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Storage and its Strategic Impacts on Smart Grid

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Presentation Outline

- ✓ Background
- ✓ Problem definition
- ✓ Objective
- ✓ Challenges
- ✓ Importance of this work
- ✓ Methodology
- ✓ Expected Outcome and benefit

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Energy Demand

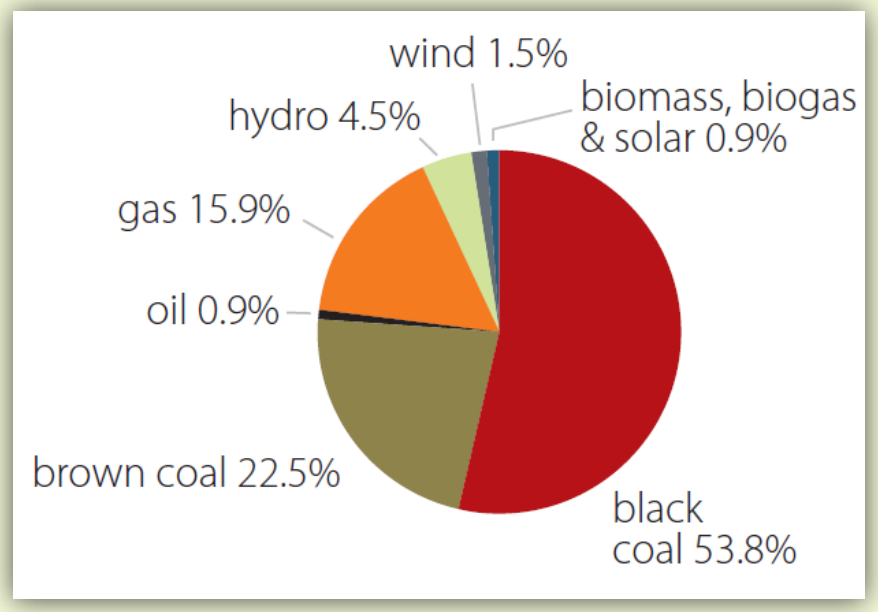
- World Demand
  - International Energy Agency predicts, world primary energy demand will increase 40% by 2030.
  - EIA forecasted, world net electricity generation will increase 87% by 2035.
  - Energy demand varies in different time of the day and in different seasons

- Australia's Demand
  - Australia's electricity use increases at an average rate of 2.8% a year
  - For the last 5 years electricity generation increased by 7% and number of customer also increased by 7%

Source: *Energy in Australia 2010 (Report)*

Australia's Energy Potential

- Conventional Energy [1]
  - Black Coal : 90 years
  - Brown Coal : 490 years
  - Gas : 63 years
  - Coal seam methane : 100 years



- Electricity Generation by Fuel[2]
  - In 2007 – 08
  - 265TWh
  - Only 7% from Renewable sources

Source
1: Energy in Australia 2010 (Report)
2: IEA, World Energy Balance, 2009, ABARE

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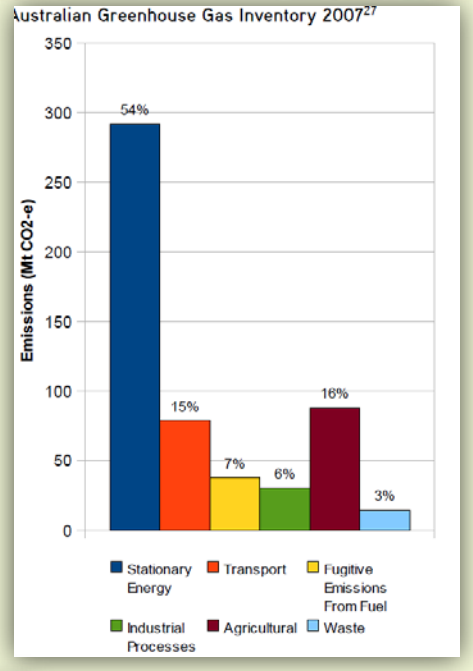
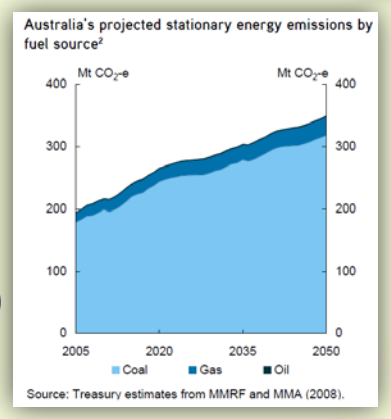
How RE comes into play?

