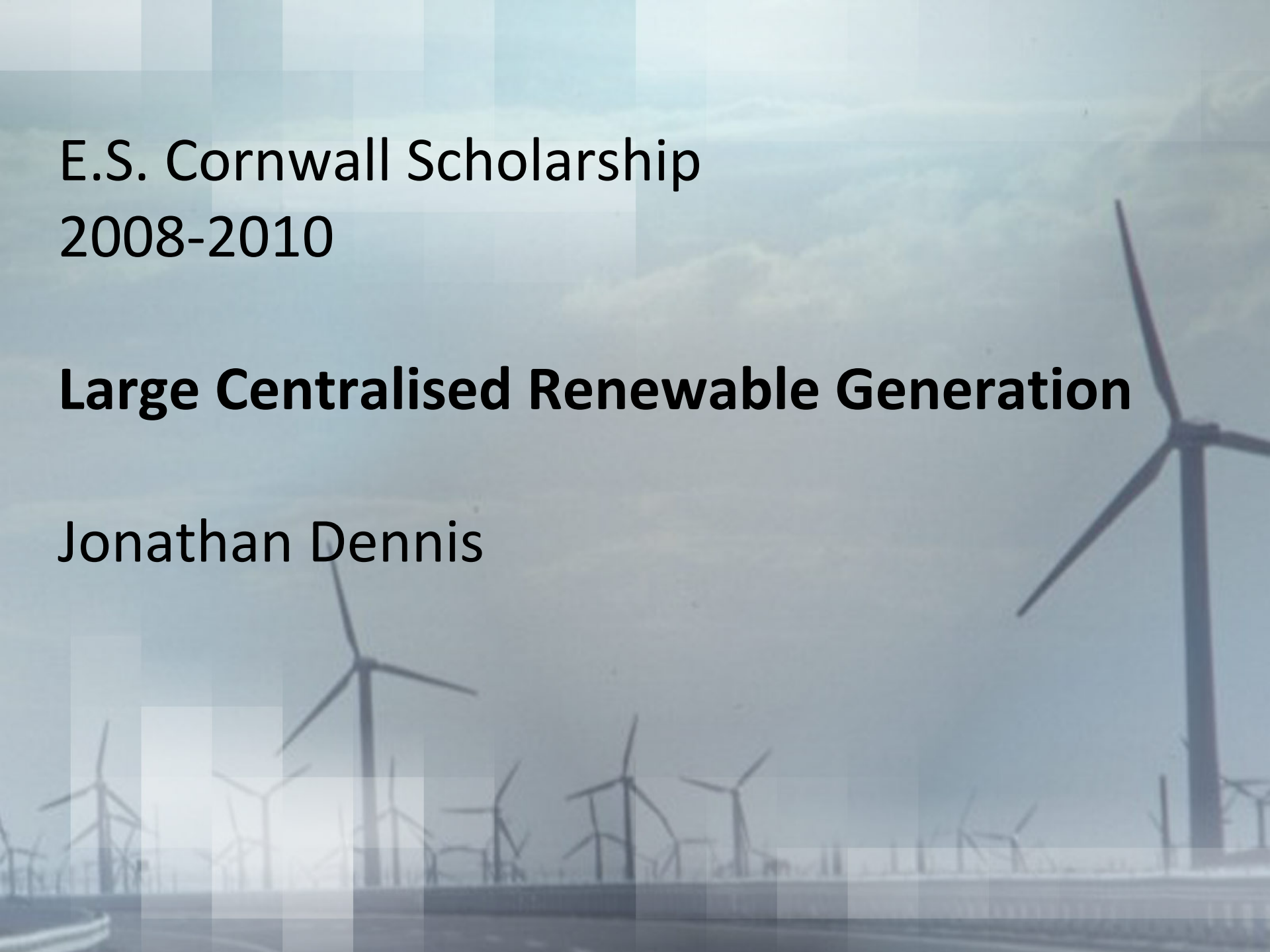


E.S. Cornwall Scholarship
2008-2010

Large Centralised Renewable Generation

Jonathan Dennis

