

# Effect of Renewable Energy Penetration in Aggregated Energy Costs

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# Objective

- The objective of this study is to analyze the effect that renewable energy penetration has had in energy costs in various countries. This will allow us to establish patterns intended to evaluate the economic feasibility of implementing renewable energy technology in a country.

# Introduction

- Developed countries have invested billions of dollars on developing the political, social and economic infrastructure needed in order to enable the use of renewable sources of energy as an alternative to fossil fuels
- These efforts are paying off decades later as today renewable energy is becoming more accessible
- Various countries are diversifying their energy matrices in order to diminish their dependence of fossil fuels as well as contribute with reducing the environment pollution created as a result of using such fuels since the 19th century.



# Introduction

- Projections from the IEA World Energy Outlook 2011 indicate that the share of fossil fuels in global primary energy consumption is predicted to fall from 81% in 2010 to 75% in 2035, as the use of renewable energy in power generation keeps growing steadily
- According to the BP Statistical Review (BP, 2013),
  - global nuclear power output had the largest decline ever due to Japan's reduction of nearly 90% of its production of nuclear power as a result of the Fukushima tragedy
  - biofuels production recorded the first drop since 2000 due to a decline in the US consumption
  - renewable energy used in power generation grew by 15.2%
  - wind energy, accounted for more than half of renewable power generation growth, with China accounting for the largest increment in wind generation
  - renewable forms of energy accounted for 2.4% of global energy consumption, up from 0.8% in 2002; renewables in power generation accounted for a record 4.7% of global power generation.

# Introduction

- It is a common belief that introducing renewable generation into the energy matrix of a country will reduce the energy costs; however, this is not always the case
- The International Renewable Energy Agency (IRENA, 2013), establishes that seven major components largely determine the cost for renewable power generation technologies,
  - resource quality, equipment cost and performance, balance of project costs, fuel (if any), operation and maintenance costs (and reliability), economic life of the project and the cost of capital
- When excellent local resources are available, mature technologies such as biomass, geothermal and hydropower can all produce electricity at very competitive costs; onshore wind is typically the next most economic, followed by solar photovoltaic (PV) and concentrated solar power (CSP).

# Renewables Technologies: A Path to Sustainability?

- It is evident that the global target is to reduce the fossil fuel consumption whilst satisfying our energy needs
- In order to achieve that objective, as a society we need to redefine our goals and how to achieve them, understand the forces behind the unsustainable engineering and define new directions of research and development that produce the methods that will let us achieve sustainable engineering
- It is important to keep in mind that our goal as society is to find balance among the three pillars of sustainability (social, economic and environmental) both at a local and global scale.

# Energy Indicators

- Socio-economic and environmental studies, among others, must be taken into consideration before choosing the technology to invest in; this decision must be taken wisely and considering the best interest of the people
- In order to assess the best path to follow, international organizations, private companies and governments use indicators to help them formulate coherent forward-looking energy strategies as well as develop planning techniques for sustainable energy development (IAEA, 2002).