- Greenhouse gas emission
  - Stationary energy sector is the major sector the emits CO_2 most
  - Australia's stationary energy sector alone emits 54% CO2 compared with other sectors
  - Queensland is the most energy intensive state in Australia which produces approximately 43tons of greenhouse gas per capita.

- Kyoto Protocol
  - Reduce Greenhouse gas emission by at least 5% below the 1990 level by 2008 and 2012

- Australia's Target
  - Committed to greenhouse gas emission target of 60% below the 2000 level by 2050 by expanding RE sector.
  - Passed legislation to generate 20% electricity from RE sources by 2020





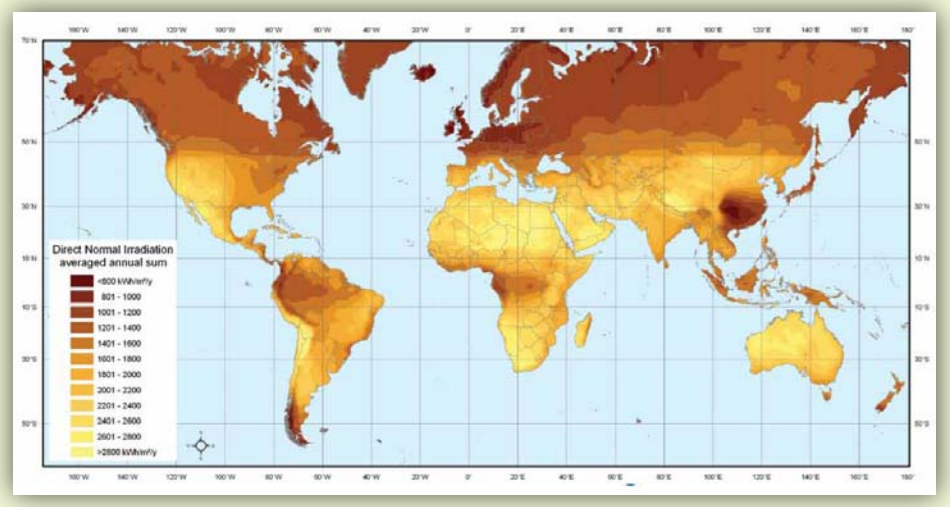
Australia's Renewable Energy Potential

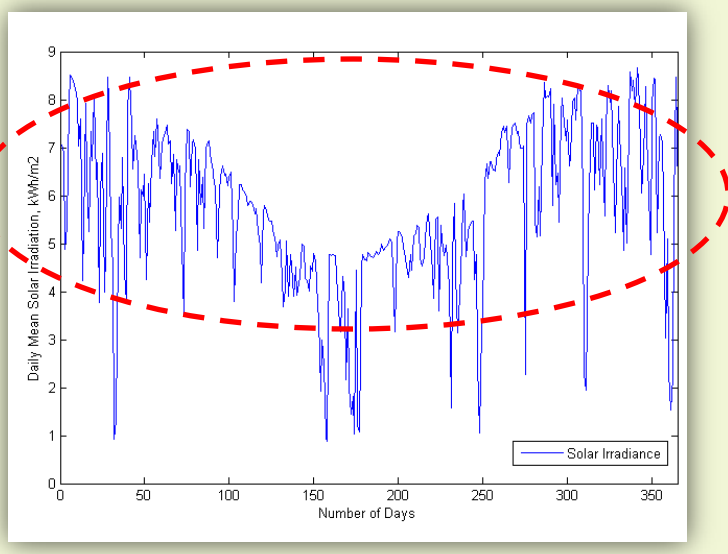
- To meet the projected electricity demand and to minimize the greenhouse gas emission RE comes into play
- Renewable Energy
  - Wind
  - Solar (CST, PV)
  - Hydro
  - Tides
  - Geothermal
  - Biomass
- Worldwide Hydro electricity provides[3] 18% electricity
- Biomass produces[4] 11% of world's energy