Outline

Technical Objectives

Technical Program

Impressions

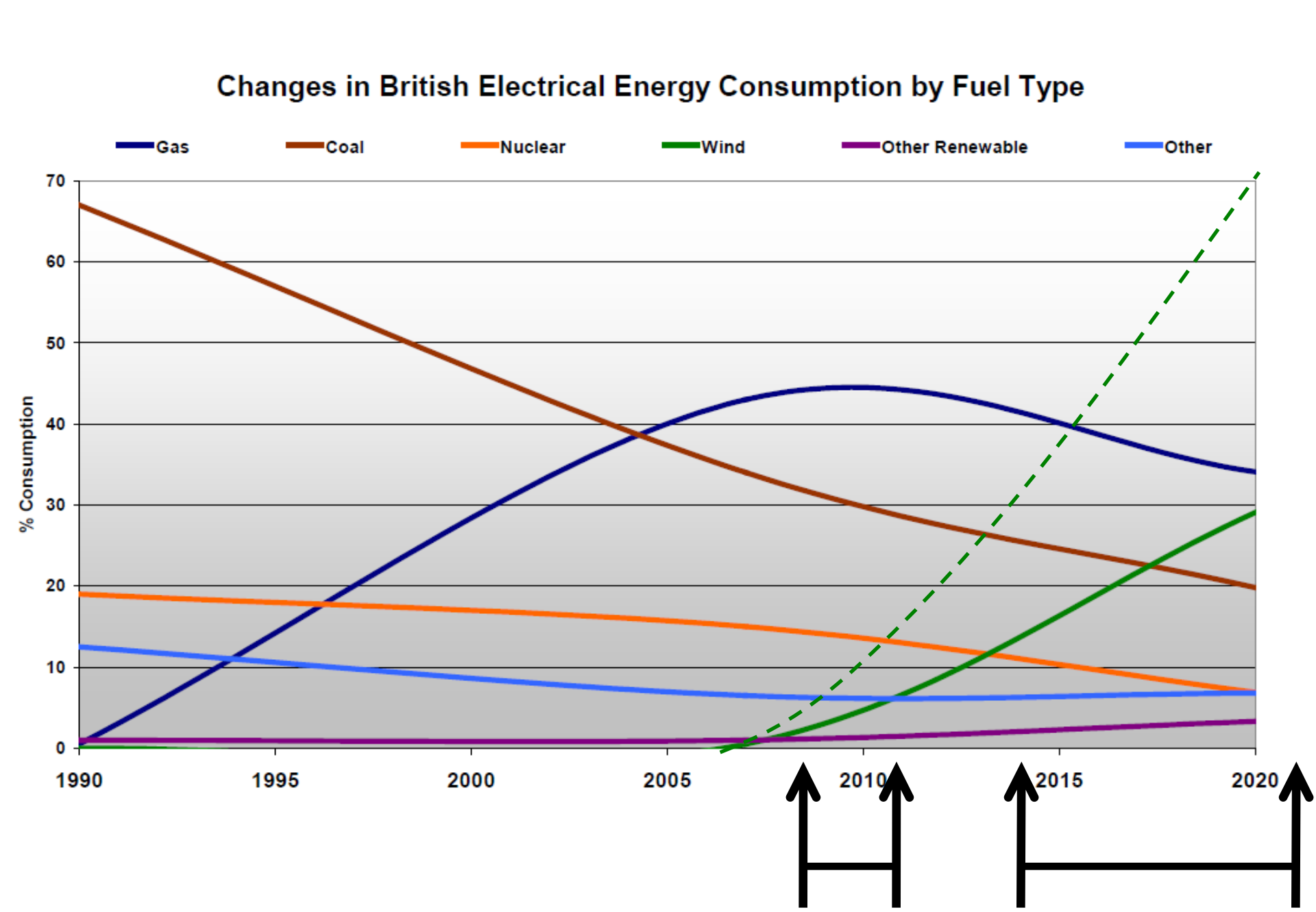
(Recommendations/Suggestions)