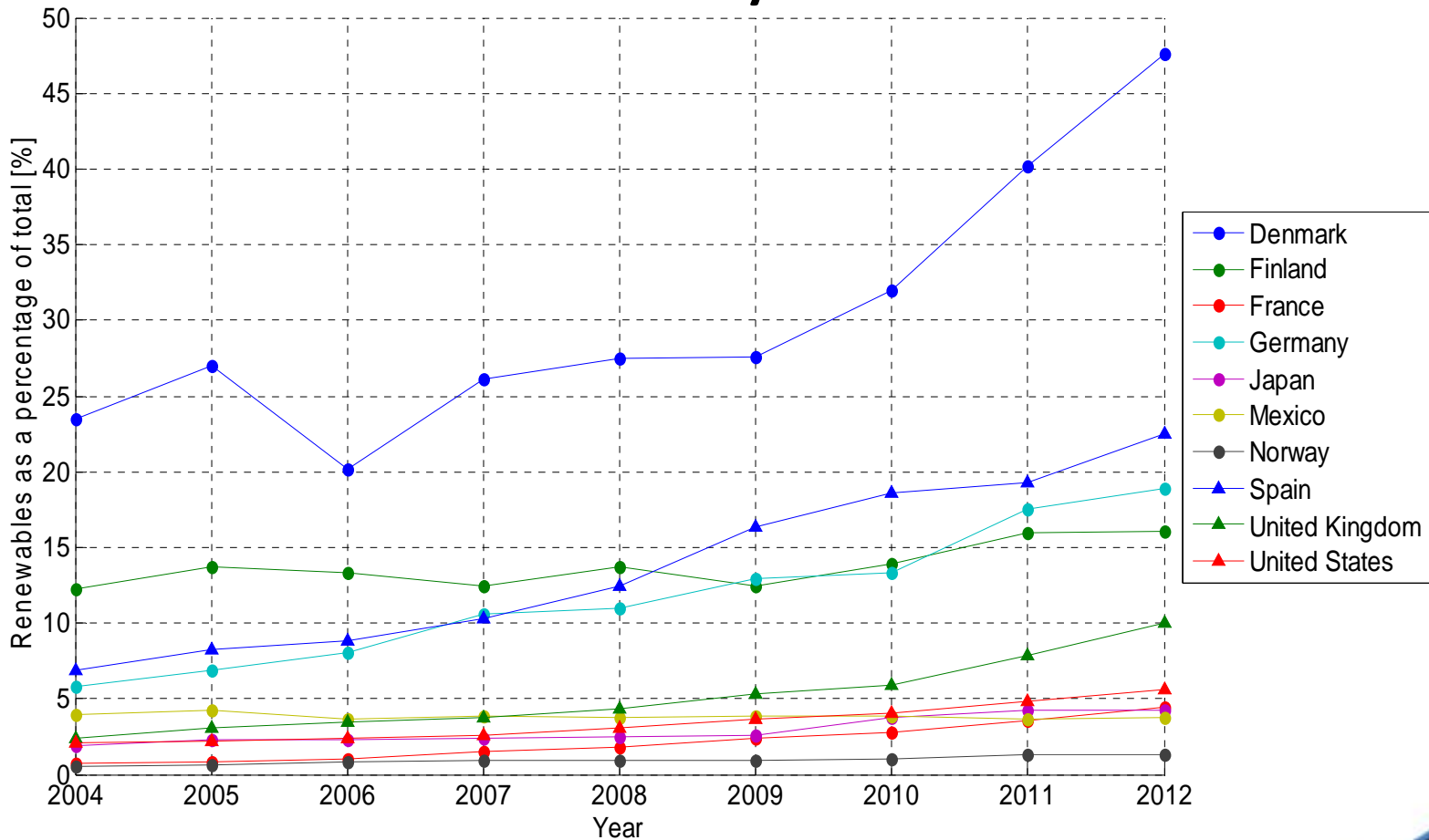
# Energy Indicators

- In this study we used three indicators from The World Bank Database and two from the International Energy Agency. These included:
  - Prices of electricity for industry (US\$/MWh)
  - Prices of electricity for households (US\$/MWh)
  - Electricity production (kWh)
  - Electricity production from renewable sources excluding hydro (kWh)
  - Electricity production from renewable sources excluding hydro (%)
- The prices of electricity for industry and households were extracted from the Key World Energy Statistics of the IEA (IEA, 2004-2012) while the electricity production indicators were extracted from The World Bank Database (WBD, 2013).