Sources:
3 : http://www.energyaustralia.com.au/common/Education/About-energy/Renewable-energy/
4 : Fact sheet 8, Biomass, Australian Institute of Energy

Solar Energy Potential

- Daily Direct Normal Solar exposure
  - Annual average solar exposure is 2200kWh/m^2/year (6kWh/m^2/day)





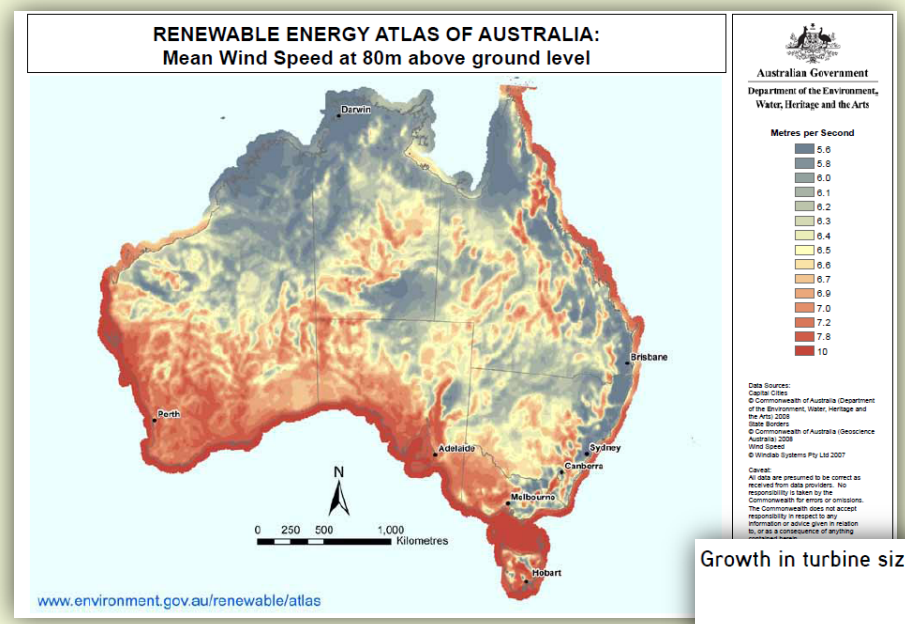
$$R = \frac{S\pi r^2}{\frac{4\pi r^2}{2}} = \frac{1367}{2} \approx 684 W/m^2$$

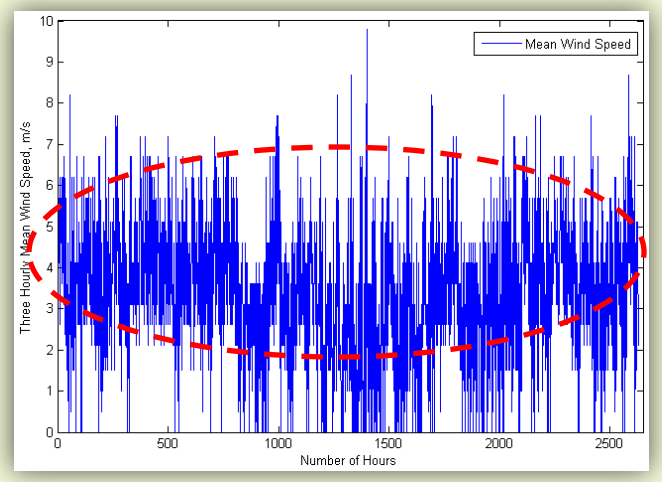
$$E_{pv} = 0.7 \times 684 \times 12 = 5.75 kWh/day$$

$$P_{out} = \eta E_i C_f = \frac{P_{stc}}{E_{in}} E_i C_f \qquad E_{pv} = P_{out}(E_H)(Solar\ Window)$$

