

UNIVERSITY OF SOUTHERN QUEENSLAND

**Energy Consumption, Economic Growth and CO₂ Emissions in
Australia: The Potential for Energy Conservation**

A Dissertation submitted by

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CERTIFICATION OF DISSERTATION

I certify that the ideas, analyses, and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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DEDICATED

TO

THE DEPARTED SOUL OF MY BELOVED FATHER, WHO
TAUGHT ME THE VALUE OF EDUCATION

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ABSTRACT

This thesis examines the role of energy on economic output, the inter-relationship between them and discusses the potential for various energy conservation alternatives to reduce CO₂ emissions in Australia. The analyses are based on time series models of the Australian economy.

The role of energy on output is examined by employing a multivariate approach. The estimation result for the production function model demonstrates the primary role of energy on economic output in Australia. The long-run relationship and bidirectional causality between energy use and economic growth is confirmed by alternative modelling frameworks, econometric methods and different energy vectors. Direct cuts in energy consumption would therefore place a negative effect on output growth in Australia.

Once reduction of energy consumption is found to be undesirable, if taken literally, this would adversely affect economic performance and, thus, the consideration of policy instruments promoting fuel switching and energy efficiency tend to be the central focus as a measure of energy conservation to reduce emissions. The possibility of interfuel substitution is examined empirically in this study by estimating a translog cost function for the aggregate economy and different sectors/sub-sectors. The empirical evidence indicates a weak form of substitutability among different energy types. However, the possibilities of substitution are found to be relatively stronger at the lower level of aggregation of the economy. For the 'Electricity generation' sub-sector, which is at the centre of the CO₂ emissions problem in Australia, the estimation results indicate the possible substitution between

coal and gas, but estimated elasticity coefficients are small in magnitude. Moreover, existing technologies in coal are found *energy using*, suggesting the proposition that a large change in relative price would be essential to encourage low emitting technologies.

The decomposition of energy intensity, CO₂ intensity and absolute CO₂ is performed by applying Logarithmic Mean Divisia Index (LMDI) decomposition approach. The result from the decomposition analysis of energy intensity shows that energy efficiency has deteriorated in electricity generation in Australia since the 1990s. This is somewhat different from the energy efficiency trends in the aggregate economy which generally show improvements of energy efficiency over the last few decades. However, several potential risk factors are observed from the recent trends, even at the aggregate level of the economy. For example, energy efficiency deteriorated in 2009 and was even reversed in 2006. It was found that some sectors/sub-sectors are lagging behind in reducing CO₂ emissions from energy efficiency improvements and therefore require particular policy attention.

The decomposition of CO₂ emissions indicates that the future path of emissions reduction, especially in the context of attaining the targets for 2020 and beyond, is very challenging for Australia. The combined impact of scale effect (as measured by increases in wealth and population) has been a dominant factor in increasing emissions. On the positive side, the wealth effect has acted to slow down the rate of increase of per-capita emissions in the most recent period. Further investigation of the inverted U-shape trajectory between per-capita emissions and per-capita income provides support for the existence of an *environmental Kuznets curve* for CO₂ emissions, along with a possibility of a turning point in the near future.

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LIST OF ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AMDI	Arithmetic Mean Divisia Index
ARDL	Autoregressive Distributed Lag
CDIAC	Carbon Dioxide Information Analysis Centre
CO ₂	Carbon Dioxide
CPI	Consumer Price index
CSIRO	Commonwealth Scientific and Industrial Research Organization
DCCEE	Department of Climate Change and Energy Efficiency
DW	Durbin-Watson
ECM	Error Correction Model
EKC	Environmental Kuznets Curve
EU	European Union
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GJ	Gigajoule
GNP	Gross National Product
IDA	Index Decomposition Approach
IEA	International Energy Agency
IFS	International Financial Statistics
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
LMDI	Log Mean Divisia Index
LR	Likelihood Ratio
LS	Lee and Strazicich
Mt	Metric tonnes

OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
PhD	Doctor of Philosophy
PJ	Petajoule
PP	Phillips and Perron
SBC	Schwarz Bayesian Criterion
SDA	Structural Decomposition Approach
SUR	Seemingly Unrelated Regression
TY	Toda and Yamamoto
UK	United Kingdom
US	United States
VAR	Vector Autoregressive
VECM	Vector Error Correction Model