# Simplified Energy Data Processing and Analysis

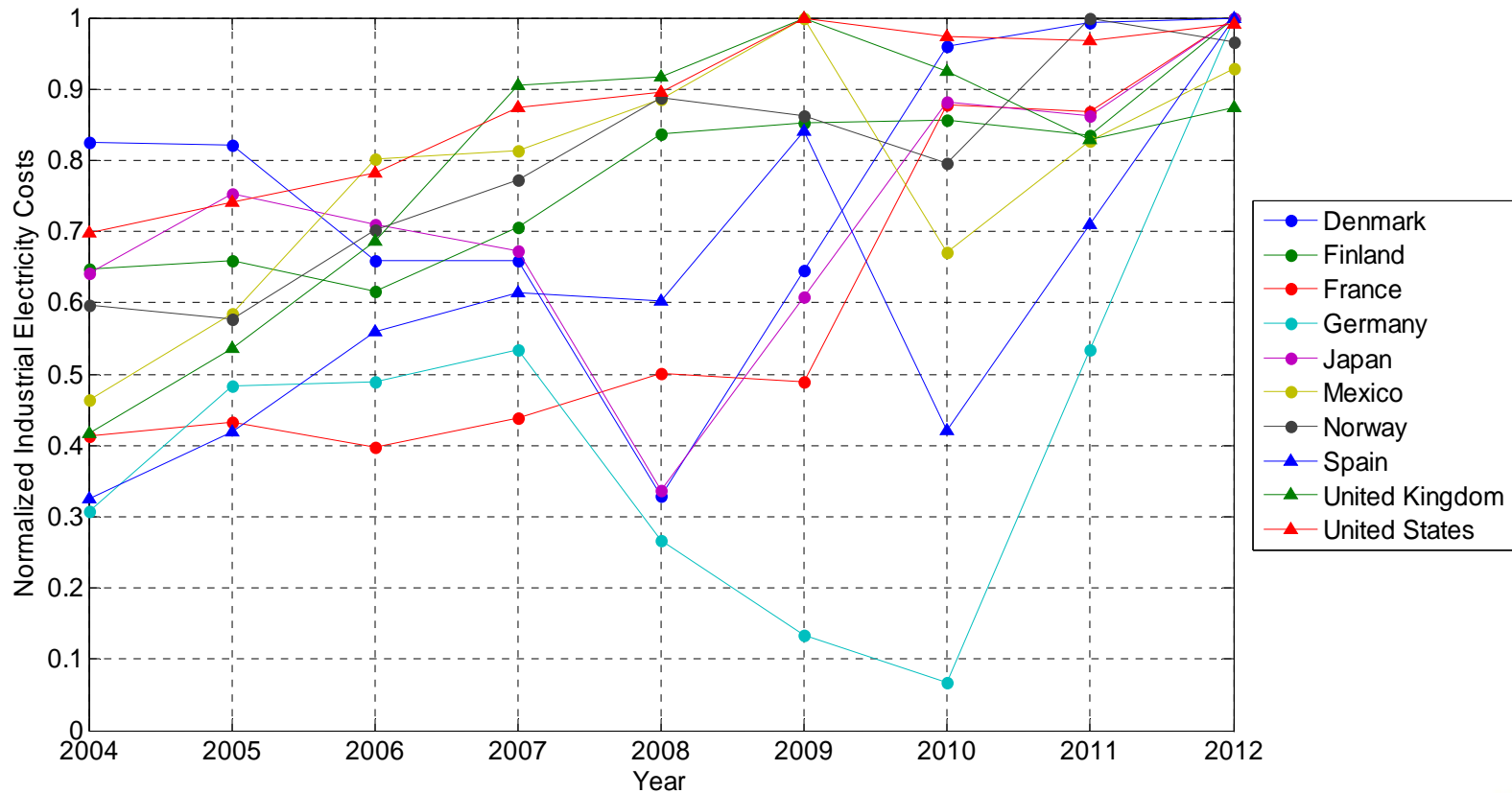
- In order to achieve the objectives of this work a reliable set of energy data was necessary, we have selected 10 countries members of the Organization for Economic Co-operation and Development (OECD). These countries have clear and well developed policies regarding the use of renewable energy resources
- The selected countries for our study are: Denmark, Finland, France, Germany, Japan, Mexico, Norway, Spain, United Kingdom and United States.

