The WADE Economic Model – Previous Results and Future Applications

World Alliance for Decentralized Energy (WADE)

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1. Brief Introduction to the WADE Economic Model

Decentralised Energy (DE)

DE technologies are those *that produce electricity at or close to the point of consumption*. They include:

· High efficiency cogeneration / CHP

· On-site renewable energy systems

· Energy recycling systems, including the use of waste gases, waste heat and pressure drops to generate electricity on-site.

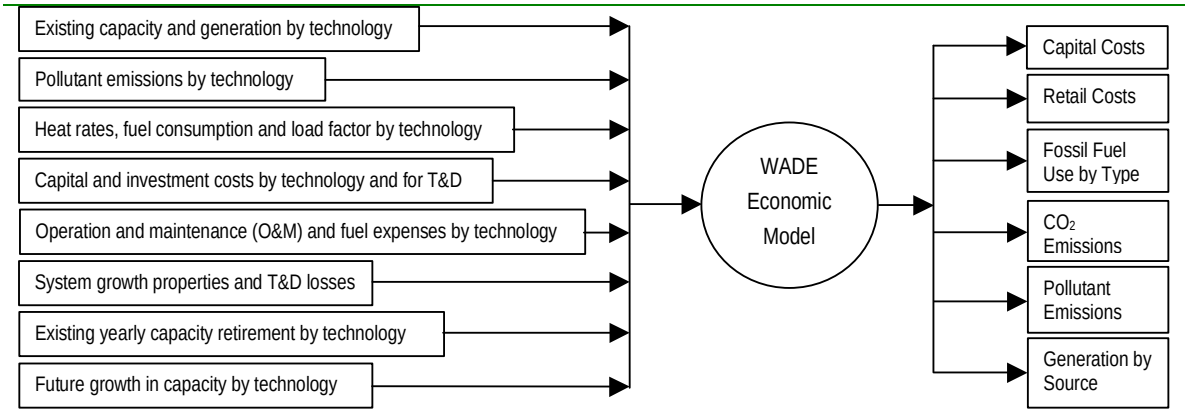
1.1 Purpose of the WADE Economic Model

The purpose of the WADE Economic Model is to calculate the economic and environmental impacts of supplying incremental electric load growth with varying mixes of decentralized energy (DE) and central generation (CG). With changed input assumptions, the model can be adapted to any country, region or city in the world. Starting with known generating capacity for year 0 and projections for retirement and load growth, the model builds user-specified capacity to meet future growth and retirement over a 20-year period.

1.2 Model inputs

Figure 1 above shows the data flow of the WADE model, and specifies the inputs required and the outputs the model gives. In total, the Model requires over 1000 different inputs on four different worksheets. The model's data input requirements are detailed and extensive, requiring comprehensive information about various aspects of existing electricity generation. The model also requires inputs on projections for future technology standards, such as pollution emissions, economic developments, such as fuel prices and overall and peak demand growth. The user can specify the yearly retirement for each technology, and determine which technologies are built to replace retired capacity and meet future demand.

Figure 1. Flow Chart: Overview of the Model Inputs and Outputs



1.3 Working of the WADE Economic Model

The model builds five cases for new capacity to meet incremental demand over 20 years, ranging between the 2 extreme scenarios of 0% DE / 100% CG to 100% DE / 0% CG. The WADE Economic Model also enables users to run any number of scenarios that, for example, favour certain technologies, change fuel prices or meet specific environmental goals.

The Model takes into account many real but little understood features of electricity system operation. For example, it takes into account the significant impact of peak time network losses on the amount of CG required to meet new demand. This is important, because peak line losses are generally higher than average losses, at a time of the largest network load.

1.4 Model outputs

The model's outputs show a range of results for the five scenarios with different shares of CG and DE. It gives the total capital costs (of both generation plant and T&D) over the 20-year period, the retail costs (levelised) in year 20, the annual CO_2 and other pollutant emissions from new and total generation in year 20, and the fuel use, both absolute and by share of generation in year 20. The model can also give results for intermediate years within the 20-year analysis period.