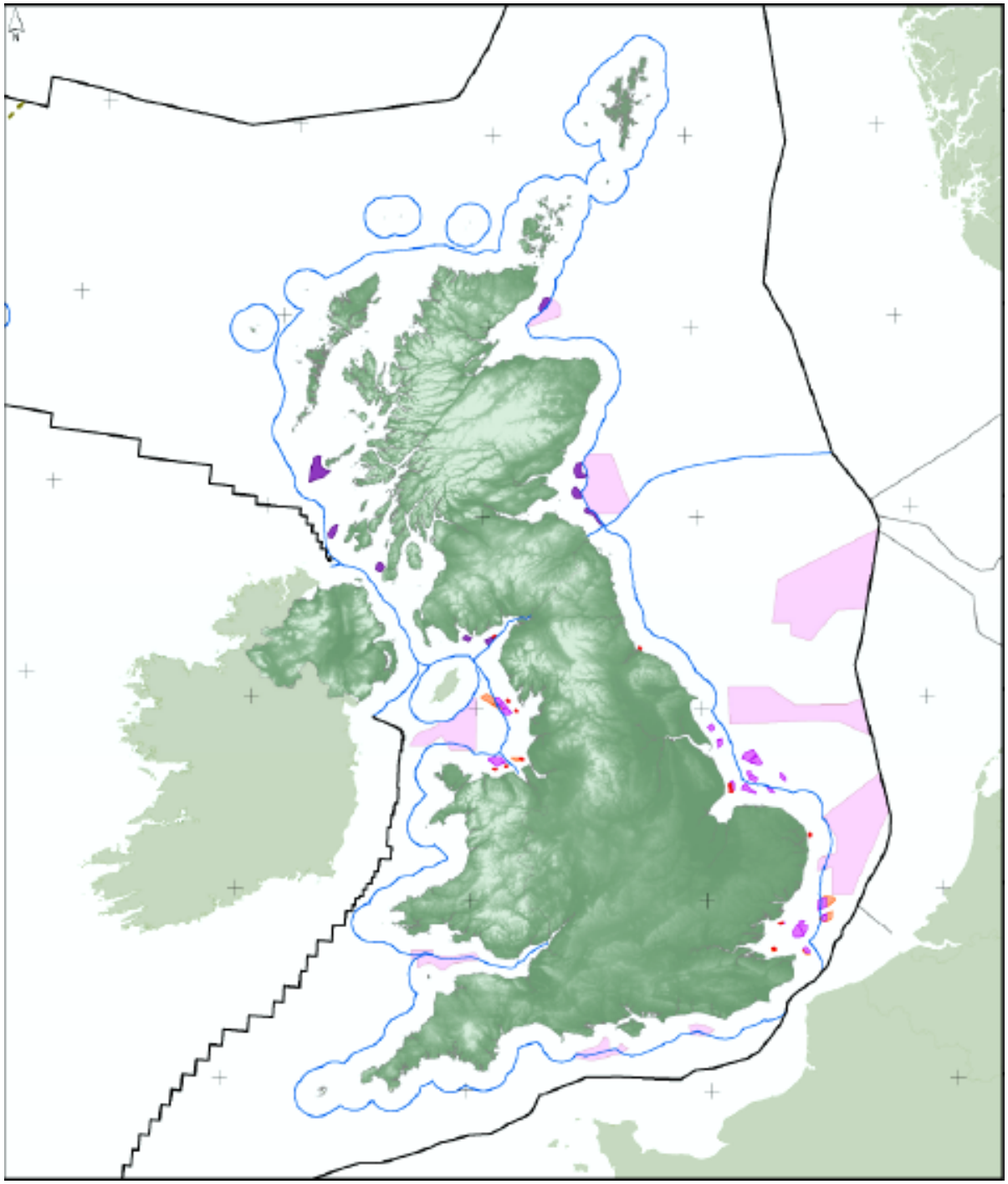
Technical Objective

To gain experience in the measures being applied internationally to manage the difficulties associated with large centralised renewable generation.

