



Sustainability and Alternative Energy

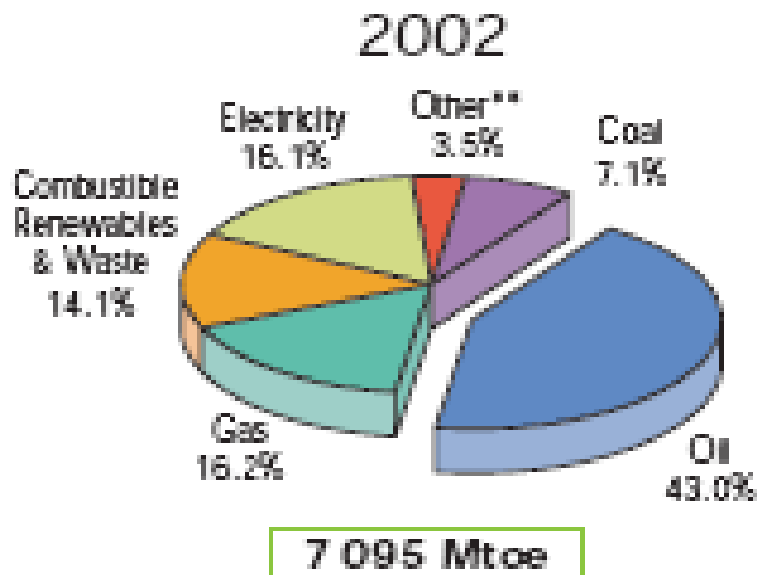
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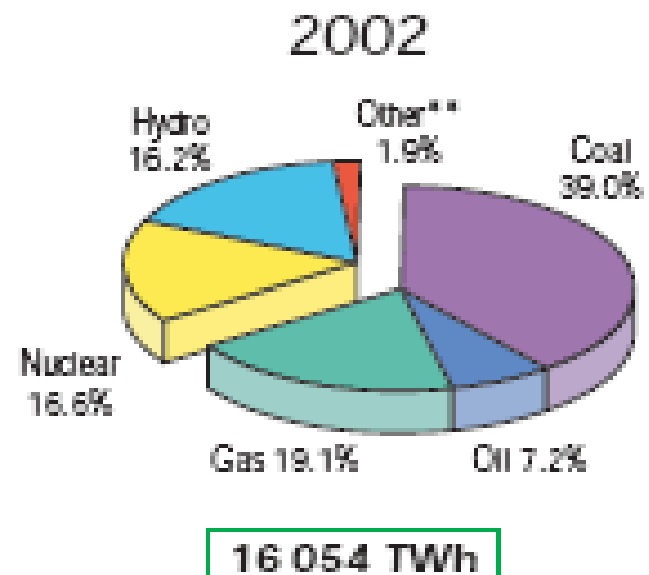


Sustainable Energy Consumption – A Challenge

Total world energy and electricity consumption:
is this situation sustainable?



Energy from fossil fuels = 66 %



Electricity from fossil fuels = 66 %



Alternative Energy – A Partial Solution to Energy Needs

■ FOSSIL FUELS: Issues and Impact

- Sustainability – remaining resources?
- Greenhouse gas production – a contribution to global warming

