
ADVANCED NUCLEAR POWER
Baseload
Renewables
Nuclear and gas integration
Geothermal
LARGE-SCALE STORAGE FOR RENEWABLE ENERGY
Innovation
Off-grid
Micro-grids
Solar, wind, hydro…where they make sense
Smart urbanization
Enhanced smart electricity grids
Electrified transport
SMART URBANISATION
OFF-GRID ELECTRICITY ACCESS

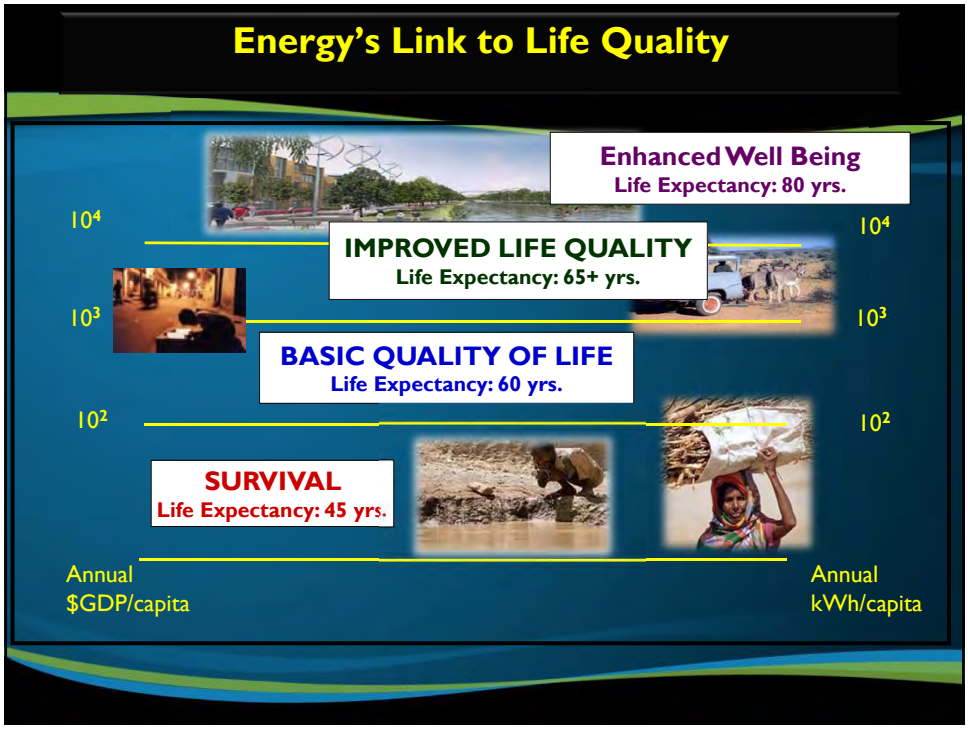
Affordable energy for humanity



Billions with no access: Electricity or modern fuels



Source: GEA 2012, data from IEA 2002, 2007, Ravvllion et al 2007


Energy's Link to Life Quality
Enhanced Well Being
Life Expectancy: 80 yrs.
IMPROVED LIFE QUALITY
Life Expectancy: 65+ yrs.
BASIC QUALITY OF LIFE
Life Expectancy: 60 yrs.
SURVIVAL
Life Expectancy: 45 yrs.
10⁴
10³
10²
10⁴
10³
10²
Annual $GDP/capita
Annual kWh/capita

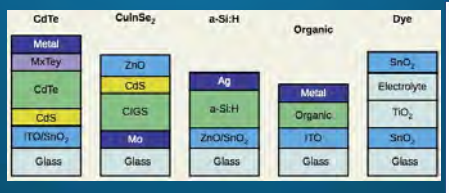

60kWh
mW
240kWh

Powerlines But No Power

Off-Grid Electricity Access

Organic Photovoltaics (OPV) as an illustrative example

- PV technologies in development form an ecosystem from silicon-based photovoltaics to thin films and emerging next-generation nanotechnology concepts
- They in turn are a part of a larger system with the potential to be integrated within smart micro-grids, along other local renewable resources