British Situation

Significant change is underway


Changes in British Electrical Energy Consumption by Fuel Type
Gas
Coal
Nuclear
Wind
Other Renewable
Other
% Consumption
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020



Senergy Econnect

Studying the impact of new renewable generation

Liaising with DNSPs on behalf of clients

Designing transmission network connections and turbine collection arrays

National Grid

Review of Planning Criteria

→ Required Boundary Capability

Offshore Development Information Statement

Power Flow Assessment of New Renewable Generation

2050 Scenario Analysis

Other Visits

Utilities:

Spanish TSO Red Eléctrica de España

Finnish TSO Fingrid

Swiss TSO Axpo

Canadian TSO HydroOne

Scottish TSOs Scottish Power and Scottish & Southern Energy

Equipment vendors:

ABB's IEC 61850 secondary-systems verification centre

Alstom's Technology Development Centre (esp. HVDC technology)

Psymetrix (wide area phasor monitoring)

RePower (wind turbines)

Siemens (wind turbines)

Other Experiences

Conferences:

2009 Cigre B4 (HVDC and FACTS) Colloquium

2010 Cigre Session

Other experiences:

Participating in the grid code compliance testing of a new wind farm

Shifts in the British national generation & transmission control centre

Organising and participating in several GB industry workshops to debate the proposed changes to the network planning standard

Substation visits

Membership of the Cigre C1 working group 24 on the economic assessment of power systems (ongoing)

Key Scholarship Impressions

Resolving the difficulties associated with connecting large centralised renewable generation to the transmission system:

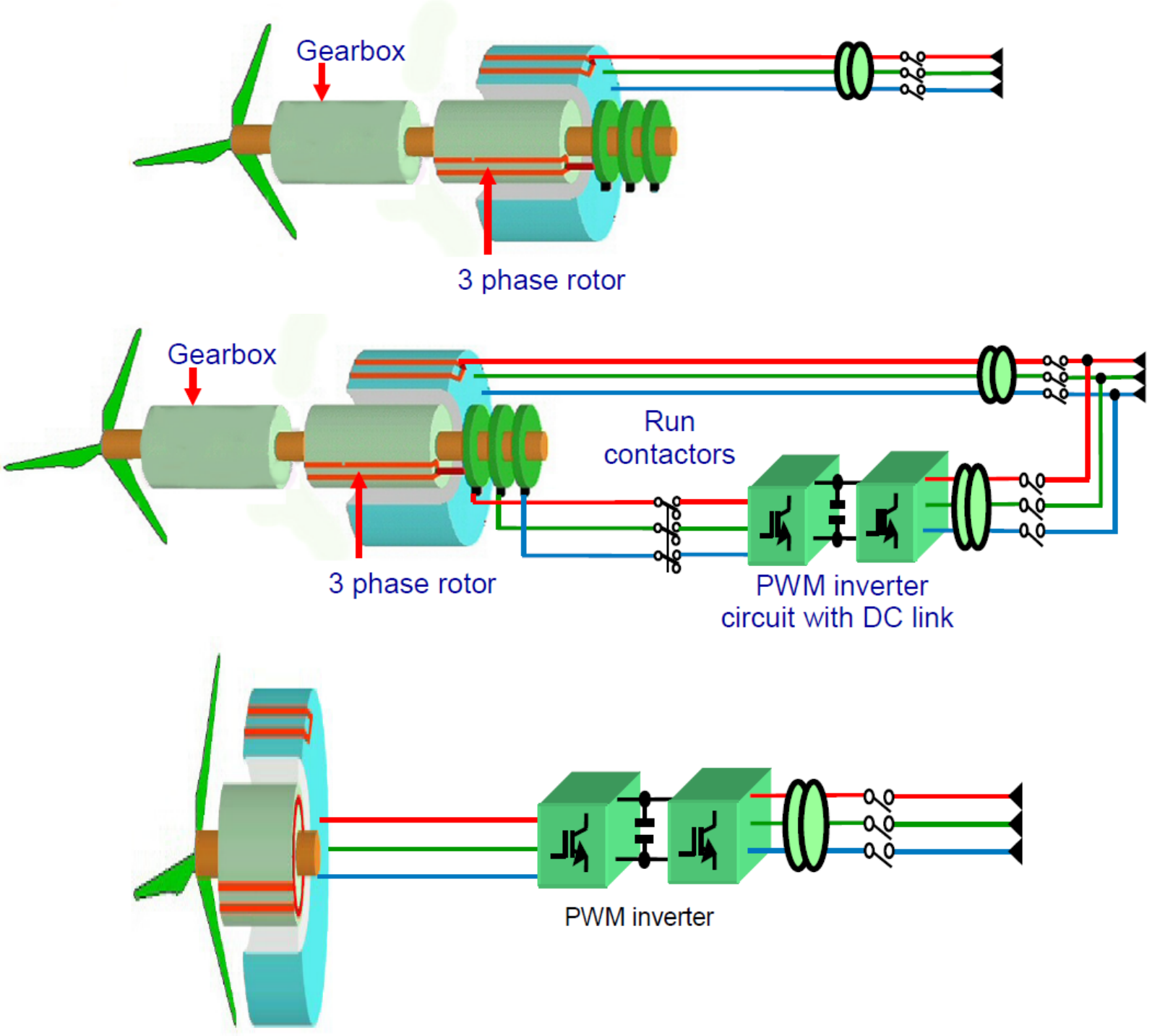
- **Characteristics of renewable generators**
- **Location of renewable energy sources**
- **Variability of renewable energy sources**