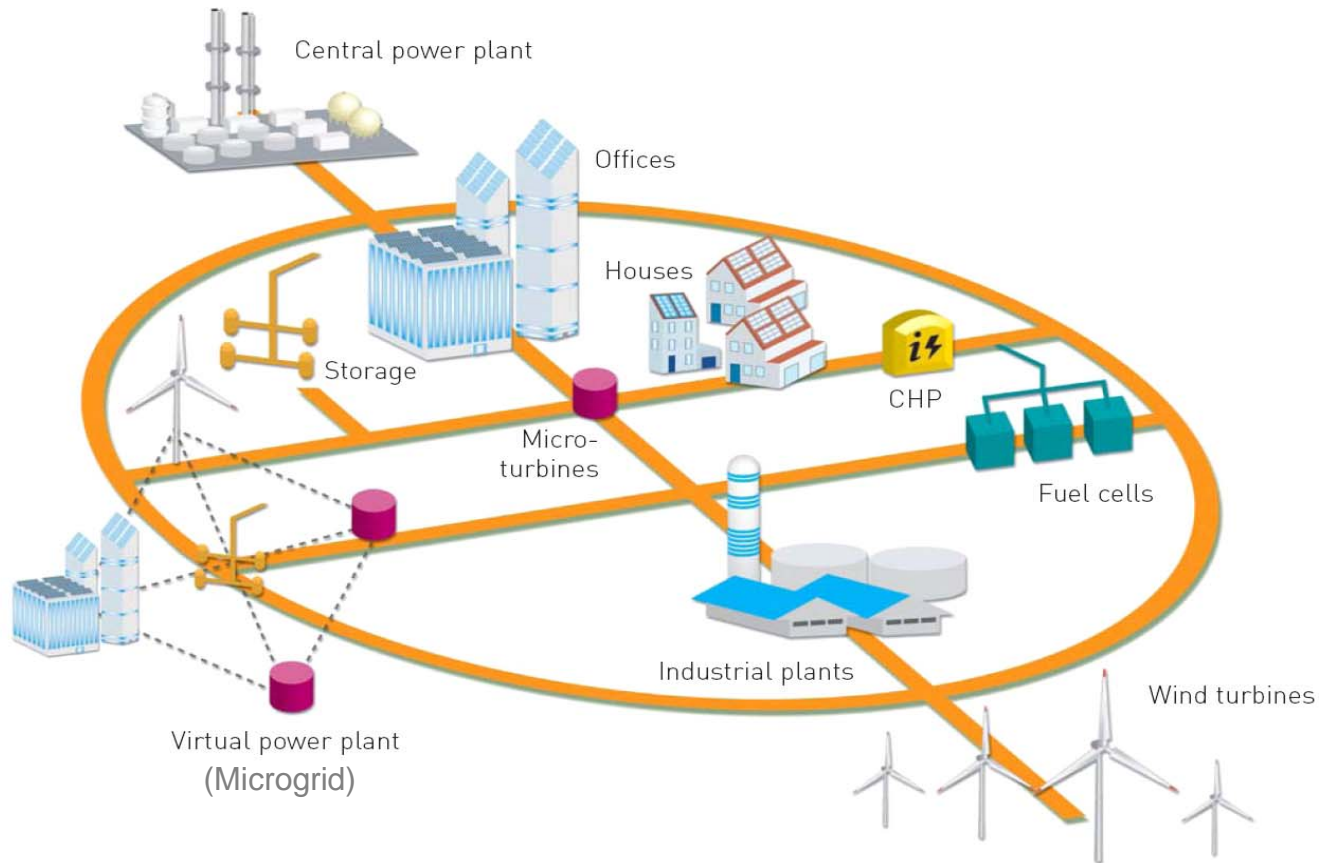
■ RENEWABLE and ALTERNATIVE ENERGY: Adding to the Energy Portfolio

- Integration target – from about 2 % to 20 %?
- Sources – wind, solar, biomass, biofuels, landfill gases, geothermal
- Hydrogen – fuel cells and the hydrogen economy (2030?)

■ CHALLENGES OF INTEGRATING THESE RESOURCES (EPRI USA)

- Maintaining SQRT – Security, Quality, Reliability, Availability
- Developing a smart power delivery system

