# Chapter 1

# Introduction

*This chapter provides an introduction to the renewable energy scene and the origins of the project.*

## 1.1 Introduction

In the ever evolving world of technology there exists a continual need for energy, especially a clean and sustainable source of energy. Luckily there are a multitude of such clean energy sources, of which wind and solar energy is the most abundantly accessible. The concept of utilising these energy sources is not new to man as is evident when one looks at windmills decorating the countryside, however, the method of harnessing these sources have changed dramatically.

Harnessing these renewable energy sources requires a substantial initial capital investment. In order to justify this investment, one has to ensure that the renewable energy scheme will be effective. The effectiveness of any renewable energy scheme in the world is dependent on an accurate analysis of the renewable energy source at the intended location in order to determine the viability of a chosen renewable energy scheme or hybrid thereof.

## 1.2 Background

South Africa is custodian of somewhat 80% of the world's Platinum Group Metals (PGM) (including platinum and rhodium) reserves. Instead of merely exporting these raw materials, it was decided that South Africa will become a manufacturer of value-added components utilising these resources. Hence, the Hydrogen South Africa (HySA) group was established by the South African government with the aim of establishing South Africa as one of the few nations that produce high-value products for the growing international hydrogen and fuel cells markets [12].

The HySA group is divided into 3 main categories as shown in figure 1.1 consisting of:

- HySA Catalysis;
- HySA Systems;
- HySA Infrastructure.

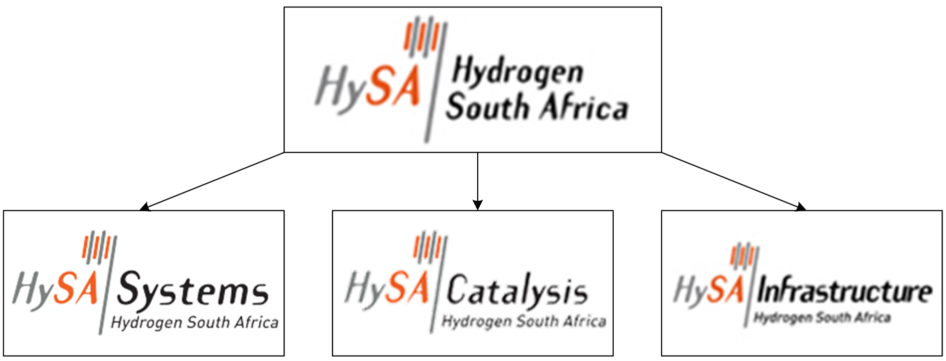


Figure 1.1: HySA family structure

One of the methods employed by HySA to generate hydrogen is by means of a Proton

Exchange Membrane (PEM) electrolyser. PEM electrolysers are considered one of the most favourable technologies for hydrogen generation from water [13].

Currently the supply, storage and transportation of hydrogen fuel is a challenging undertaking [14]. Some of hydrogen's inherent properties, being colorless, odourless and tasteless, further complicates the situation.

The ultimate goal is to have an off-grid (independent from an utility such as Eskom in South Africa) hydrogen production facility, powered by a small scale renewable energy system. This will allow for hydrogen production where the hydrogen is required, circumventing the need for excessive storage and transportation thereof. Future possibilities of small scale renewable energy systems include connecting to the electricity grid, not to draw power, but rather to deliver extra energy to the grid as an independent power provider (IPP).

Keeping in line with the HySA Infrastructure initiative, this simulation model will help pave the way forward to produce hydrogen from a clean and renewable energy source.

## 1.3 Purpose of research

### 1.3.1 Primary objective

The variable nature of the wind speed and the sun solar irradiance makes simulating the probable power output of these renewable energy sources very difficult. This is further complicated when one takes the specific hardware used for harnessing these energy sources into account.

The primary focus of this project was to develop a simulation package, consisting of various sub modules, representing the main components of a small scale renewable energy system as illustrated in figure 1.2.