… as <u>economically</u> as possible.

Key Scholarship Impressions

Characteristics of Renewable Generators:

- Not all turbines are created equal


Gearbox
3 phase rotor
Gearbox
Run
contactors
3 phase rotor
PWM inverter
circuit with DC link
PWM inverter

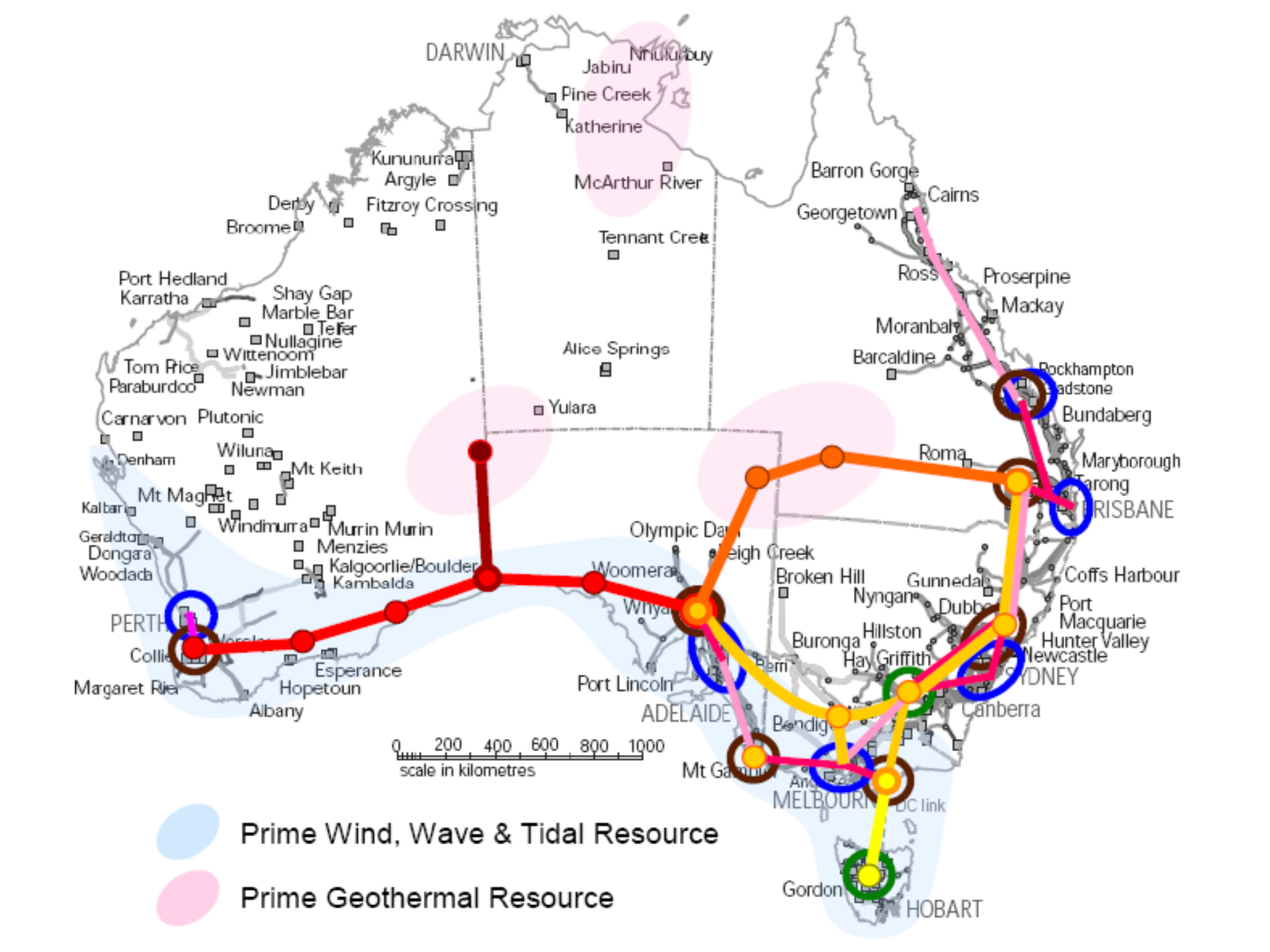
Key Scholarship Impressions

Characteristics of Renewable Generators:

- Not all turbines are created equal

Location of Renewable Generation

- N-1 is not always the best approach
- HVDC technology is evolving rapidly
- Multi-function, interconnected network design


DARWIN
Nhulunbuy
Jabiru
Pine Creek
Katherine
Kununurra
Argyle
McArthur River
Barron Gorge
Cairns
Derby
Fitzroy Crossing
Broome
Georgetown
Tennant Creek
Port Hedland
Karratha
Shay Gap
Marble Bar
Telfer
Nullagine
Wittenoom
Tom Price
Paraburdoo
Jimblebar
Newman
Alice Springs
Ross
Proserpine
Mackay
Moranbah
Barcaldine
Rockhampton
Gladstone
Yulara
Carnarvon
Plutonic
Denham
Wiluna
Mt Keith
Bundaberg
Roma
Maryborough
Tarong
Mt Magnet
Kalbarri
Windimurra
Murrin Murrin
BRISBANE
Geraldton
Dongara
Menzies
Olympic Dam
Woomera
Leigh Creek
Kalgoorlie/Boulder
Kambalda
Broken Hill
Gunnedah
Coffs Harbour
Woodada
Nyngan
Dubbo
Port Macquarie
PERTH
Hillston
Buronga
Hunter Valley
Griffith
Newcastle
Esperance
Port Lincoln
SYDNEY
Hopetoun
Albany
ADELAIDE
Canberra
Bendigo
0 200 400 600 800 1000
scale in kilometres
MELBOURNE
BC link
Gordon
HOBART
Prime Wind, Wave & Tidal Resource
Prime Geothermal Resource

Key Scholarship Impressions

Characteristics of Renewable Generators:

- Not all turbines are created equal

Location of Renewable Generation

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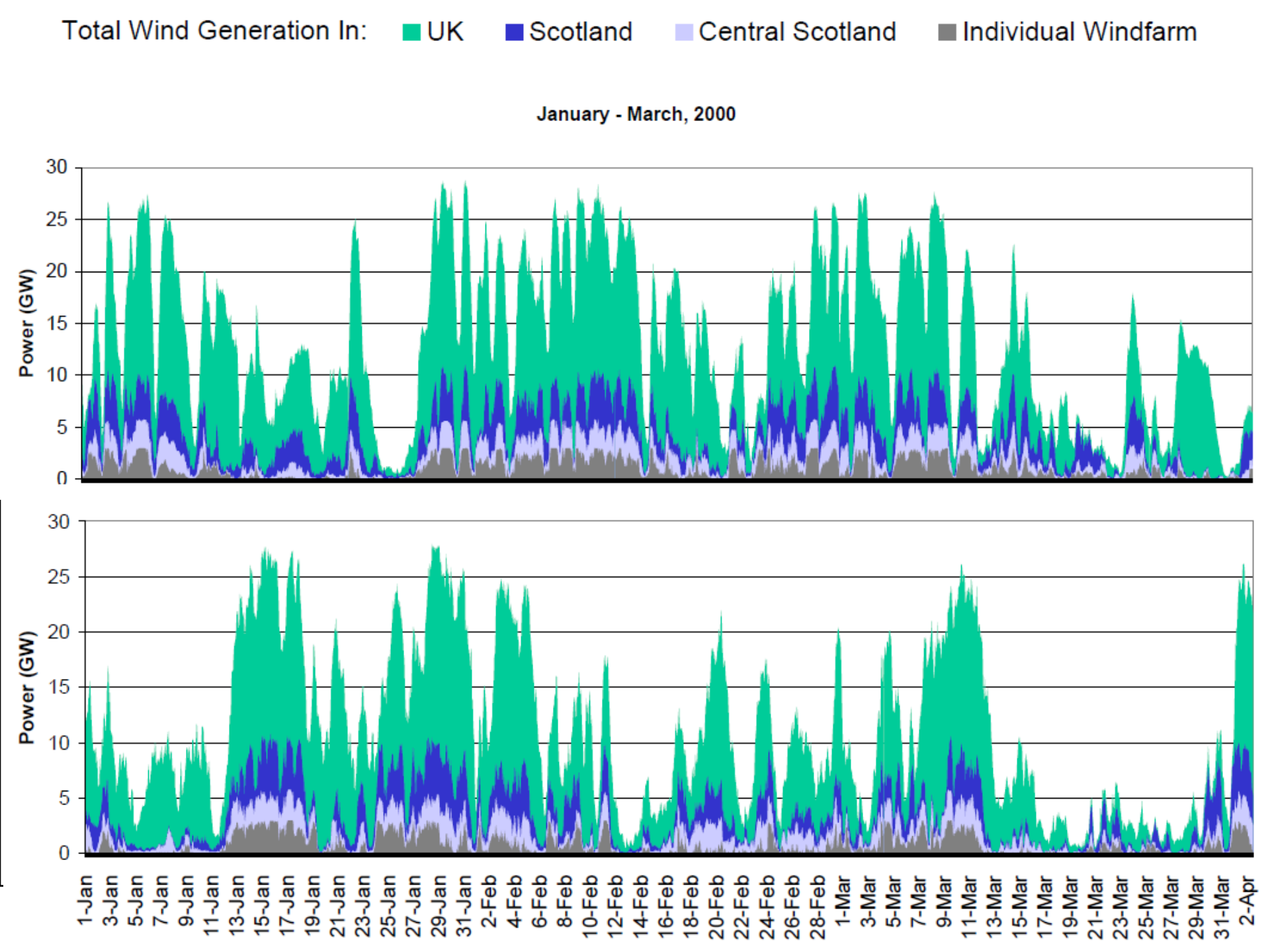
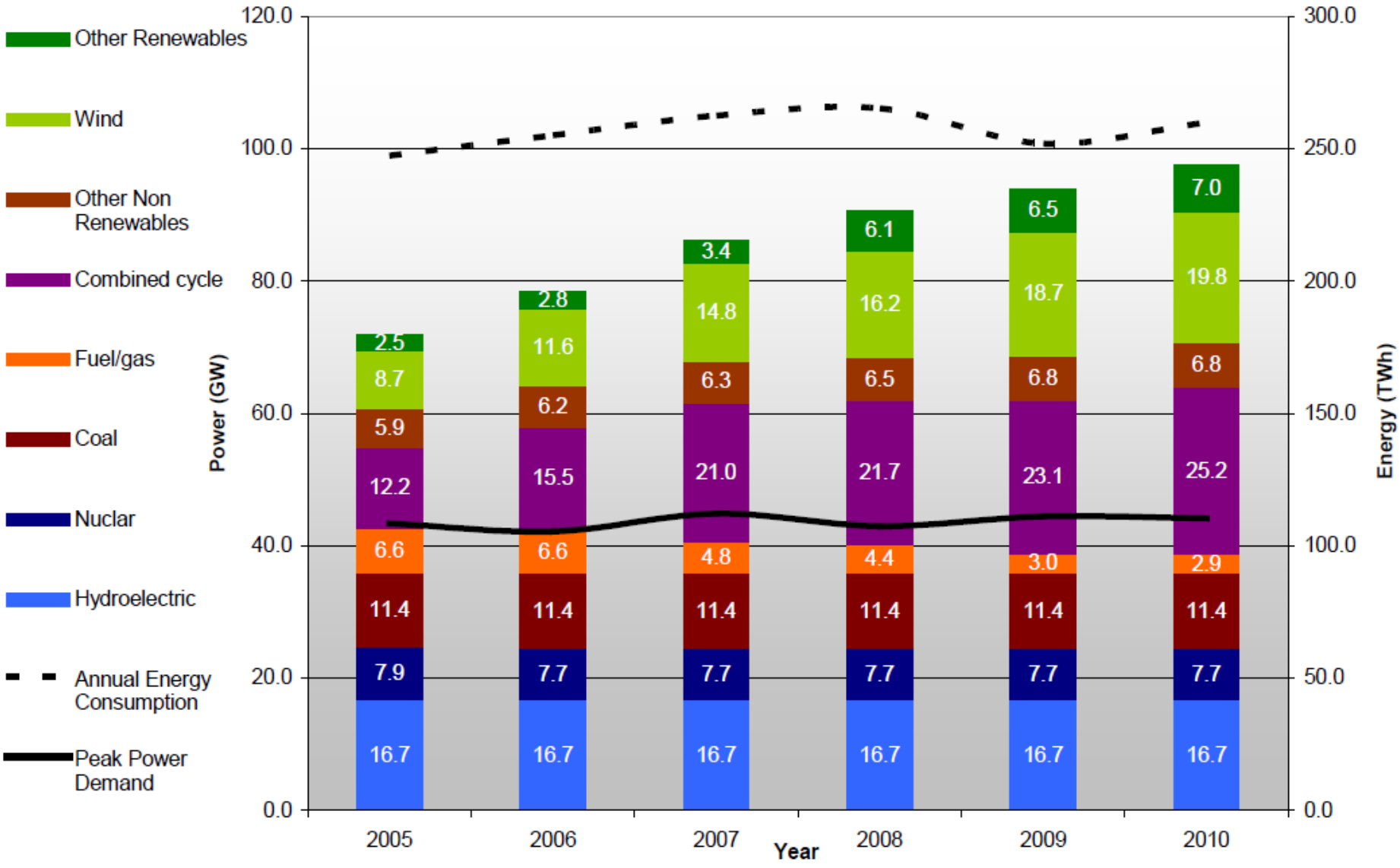
Intermittency of Renewable Energy:

- Wind generators are *very* correlated → cost


Total Wind Generation In:
UK
Scotland
Central Scotland
Individual Windfarm
January - March, 2000
Power (GW)
0
5
10
15
20
25
30
1-Jan
3-Jan
5-Jan
7-Jan
9-Jan
11-Jan
13-Jan
15-Jan
17-Jan
19-Jan
21-Jan
23-Jan
25-Jan
27-Jan
29-Jan
31-Jan
2-Feb
4-Feb
6-Feb
8-Feb
10-Feb
12-Feb
14-Feb
16-Feb
18-Feb
20-Feb
22-Feb
24-Feb
26-Feb
28-Feb
1-Mar
3-Mar
5-Mar
7-Mar
9-Mar
11-Mar
13-Mar
15-Mar
17-Mar
19-Mar
21-Mar
23-Mar
25-Mar
27-Mar
29-Mar
31-Mar
2-Apr

Growth of Demand and Generation Capability in Spain and Portugal



Key Scholarship Impressions

Characteristics of Renewable Generators:

- Not all turbines are created equal

Location of Renewable Generation

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- HVDC technology is evolving rapidly
- Multi-function, interconnected network design

Intermittency of Renewable Energy:

- Wind generators are *very* correlated → cost
- Planning & operations more complex & ambiguous
- Generation subsidies can skew operation & planning

Personal Growth / Interest

Broadened Perspective

Unfamiliar situations → Initiative & Confidence

Dealing with uncertainty & things not going according to plan

Many fond memories and new friends

Thank you!