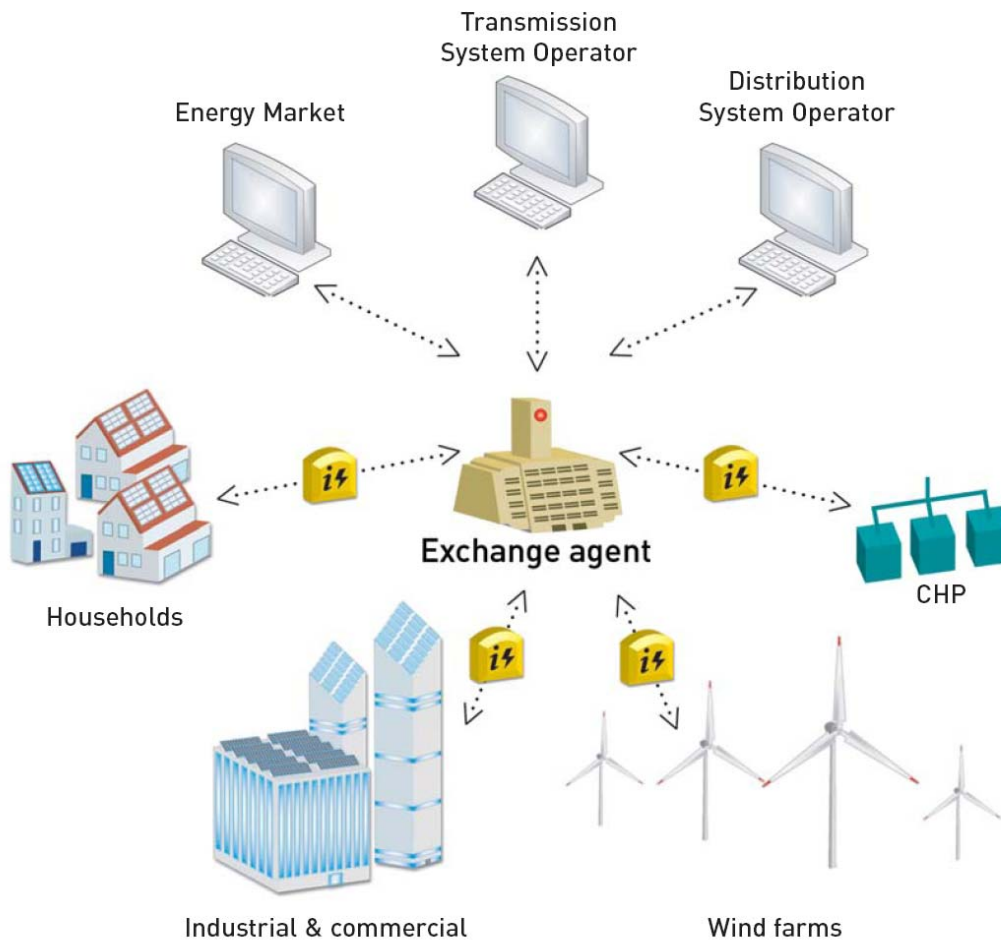
Vision – The Intelligent Electric Grid of the Future



***Future:** Operation of system will be shared between **central and distributed generators**. Control of distributed generators could be aggregated to form microgrids or 'virtual' power plants to facilitate their integration both in the physical system and in the market.*



OPPORTUNITY – COMMUNICATIONS – ELECTRICITY MARKETS





Recent McGill Contributions

■ Wind Energy Systems

- Managing wind variability – electricity storage, including batteries
- Wind-hydro integration – stochastic energy management strategies
- Advanced power electronic interfaces – managing storage

■ Electricity Infrastructure - Remote Community

- Integration of renewables – managing load and wind intermittency
- Battery storage – quantifying the benefits