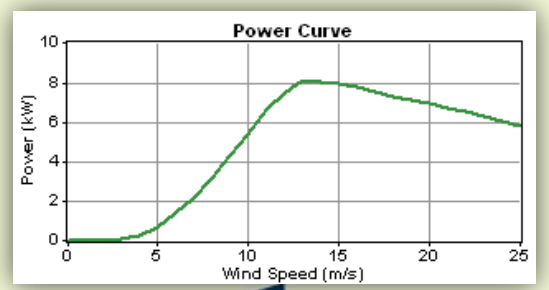
Wind Energy Potential

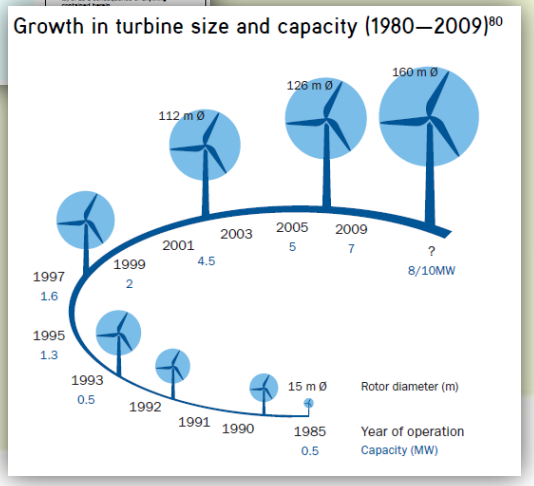
- Wind speed varies with height





$$P = \frac{1}{2}\rho C_p A V^3 N_g N_b$$





$$V_2 = V_1\left(\frac{Z_2}{Z_1}\right)^{\alpha}$$

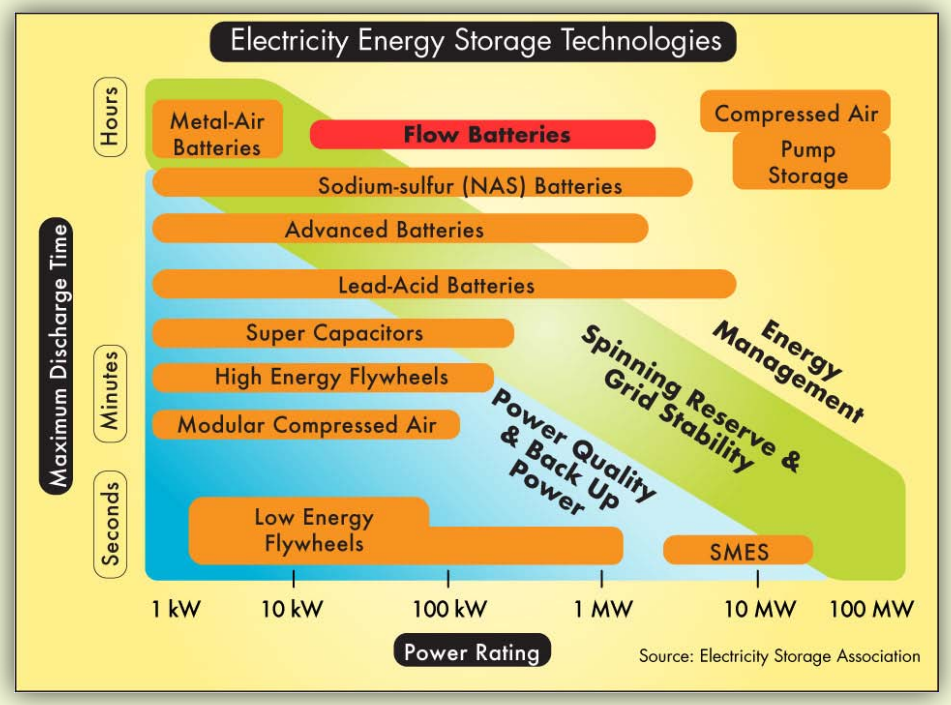
Source: RE Atlas, Australia

Problem of Solar and Wind Energy

- Solar Energy level is variable
- Sun doesn't appear 24 hours a day (Natural diurnal cycle)
- Wind speed also variable (effect of Sun and temperature)
- So, electrical energy from Solar and Wind is not consistent to meet the required PQ
- Storage helps to overcome this problem