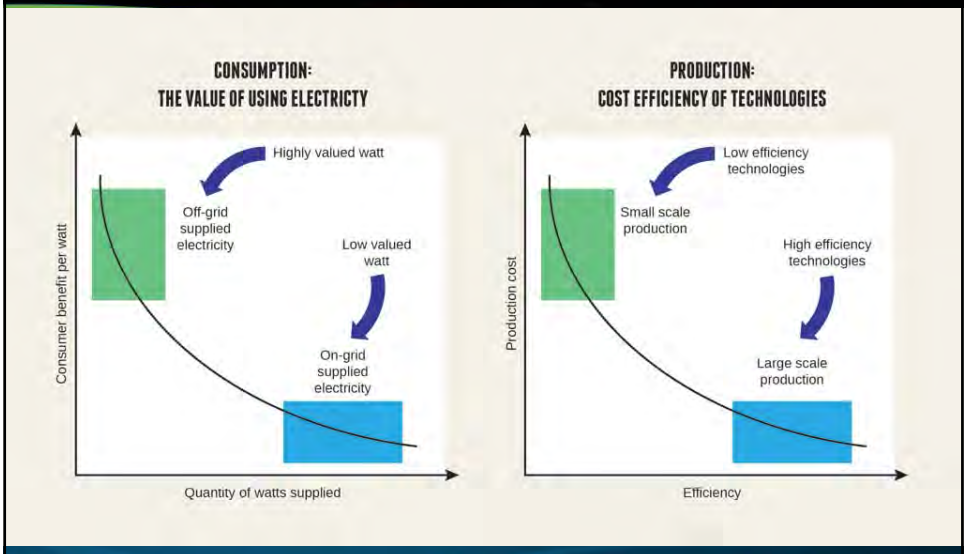


Low Cost Innovations:
Critical Pathways for Human Development Goals

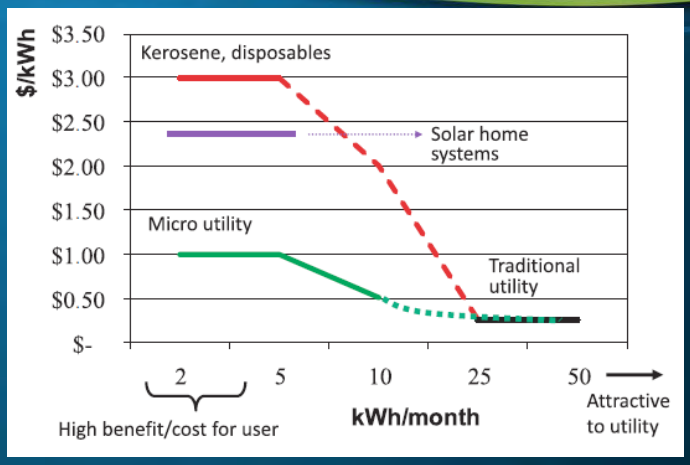
Flexible, Portable, Light-weight and Resilient.
Attractive Price.

Value: Quantity: Price

Low Willingness To Pay: High kWh
High Willingness to Pay: Low kWh



Effective cost for lighting service



Source: Modi, 2010, also see GEA 2012, World Bank 2008

Solar Suitcase

Solar Suitcase for Medical Use

Provision of Critical Lighting Needs

Reducing Maternal Mortality

Source: We Care Solar (2012)