■ Electricity Markets

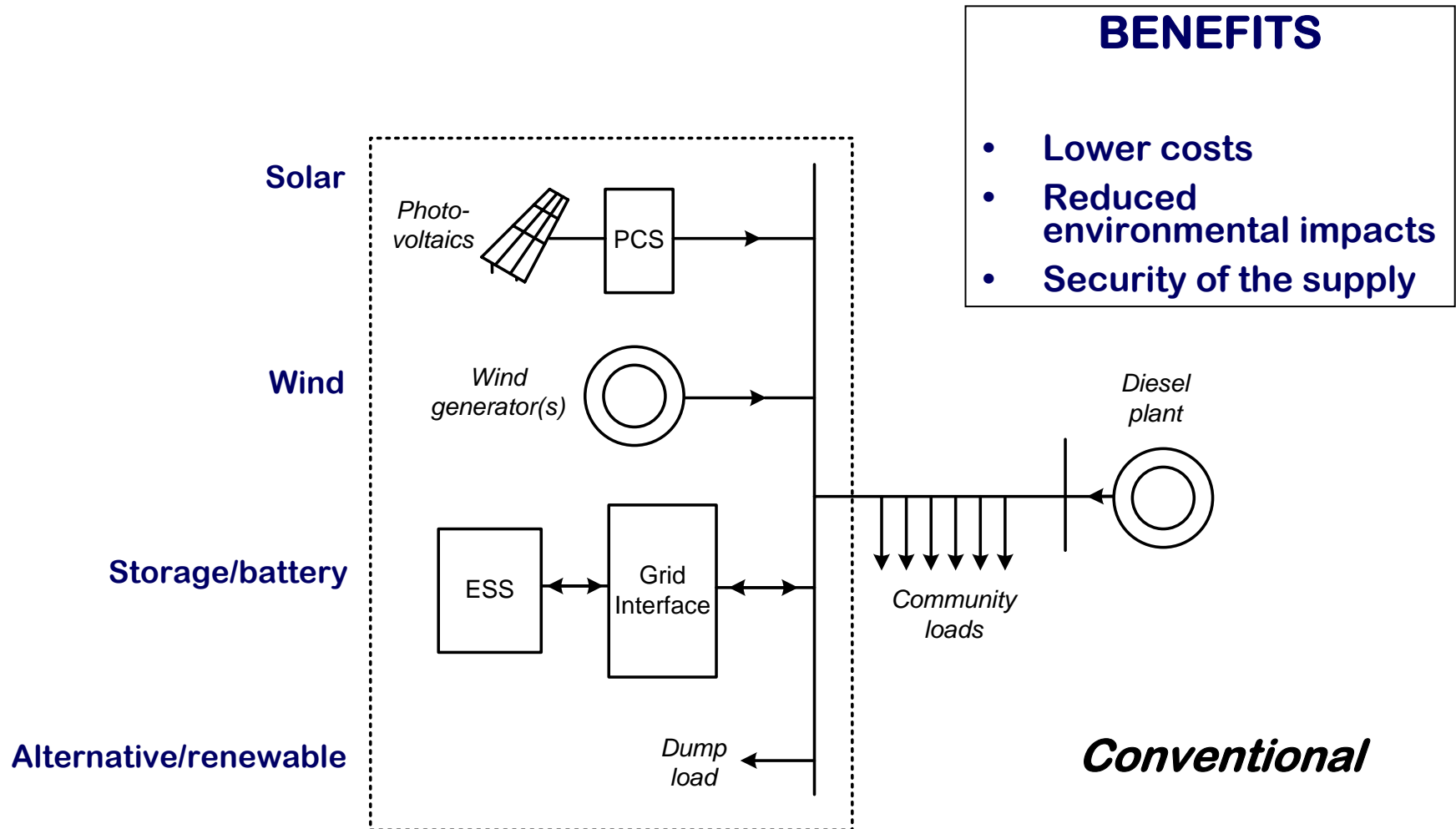
- New approaches to bidding strategies in an open market

■ Protection Systems – New Approaches Protection

- Intelligent relays – use of data mining approaches



Benefits – Supplying Remote Communities





Vision – Research Needs in Alternative Energy Systems

■ Exploiting Renewable Energy And Distributed Generation Capabilities

- Plug in hybrid electric vehicles interaction – alternative transportation
- Small wind integration – a contribution to GHG reduction
- Microgrids – autonomous reliable supply systems
- Intelligent metering systems – empowering the consumer

■ Optimal Wind Energy System Integration

- Optimal management of combined wind and hydro resources
- Electricity markets – exploiting “green” energy
- Managing wind energy intermittency – a case for energy storage



Research Support: Interdisciplinary - Team Funding

■ Government Funding - McGill

- Canada Research Chair - Powering the information technology infrastructure

■ Government - Industry Partnerships - McGill

- NSERC Strategic Grant Project – “Design and operation of transcanadian power grids: an integrated approach”
- Canada Foundation for Innovation – Laboratory infrastructure for “control and optimization of electricity networks”
- Hydro-Quebec/McGill/NSERC Industrial Research Chair – “Integrating renewable energy into the distribution grid” – in preparation

■ Government - Industry Partnerships - Canadian Network

- NSERC Canadian Wind Energy Strategic Network – 39 researchers, 16 universities 15 industry and government partners



Future Opportunities: Provincial & National Initiatives

- **Faculty Sustainable Energy Centre: A Multidisciplinary Effort**
 - Development of new energy resources – wind, solar, biofuels, fuel cells
 - Development of storage systems – batteries, capacitors, hydrogen
 - Grid operation issues – stability and security of the supply

- **Establishing Canada as a Sustainable Energy Superpower: A Canadian Academy Of Engineering Priority - National Projects**
 - Electrical infrastructure upgrade – a national electric grid in support of the integration of renewable energy sources
 - Gasification (fossil fuels and biomass)
 - Greenhouse gas (GHG) management and carbon sequestration