# Simplified Energy Data Processing and Analysis



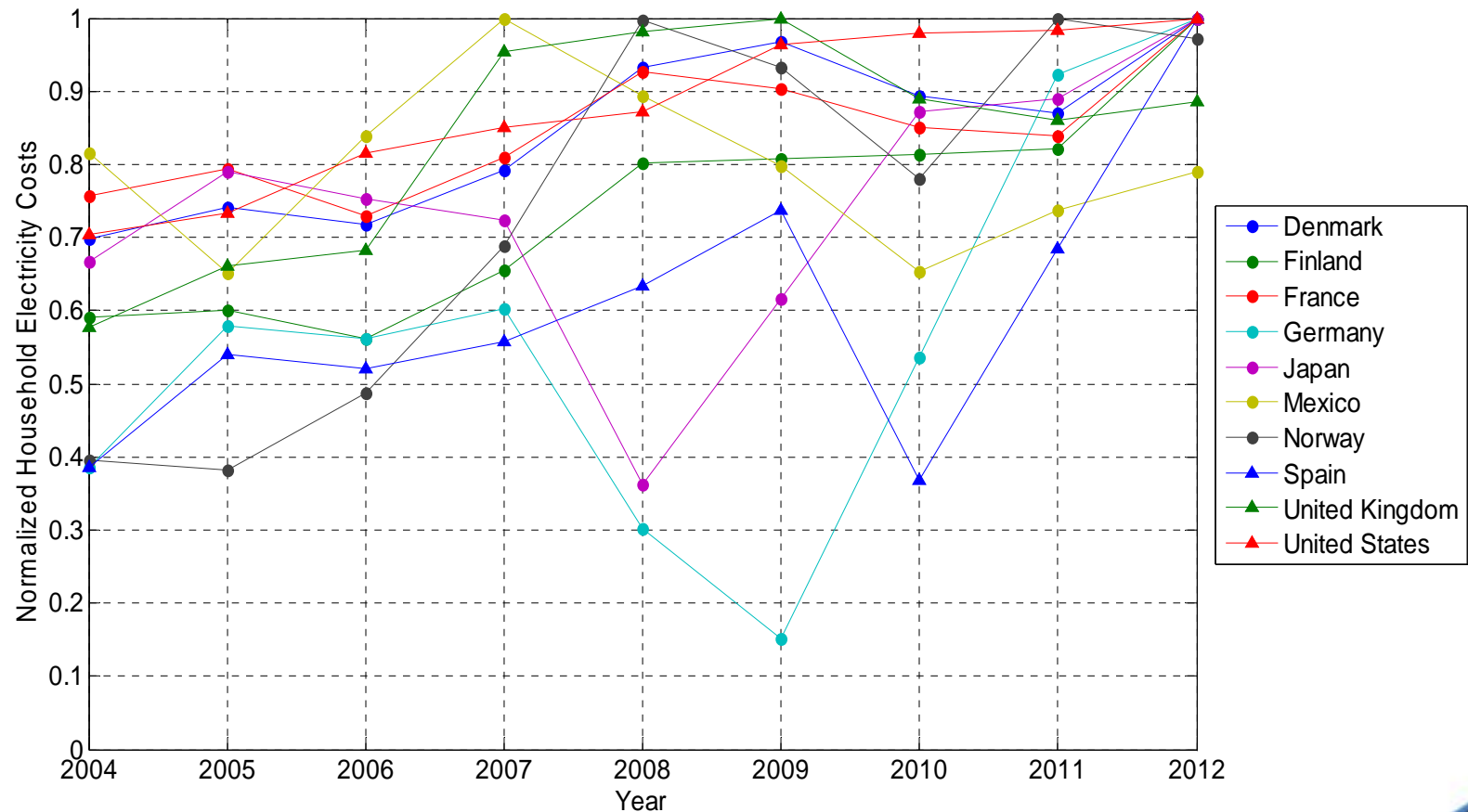
**Figure 1: Electricity Generation from Renewables as a Percentage of Total**