Enhanced Solar Suitcase

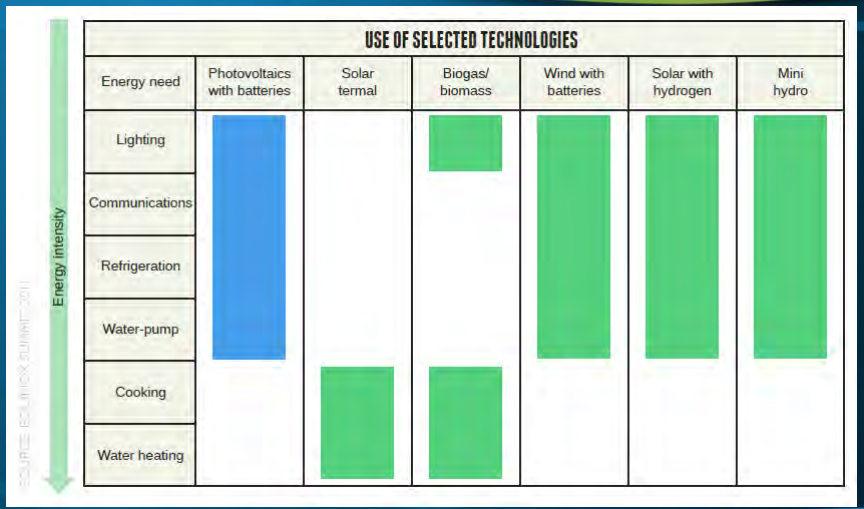
Solar Suitcase for Medical Use

Provision of Critical Lighting Needs

Reducing Maternal Mortality

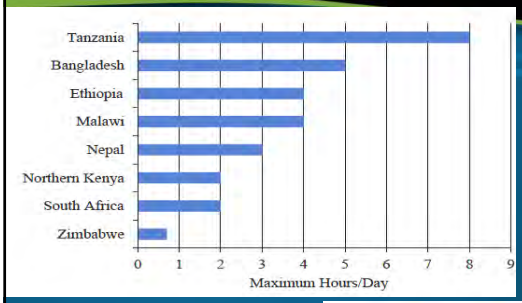
Source: We Care Solar (2012)

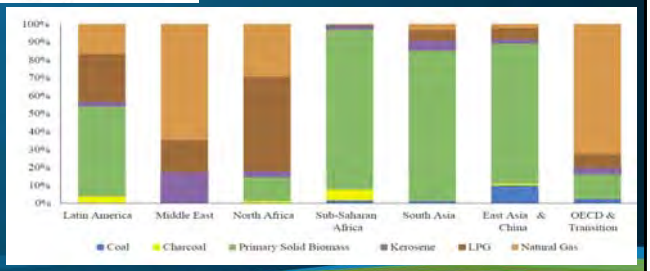
Technological solutions for diversity of needs:



Human Development Imperative:

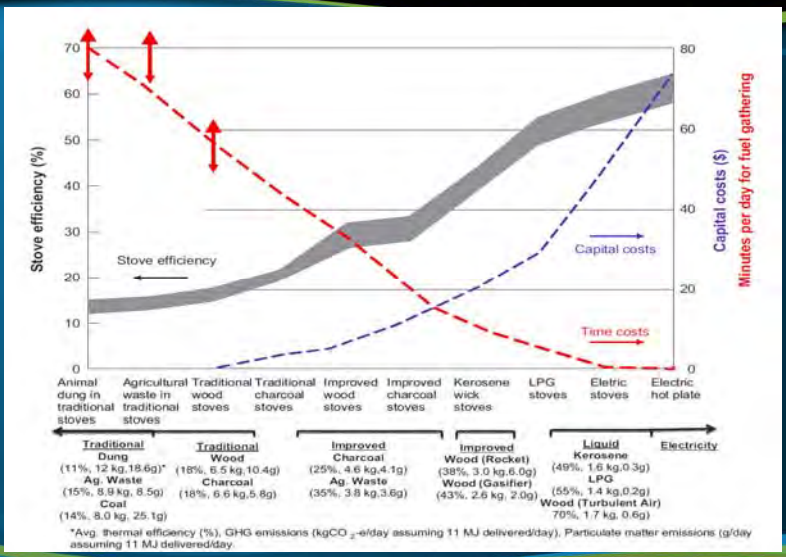
Sacrifice of human time for energy





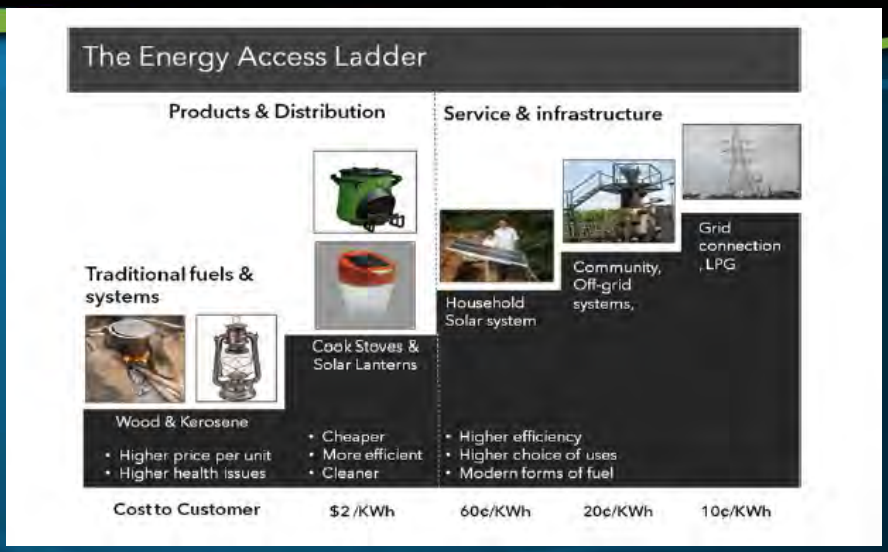
Source: GEA 2012, UNDP 2007, World Bank, 2010