Energy Storage Systems

- Storage can act as energy sink and power source
- Storage system can function as a shock absorber for the grid making it less vulnerable to energy spikes and dips
- Storage is the key to integrate intermittent resources
- Storage use converters or some other means to supply stored energy to the grid



Objective of this Study

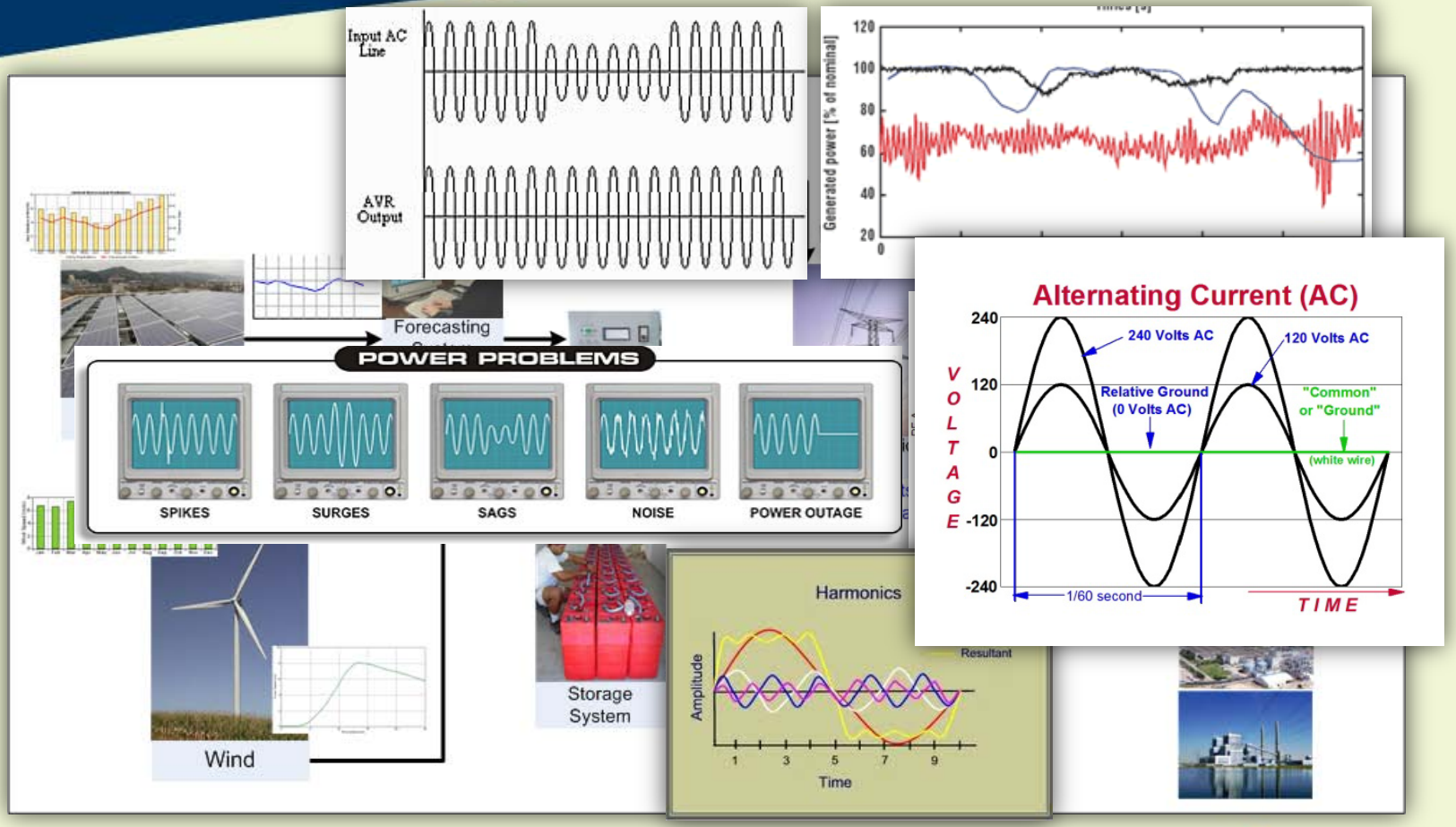
- ✓ To find impacts of Storage (with Wind and Solar energy) on the power distribution network when wind speed, solar radiation, Grid supply and Load demand varies.
- ✓ To develop the mitigation techniques to overcome these impacts.