These sub-modules will provide mathematical representations of the system compo-

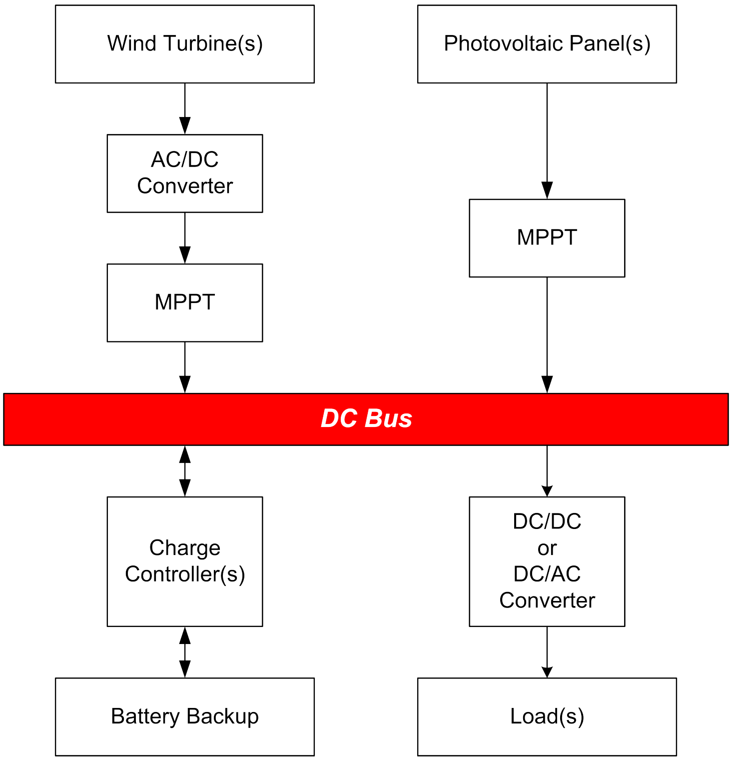


Figure 1.2: High level block diagram of a hybrid renewable energy system [1]

nents, e.g. the wind turbines. The environmental variables (wind and solar) at a specific location must be known in order to accurately utilize the above-mentioned modules. This entailed determining the solar irradiation available at the specified location in conjunction with the optimal tilt angle for the PV panels to maximize power output. A similar analysis of the wind determines what the probable energy output would be for a prescribed turbine at a certain nacelle (hub) height.

### 1.3.2 Secondary objective

As a secondary objective, this mathematical simulation model was integrated with the financial feasibility model developed by Mr. R.P. Louw [15] in order to determine the optimal system configuration in terms of financial viability and component selection.

### 1.3.3 Project demarcation

The main focus of this project was on the creation and integration of the various system modules, and accompanying calculations, for the various renewable energy sources (wind and solar), rather than measuring the environmental data itself. The environmental data required for the simulation is usually acquired over long periods at the intended locations. This data can usually be sourced from meteorological and agricultural institutions such as the South African weather services [16]. Physically obtaining, formatting and verification of this data, does not fall within the project's constraints.

## 1.4 Research methodology

Due to the software nature of the project, the research methodology employed is based on the outcomes of the design science research contribution criteria as set forth by March et al. [17] which required the following:

- Identify and provide a clear description of the information technology (IT) problem;
- Demonstrate that there is no adequate solution currently available;
- Development and presentation of a novel IT artifact (models or methods);
- Rigorous evaluation of the IT artifact while assessing the usefulness thereof;
- Documentation of the benefits brought about by the artifact.

The simplified waterfall life-cycle model as shown in figure 1.3, was implemented due to the linear nature of the model combined with constant feedback helped to identify any errors at an early stage of the project, and in doing so, help with the verification and validation of the project as discussed in section 3.5.

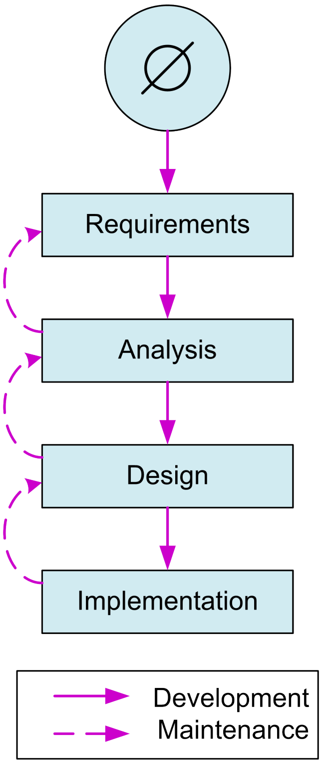


Figure 1.3: Simplified waterfall life-cycle model [2]

## 1.5 Dissertation outline

The flow of the dissertation presented is outlined by:

1. Problem definition describing the need for a renewable energy simulation model:
   - Current approaches to solving the problem;
   - Proposed solution;
2. Technology analysis that revealed what methods and models are available and how they can be adapted to realize the simulation model:
   - Mathematical hardware models;
   - Statistical methods for data manipulation and representation;
3. Implementation of the proposed solution:
   - Functional architectural analysis of the system;

- Programming and integration of the various modules;

4. Evaluation of the proposed solution's results:

   - Accuracy of the simulation's results;
   - Data resolution effects on output calculations;

5. Conclusion:

   - Project summary;
   - Recommendations regarding the implementation and further development of the simulation model;