Cost of energy services: human time vs fuel vs capital



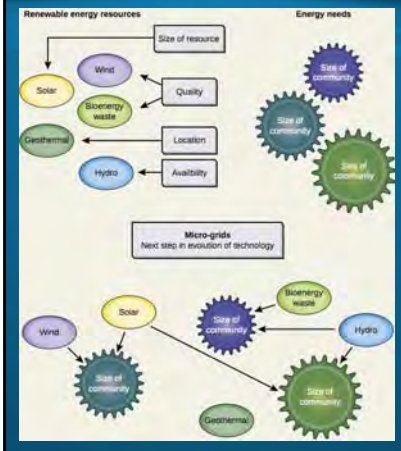
Source: GEA 2012, Chapter 1

Energy Access Ladder

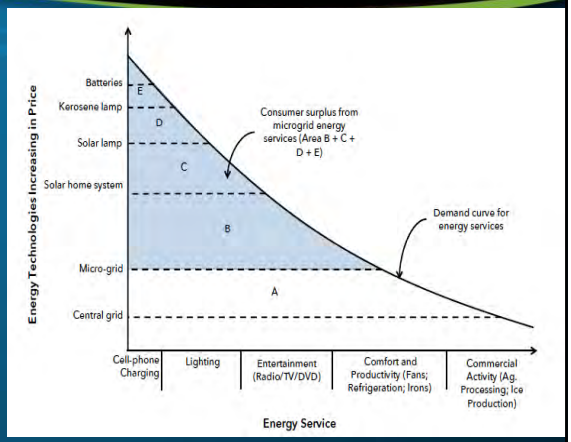


Source: Acumen Fund, 2012

Off-Grid Electricity Access:
Smart micro-grids create a consumer surplus

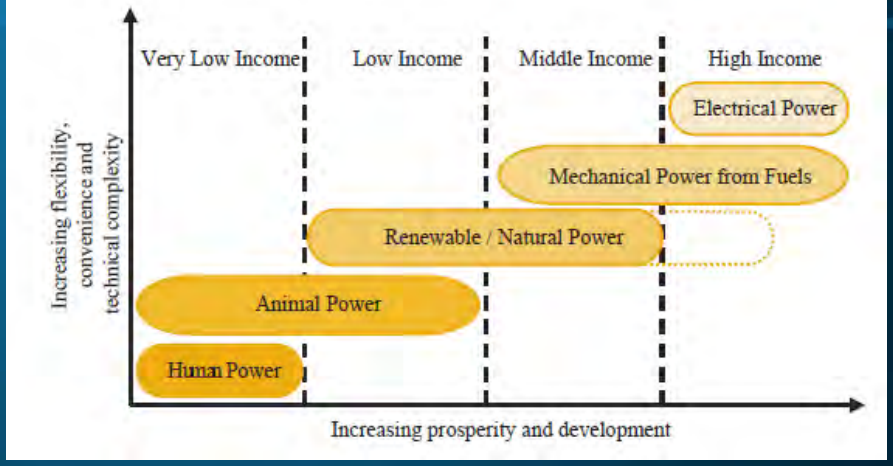


Source: Nathwani et al 2014



Source: MicroGrids for Rural Development, Daniel Schnitzer, Jay Apt et al, 2014

Energy Ladder for human development

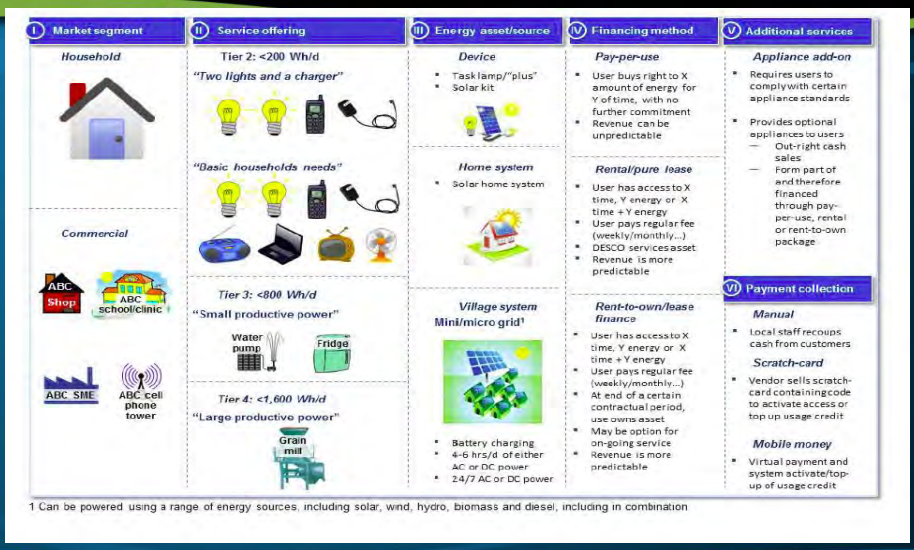


Technological Innovations : Scale and Market Segments

		Appliance providing energy service	Power need	Usage amount	Energy need appliance per day	Cumulative energy need per day*	Example product
		Unit	*[Wp]*	*[hrs / day]*	*[Wh / day]*	*[Wh / day]*	
Tier 4 <1,600Wh per day		Grain Mill	750	4	3000	3744	
Tier 3 <800Wh per day		Water Pump	150	2	300	744	Sunpump SDS 128
		Fridge	150	2	300	444	Steca PF 166, no battery
	TIER 2 <200Wh per day	TV / Tablet Comp	12	6	72	144	MacBook pro (65Wh), iPad (34Wh)
		Lighting	10	6	60	72	Fosera Lamp 200 (1.6W)
		Phone	5	2	10	12	iPhone (10Wh)
		Task Light	0.5	4	2	2	d.light s1/s2

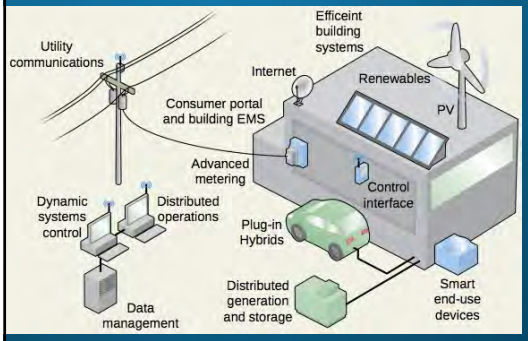
** The 'Cumulative energy / day' - column reflects the cumulative energy need if all appliances would be used in a given day. For example, running a task light, phone, lights and TV for the hours shown above would require a total of 144Wh. Adding a fridge would require a total of 444Wh and so on.*

Can Market Models Deliver?