2. Design and Development of the WADE Economic Model

2.1 Design of the model and first application of the model

The WADE Economic Model was designed in 2002 by Marty Collins and Tom Casten of Primary Energy, a WADE Member in the US. They realised that there was no computer model available that directly compared conventional centralised generation to a decentralised energy system. Furthermore, many existing electricity models separated the supply and demand sides, and did not analyse the system as a whole. For instance, transmission and distribution requirements were often neglected, despite the significant implications of these on the costs and efficiency of the system as a whole. The model that was envisioned would include these essential elements, and thereby offer a comprehensive simulation of the electricity system as a whole.

They created the model initially with the purpose of applying it to the US electricity system, and therefore designed it to directly fit the American situation. It was subsequently realised that the model had relevance and validity that reached far wider than the US, and the idea of running the model for other countries around the world emerged.

2.2 Subsequent applications and development of the WADE Economic Model

During the use of the model subsequent to the US application, WADE has been developing and improving the model further, in order to reflect different circumstances in other countries, and fine-tuning the model to varying local circumstances. As a result, the model's possibilities have been extended, new functions have been added and user-friendliness has been improved.

However, the fundamental assumptions and functioning of the model have not changed, as they have withstood extensive examination and scrutiny for each new application. This shows their relevance and validity in many different circumstances, and has created confidence in the reliability of the WADE Economic Model.

3. Previous Model Applications

3.1 An overview of previous model applications

The WADE Economic Model has been applied to a range of different countries and areas. Table 1 gives an overview.

Table 1. Previous applications of the WADE Economic Model

Area	Year	Organisation	Use of Results
Brazil	2003	WADE	Presented at the WADE Annual Conference, Brazil, 2003.
China	2005	WADE for the UK Foreign and Commonwealth Office	Presented at the WADE DE/CHP Conference 2005. It emphasized the potential of DE, formed the basis of the establishing of the WADE China Group, and was translated into Chinese.
European Union	2003	WADE for the European Commission DG-FER Programme	The DG-FER Programme is one of a range of initiatives contributing to EU policy development.
Ireland	2004	WADE for the Republic of Ireland Government	Being used by the government to inform the design of incentives for CHP in national policy
Nigeria		Government of Delta State, Nigeria	Not Available
The Canadian Province of Ontario	2003	WADE for the Canadian Federal Government	Not known.
Thailand	2004	European Commission COGEN-3 Programme	Not known.
UK	2006	WADE for Greenpeace, UK	To provide inputs to UK Energy Review, 2006.
USA	2002	Primary Energy, Inc.	Extensive media and lobbying use.
World	2004	WADE	Used for the WADE DE World Survey 2004

General remarks on previous applications:

- The WADE Economic model has been used in a variety of circumstances, which have contributed to its improvement. For example, the areas of previous applications vary greatly in terms of area (e.g. USA and Ireland), energy sources (e.g. Nigeria and Ontario), technologies (e.g. UK and Brazil) and future demand scenarios (the EU and China). This emphasises the wide applicability of the model and its strong basic principles, which have proved relevant in all cases.
- Several reputable organisations and governments have used the WADE Economic model. This suggests growing interest and trust in the model, and its uniqueness in directly comparing DE and CG.
- The results of the WADE Economic model have been used for various purposes, ranging from promotion only, to directly informing policy development. The use of

the model outputs has become more substantial and influential over time, which we expect to continue. Government involvement is key in ensuring the model results are put into actions through strategy decisions and policy measures. The model applications are therefore not merely a theoretic or academic exercise, but of practical interest to inform energy choices.

3.2 Current Model Applications

Currently the model is being used in several places around the world, as shown in table 2.

Table 2. Current applications of the WADE Economic Model.