Impacts due to Wind & Solar Energy Integration

- Steady state **voltage rise** due to Wind speed variation
- **Over current** problem due to high Peaks of wind speed
- **Flicker** problem due to dynamic operation of wind turbine and switching operation of generator
- **Voltage drop** due to switching operation of generator
- **Harmonics** due to power electronics converters
- Power system **oscillation** due to inability of the controller to cope with the variation from generation and load demand
- Voltage **stability** problem due to excessive reactive power demand from power system

- Voltage **fluctuation** and **frequency deviation** due to irregular solar radiation
  - Voltage **stability** problem
  - Sudden **voltage drop**
  - Difficulty to maintain Demand response
- **Harmonics** due to electronic inverter, filter, controllers etc.

Impacts on Grid



These impacts need to be managed to integrate large scale Storage & RE into the Grid

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Methodology

Expected Outcome and benefit

Outcome

- This study explores the scope for large scale storage integration to the grid by
  - Finding the impacts on the grid
  - Developing the mitigation techniques
- Large scale RE integration into the grid

- Grid optimization for large RE generation will be improved
- Energy utility companies will be benefited
- Different stakeholders will be benefited by selling extra energy
- Will help to build zero carbon emission from stationary energy
- World will be benefitted by better environment

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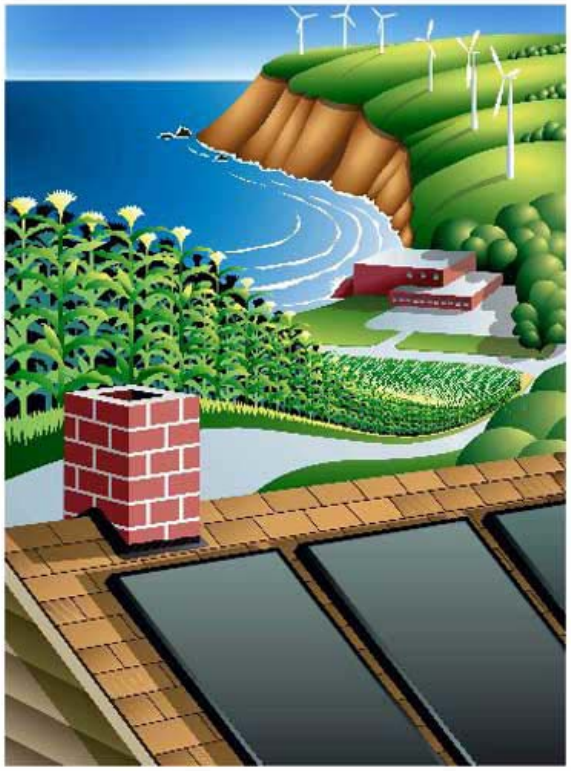

Thank You

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