Source: Bardouille and Muench, 2014

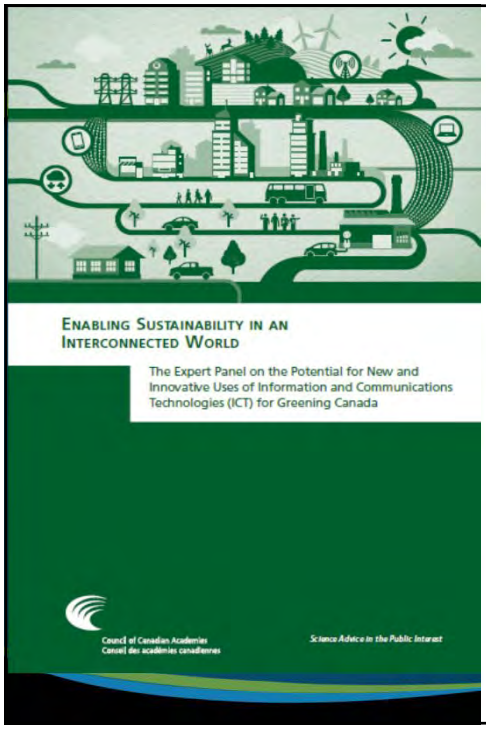
Smart Grids



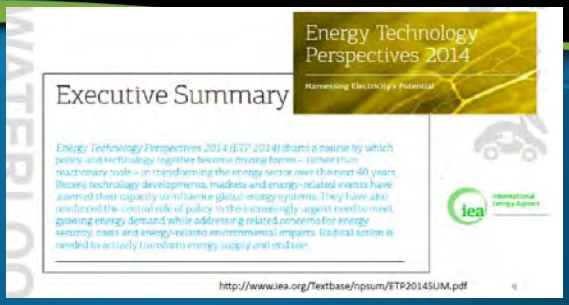
Existing grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralised generation	Distributed generation
Hierarchical	Network
Few sensors	Sensors throughout
Blind	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Manual check/test	Remote check/test
Limited control	Pervasive control
Few customer choices	Many customer choices

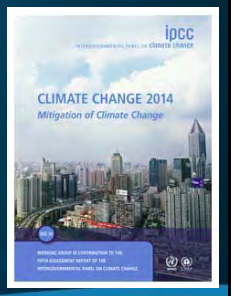
Smart Energy Networks

39



Radical action needed

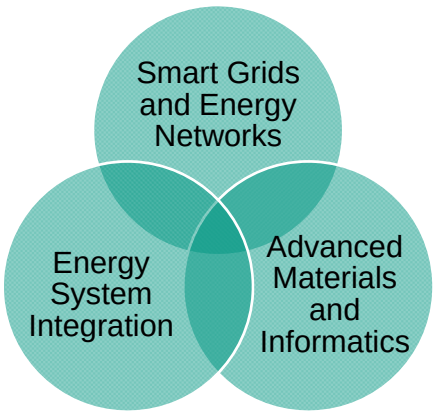




"Massive diffusion of new technologies for meeting thermal energy, motive power and electricity needs is required to meet the grand challenge of improving energy access….This requires innovation on both technological and institutional levels. Providing universal access to electricity is not just a moral imperative. ..it delivers substantial social, health and environmental benefits." GEA, Chapter 19, pp- 1401-1457

Next Generation Energy Solutions

KIT Karlsruhe Institute of Technology



- University of Waterloo and KIT Collaboration

The spirit of 'why not?'