Area	Organisation	Planned Use of Results
Australia	Commonwealth Scientific and Industrial Research Organisation (CSIRO), a Federal Government Agency.	Part of the Energy Transformed Flagship Programme of CSIRO to evaluate the potential for low emissions DE technologies in Australia.
The City of Calgary	NewERA, Canada's Alliance for DE.	Will be used to engage utilities and government organisations in debate to consider relative advantages and disadvantages of DE compared to CG.
Germany	IZES gGmbH (Institut für ZukunftsEnergieSysteme) for the German Ministry for Environment	Will be used to inform future energy and environmental policy of the German government.
Portugal	COGEN Portugal	To strengthen COGEN Portugal's influence in national policy development.
The Canadian Province of Ontario	NewERA, Canada's Alliance for DE	Will be used to engage utilities and government organisations in debate to consider relative advantages and disadvantages of DE compared to CG.
Sri Lanka	WADE for the European Commission	Part of project to develop a complete Energy Plan for the country

3.3 Results of Previous Model Applications

Table 3 gives an overview of the results from previous WADE Economic Model Applications[1] for seven parameters: capital costs, retail costs, CO_2 emissions, fossil fuel use, NO_x emissions, SO_2 emissions and PM10 emissions. The figures represent the percentage saving for the 100% DE scenario compared to the 100% CG scenario. Figures 2 to 6 show these results graphically.

[1] The results for the Nigerian and Thai applications are unfortunately not available.

Table 3. Results from previous applications of the WADE Economic Model.

	Brazil	China	EU	Ireland	Ontario	USA	World
Capital cost	46%	38%	45%	29%	58%	44%	30%
Retail costs	40%	28%	37%	16%	42%	40%	29%
CO_2 emissions	-22%	56%	12%	34%	41%	49%	47%
Fossil fuel use	-17%	30%	5%	64%	32%	14%	11%
NO_2 emissions	-169%	89%	60%	43%	29%	58%	66%
SO_2 emissions	-8%	89%	22%	40%	2%	68%	72%
PM10 emissions	-171%	58%	39%	39%	38%	43%	44%

Figure 2. Retail cost results for previous WADE Economic Model Applications

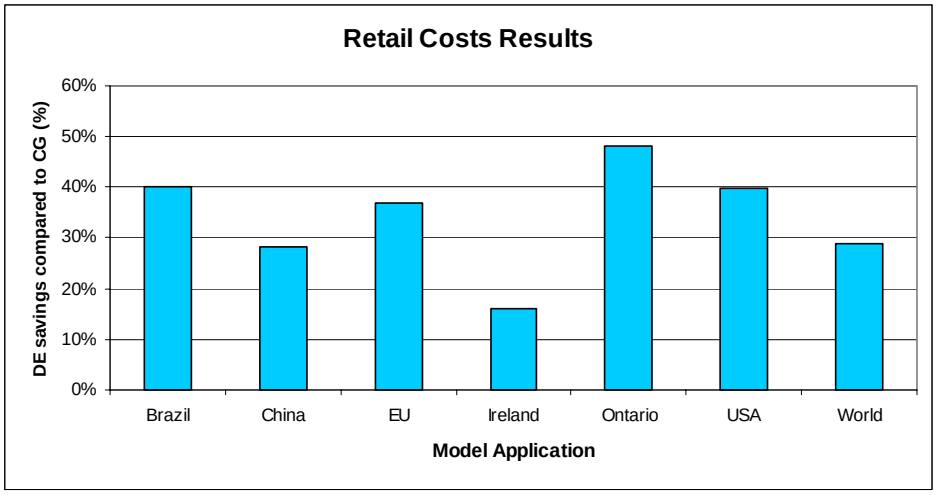
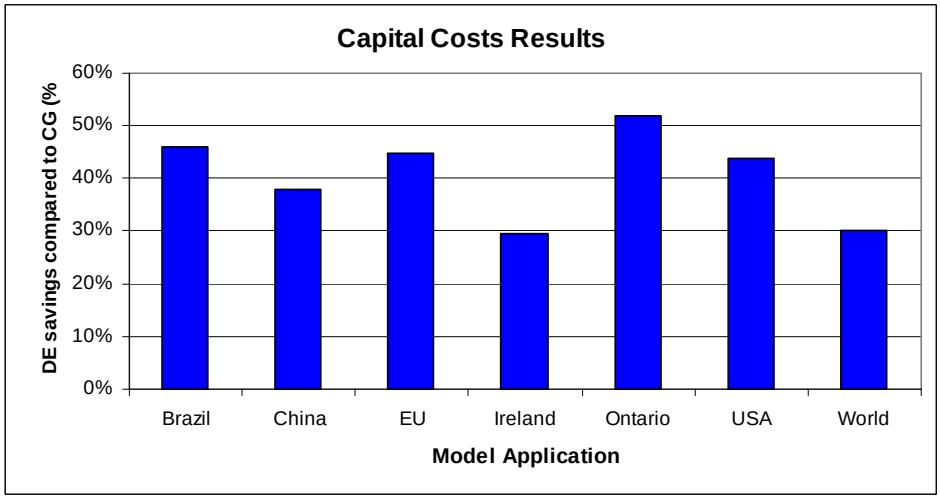