# Simplified Energy Data Processing and Analysis



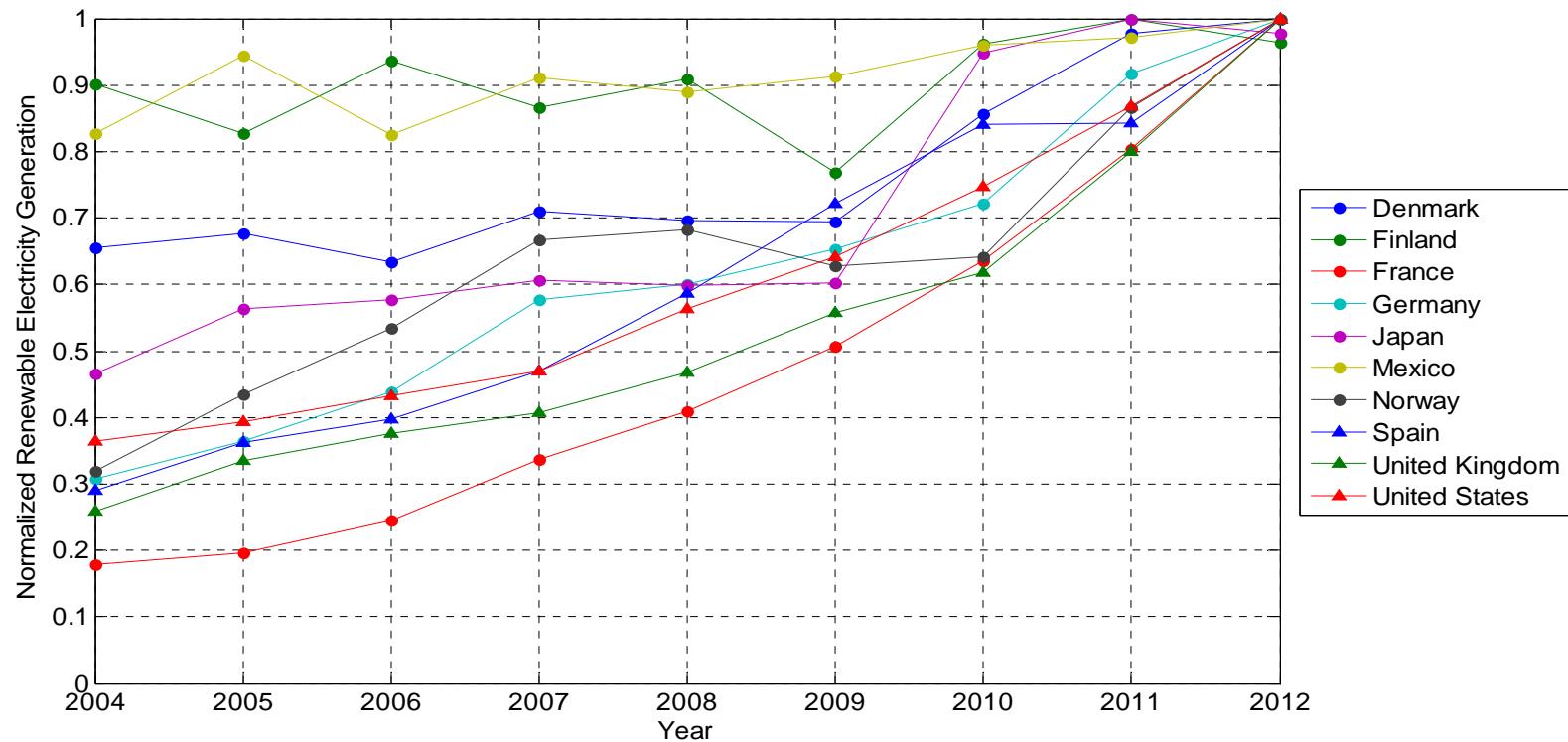
**Figure 2: Industrial Electricity Costs Normalized by Country**

# Simplified Energy Data Processing and Analysis



**Figure 3: Household Electricity Costs Normalized by Country**

# Simplified Energy Data Processing and Analysis



**Figure 4: Normalized Renewable Electricity Generation by Country**

# Simplified Energy Data Processing and Analysis

Country	Industrial	Household	Renewable
Denmark	21.23	43.27	24.14
Finland	54.61	69.00	3.75
France	142.59	32.03	3.69
Germany	224.19	159.55	13.06
Japan	55.95	49.79	2.29
Mexico	100.10	-2.96	-0.20
Norway	61.75	145.61	0.75
Spain	207.38	159.27	15.59
United Kingdom	109.52	53.38	7.59
United States	41.98	41.98	3.48

**Table 1: Percentage Change in Electricity Costs and Renewable Generation from 2004 to 2012**

# Conclusions

- This paper has presented our initial studies on the effects of renewable energy penetration on the final energy costs to the user
- Although some other indices used in the study of renewable energy were presented, our paper introduced a simplified analysis of the energy sector that uses the electric sector behavior as an indicator of the overall effect of renewables over the cost of energy
- A diverse group of countries was selected and the analysis of the available data demonstrated that levels of renewable penetration don't directly correlate to change in energy costs.



# Conclusions

- The results presented in Table 1 help us as an indication of what practices in renewable energy integration to replicate and which to avoid, in terms of the level of success that those countries had with them
- In this respect, Denmark has gained the most from their strong investment in renewables for electric generation, by containing substantially their increase in energy costs with respect to the other members of the OECD community, while the case of Spain has had many difficulties that are manifested in their results for the same evaluation period and a comparable relative investment in renewables.

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# Questions

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