WISE
WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

Jatin Nathwani, PhD, P.Eng
Executive Director, WISE
Professor and Ontario Research Chair in Public Policy for Sustainable Energy

UNIVERSITY OF WATERLOO

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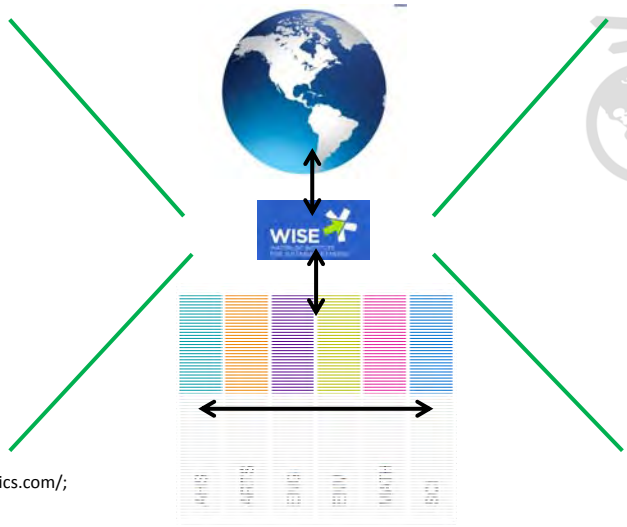
PORTAL TO THE WORLD



http://www.psdgraphics.com/;
http://uwaterloo.ca

45

WATERLOO

WISE
WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

VISION AND MISSION

Our **vision** is simple: **clean energy, accessible and affordable for all.**

Our **mission** is to conduct **original research** and **develop innovative solutions and policies** to help transform the energy system for long-term sustainability

Collaborate
At WISE, we believe the biggest breakthroughs come from uniting leading researchers from dozens of disciplines.

Reach out
Change requires many partners. We're working with industry, government and the non-profit sector to create sustainable energy solutions.

Influence
Our research shapes public attitudes, informs energy policies and improves quality of life at home and around the globe.

46

WATERLOO

WISE
WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

TRANSFORMING OUR ENERGY FUTURE

47

WISE
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CULTURE OF INNOVATION

VELOCITY

Empowering our innovators to freely develop their ideas - and reap the rewards
» **WatCo** ready to assist

accelerator centre

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» 16,000 students earned $187M in 2011/12