Figure 3. Capital cost results for previous WADE Economic Model Applications



Two main conclusions can be draw from the cost results for the previous applications shown in figures 2 and 3.

- Firstly, the cost results are surprisingly similar, as in all cases DE was cheaper than CG. The DE savings differ somewhat between countries, but this depends on local circumstances. For instance, building transmission and distribution in a small and relatively dense country like Ireland is clearly easier than in a much larger, so the advantage of DE requiring less T&D is less important.
- Secondly, capital costs and retail costs results are similar in each application, with the capital cost saving generally slightly higher than the retail cost saving, due to the higher fuel prices and operation and maintenance costs for DE.

Figure 4. CO_2 emissions results for previous WADE Economic Model Applications

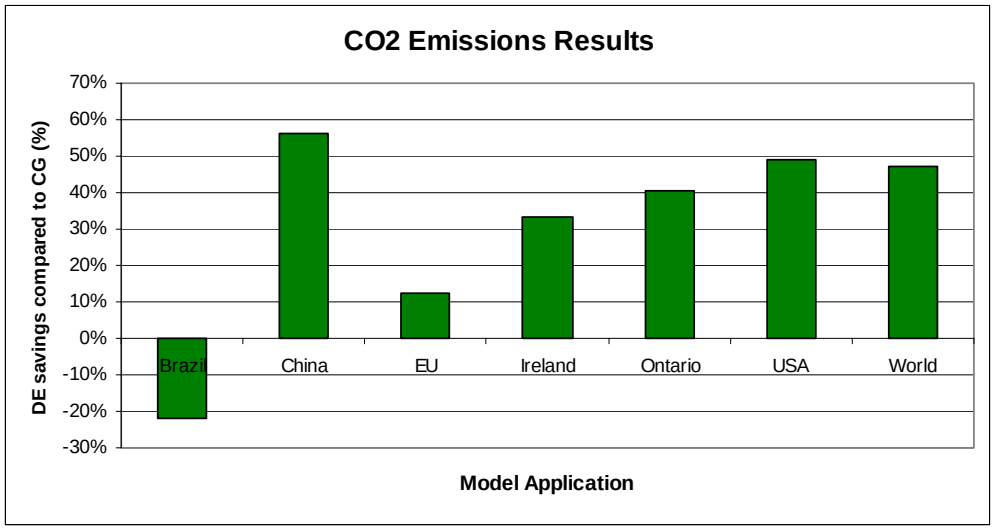


Figure 5. Fossil fuel use results for previous WADE Economic Model Applications

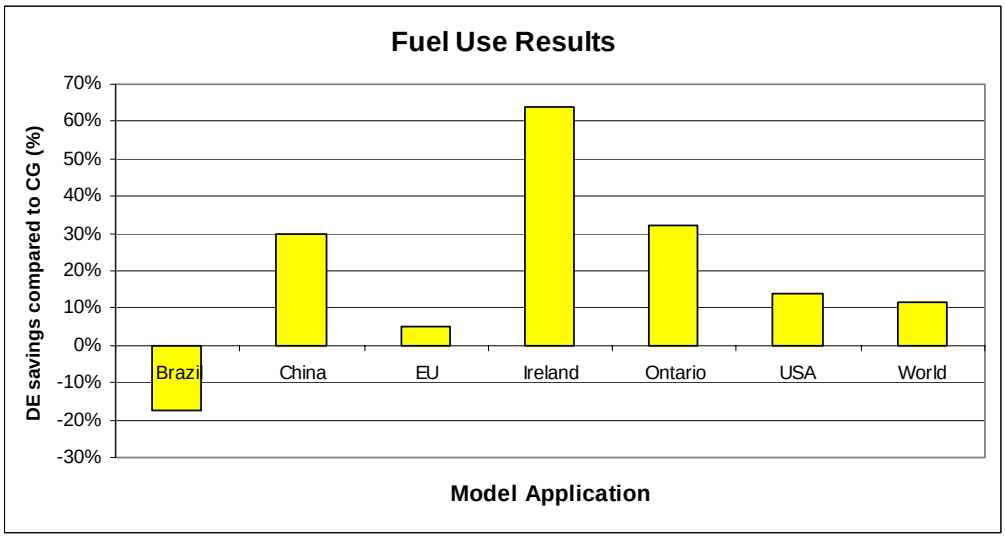
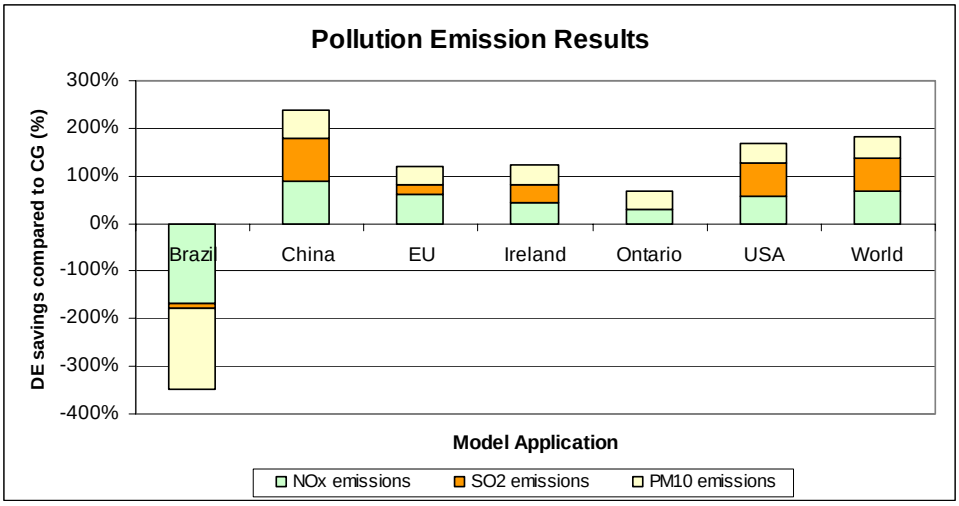


Figure 6. Pollutant emissions results for previous WADE Economic Model Applications



Figures 4 to 6 indicate the following:

- Emission and fuel use results show positive DE savings in all cases, except the Brazil application. This is due to the fact that the main CG option in Brazil remains large-scale hydro plants. Decentralising the energy system therefore means replacing renewable energy with gas-fired sources.
- The potential for CO_2 and pollutant emission savings depends heavily on the future fuel mix. For instance, fossil fuel use savings are lower for the US than for Ontario, while CO_2 emission savings are higher. This can be explained through the difference in likely future fuel mix.

