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**An ecological economics of
eco-efficiency
- theory, interpretations and applications**

A thesis presented in partial
fulfilment of the requirements for the degree of
Doctor of Philosophy in ecological economics

At Massey University, Palmerston North


Nigel Alan Jollands

2003



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This is to certify that the research carried out for my Doctoral thesis entitled "An ecological economics of eco-efficiency – theory, concepts and applications" in the School of People, Environment and Planning, Massey University, Palmerston North, New Zealand is my own work and that the thesis material has not been used in part or in whole for any other qualification.

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Abstract

Eco-efficiency emerged onto the world stage as the business input into the 1992 Rio Earth Summit. The concept has served to bring the business community into the sustainability debate and enabled businesses to demonstrate significant environmental improvement. The concept is also beginning to play a key role in national sustainable development policy. However, the recent interest in eco-efficiency has highlighted several unresolved and sometimes contentious issues which are addressed in this thesis.

The overall aim of this thesis is to contribute to the understanding of the eco-efficiency concept and its analytical application by situating the research within an ecological economic framework.

This thesis begins by arguing that conventional 'eco-industrial épistémé' interpretations of eco-efficiency are developed within the narrow confines of a world view that is committed to business-as-usual. This assumes controllability of production processes, sees technology as a fix for environmental problems and assumes independence of economic and environmental production processes. This thesis then proposes to broaden the notion of eco-efficiency by applying an ecological economic theoretical framework. This thesis recommends a nested-hierarchy framework of three tiers for interpreting eco-efficiency. The thesis uses ecological economic theory to argue that eco-efficiency must be embedded within physical scale (first tier) and social considerations (second tier). The third (eco-efficiency) tier is interdisciplinary and pluralistic. It encourages a view that perspectives of eco-efficiency are context dependent. It also promotes tolerance and acceptance that all perspectives of eco-efficiency provide important insights into eco-efficiency.

Previously, little attention has been devoted to measuring and analysing eco-efficiency for national policy purposes. This thesis develops and applies three promising analytical techniques to aspects of New Zealand's eco-efficiency; Divisia decomposition analysis (for isolating structural and technical components of change), inverse-Leontief based multiplier analysis (for measuring indirect effects) and principal components analysis (for reducing the number of indicators to a manageable level). All three empirical chapters identify the road transport sector as having relatively low and decreasing energy and CO₂ efficiencies. This is of concern as the sector has proven to be one of the most difficult to influence from an environmental perspective. Several other sectors warrant attention by virtue of their low eco-efficiency measures; 'other mining', 'other farming', dairy farming, meat products and dairy products. Urgent attention is required to improve the environmental behaviour of these sectors.

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List of abbreviations used in this thesis

BAU	Business as usual
BOD	Biological oxygen demand
CO ₂	Carbon dioxide
DRP	Dissolved reactive Phosphorous
EECA	Energy Efficiency and Conservation Authority
EIE	Eco-industrial épistémé
EKC	Environmental Kuznets Curve
EPIP	Environmental Performance Indicators Programme
GDP	Gross Domestic Product
ID	Index decomposition
ILM	Inverse Leontief matrix
IO	Input-output
IOD	Input-output decomposition
IPCC	Intergovernmental Panel on Climate Change
ISEE	International Society for Ecological Economics
ISEW	Index of sustainable Economic Welfare
kJ	Kilo Joule
MB	Marginal benefit
MC	Marginal cost
MEC	Marginal external cost
MK	Manufactured capital
MPP	Maximum power principle
MRPT	Marginal rate of product transformation
MRS	Marginal rate of substitution
MRTS	Marginal rate of technical substitution
MSB	Marginal social benefit
MSC	Marginal social cost
N ₂ O	Nitrous oxide
NH ₄	Ammonia
NHS	British National Health Service
NK	Natural capital
NZBCSD	New Zealand Business Council for Sustainable Development
NZSIC	New Zealand Standard Industrial Classification
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of Petroleum Exporting Countries
PCA	Principal components analysis
PPF	Production possibility frontier
QEM	Quality equivalent method
sej	Solar emjoule
TKN	Total Kjeldahl Nitrogen
UN	United Nations
WBCSD	World Business Council for Sustainable Development
WCED	World Council on Environment and Development
WTP	Willingness to pay
ΔG	Gibbs free energy change