48


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ENTEGRUS
ThermAtlantic
energent
Mitsui
SIEMENS
BASF
NextEnergy
First Solar
BLUEPOWER
cisco
hydro one
ONTARIO POWER GENERATION
EMERSON
IBM
WWF
CIHR IRSC
Deep Blue NRG
KACO
Microsoft
CanadianSolar
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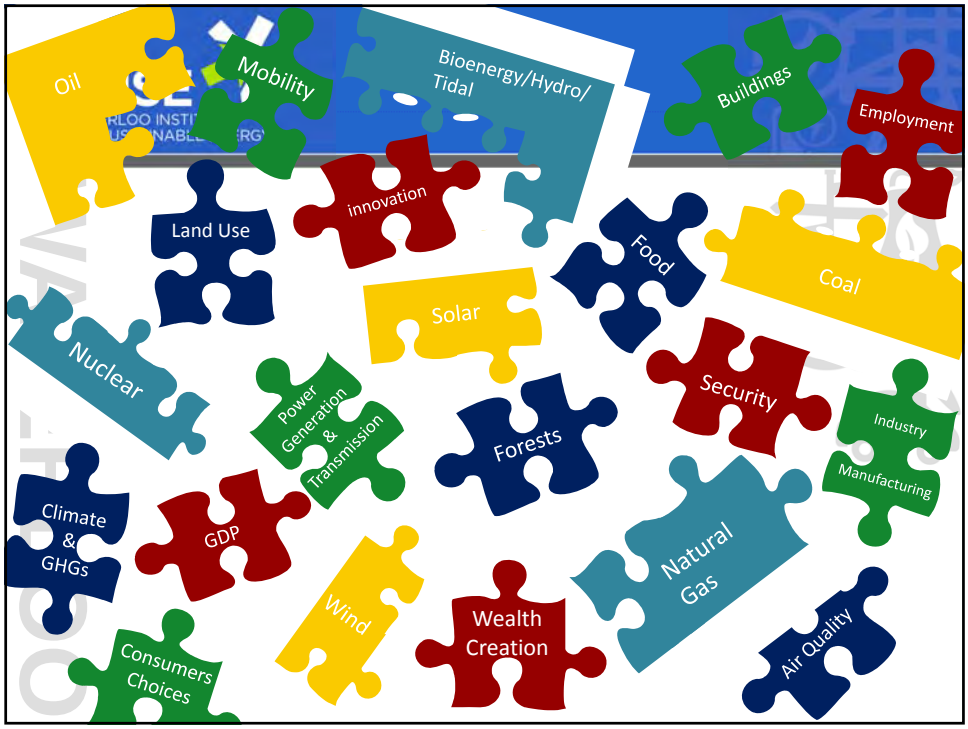
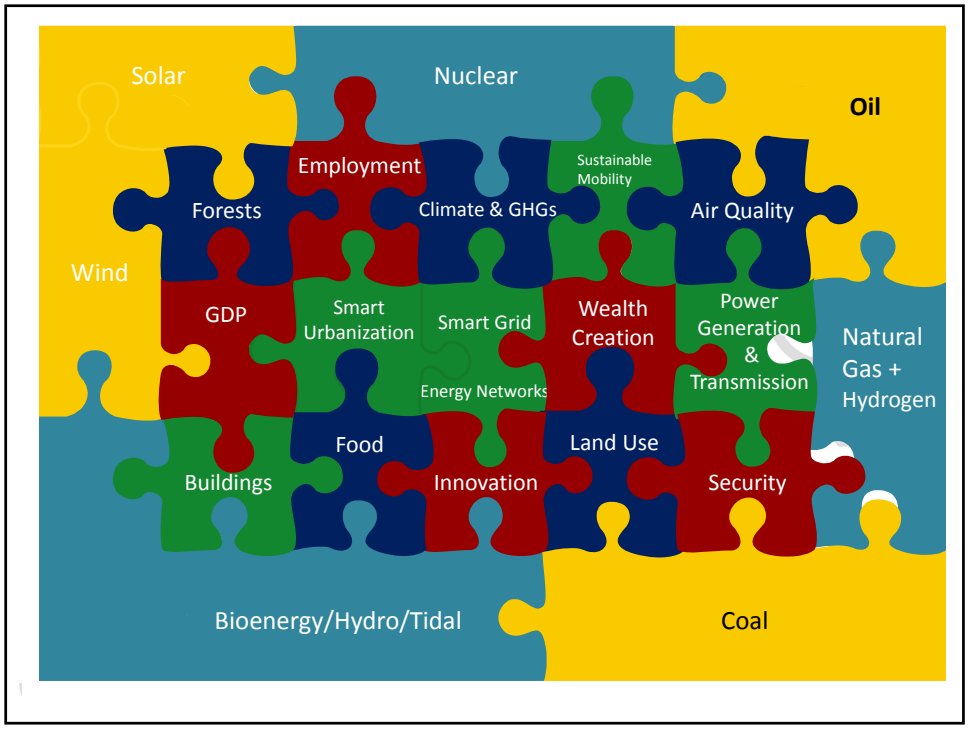

Oil
Mobility
Bioenergy/Hydro/
Tidal
Buildings
Employment
innovation
Land Use
Food
Coal
Solar
Nuclear
Power
Generation
&
Transmission
Security
Industry
Manufacturing
Forests
Climate
&
GHGs
GDP
Natural
Gas
Wind
Wealth
Creation
Air Quality
Consumers
Choices


Paths to a
Sustainable Life Quality


Solar
Nuclear
Oil
Employment
Sustainable Mobility
Forests
Climate & GHGs
Air Quality
Wind
GDP
Smart Urbanization
Smart Grid
Wealth Creation
Power Generation & Transmission
Natural Gas + Hydrogen
Energy Networks
Food
Land Use
Buildings
Innovation
Security
Bioenergy/Hydro/Tidal
Coal

- Contact Info
- **Jatin Nathwani, PhD, P.Eng**

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  Professor and Ontario Research Chair in Public Policy for Sustainable Energy
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- Mobile: +49 (0) 173 719 4511