3.4 Scenario modelling

Previous applications of the WADE Economic Model have included a wide range of scenarios to analyse the sensitivity of the results to changes in inputs, so as to compare various possible future developments. Table 4 gives an overview of these scenarios.

Table 4. Scenarios run for previous applications of the WADE Economic Model.

Scenario type	Sensitivity parameter	Examples
Electricity demand	Demand growth and/or peak demand growth	Demand growth /2, zero-demand growth, negative demand growth. Model outputs are highly sensitive to changes in projected demand growth.
Financial	Financing term	Financing term x2
	Fuel price	Fuel price x2, Fuel price /2
	T&D costs	T&D costs x2, zero T costs
Generation portfolio	Future growth determination	High-coal generation, high renewables scenario, no-nuclear scenario
Electricity system properties	T&D safety margin	No T&D safety margin, increased T&D safety margin

Table 4 shows the large number of scenarios that can be run using the WADE Economic Model. Many of these scenarios are relevant to every application in any area, for example fuel price sensitivity, while others are very specific, for instance those analysing particular generation portfolios. Clearly the list of possible scenarios is not exhausted, so it is likely that in the course of future applications new scenarios are developed to analyse different parameters, such as the impact of different carbon mitigation strategies, or fuel supply issues.

4. New Applications of the WADE Model

4.1 New Opportunities

WADE is keen to identify new opportunities to apply the model to new regions, and to work with organisations and governments all over the world to strengthen the model further.

Issues of particular interest include:

- Sub-national areas, for instance Canadian provinces (comparable to the Ontario application), US or Indian States. Electricity supply and energy policy is increasingly influenced by state-level initiatives, so applications of the WADE Economic model on this level can be valuable in comparing different strategies. For example, it could be used to analyse the impact of state-level carbon emission trading regimes.
- Cities. These represent a completely different kind of area in terms of energy system. Generally there is a spatial separation of generation and demand, and strong interconnection with adjacent areas. Furthermore, transmission and distribution issues have to be considered separately. This poses new challenges for the WADE model.
- Developing countries. These often face important choices concerning future energy and electricity supply. In addition, they have a large potential for DE, and represent an opportunity to leapfrog the Western model of large-scale central generation. The current application to Sri Lanka is a good example of this.

4.2 Further Development of the WADE Economic Model

There is further scope for improving and developing the Economic Model further. WADE undertakes this work both as part of specific applications in cooperation with other organisations, and by WADE itself in response to new findings or developments in the energy sector. Recent updates have improved the detail of the outputs for fuel-use, and added the possibility for users to incorporate CO_2 emission costs in the results.

Future development of the model is likely to include changes to improve its applicability to smaller areas, such as cities, and to extend the freedom for users to specify separate transmission and distribution characteristics of the system to be analysed. Other possible additions are new technologies, such as Carbon Capture and Storage, and the internalisation of externalities other than carbon emissions.

4.3 Requirements for Using the WADE Model

The WADE Economic Model is accessible and easy to use. There are a few requirements, though, for any successful model application.

- Reliable and up-to-date input data. These form the basis of any model application, and it is therefore essential for building a reliable base scenario from which further model runs can be done. Collecting the data for the model therefore requires some time and effort, but in most cases the data are available from government statistics and other sources.

- Realistic scenarios of future electricity demand growth and technology developments, as well as probable generation portfolios for meeting future electricity needs. It is useful to have a particular real-life issue to analyse, as scenarios can be built around this. These are obviously somewhat speculative, but the model allows the user to do sensitivity analysis, enabling the comparison of various alternatives.

4.4 Practicalities

The WADE model application can be carried out by the Model purchaser, or WADE can undertake this for an additional charge. In the latter case it is a 'turnkey project' for the organisation that commissions the run, and can be completed by WADE in about two months, depending on the availability of data, the requirements of the application and the local circumstances.

For more information on the model itself, previous applications or applying the model in a new project, please contact WADE.

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