A ‘Green Economy Tourism System’ (GETS): Architecture and Usage

Alexandra Law[a],
G. Michael McGrath[b], and
Terry DeLacy[a]

[a]School of International Business
[b]School of Management and Information Systems
Victoria University, Melbourne, Australia
alexandra.law@live.vu.edu.au
michael.mcgrath@vu.edu.au
terry.delacy@vu.edu.au

Abstract

The world’s climate is changing and we are seeing the emergence of a new ‘green economy’ around the world. Tourism destinations are challenged to adapt to this new reality in order to stay competitive and sustainable. This paper reports on the development of a decision support system (DSS) to assist destinations with this transition. Based on system dynamics theory, GETS is being developed with the aim to allow for scenario modelling around greenhouse gas reductions, enhancing environments and ecosystems; global, regional, local economic and socio-cultural trends; as well as intersecting with changing market demand, supply chain dynamics, destination competitiveness as well as brand positioning and funding options. This paper introduces the system architecture of GETS and provides a usage example to demonstrate how the desired system capabilities may be achieved.

Keywords: green tourism; sustainability; decision support systems (DSS).

1 Introduction

This paper introduces the system architecture and usage examples of a decision support system (DSS) which is being developed to assist tourism destinations into the new green economy. Countries worldwide are attempting to meet ambitious emission reduction targets and adapt to their individual climate change risks. The UK, for instance, has announced plans to reduce carbon dioxide (CO_2) emissions by 60% by 2050 (compared to 1990 levels) and Germany has committed to a 40% reduction by 2020 (Kannan, 2009; Röttgen, 2010). Such ambitious targets require significant changes, not only in a country’s energy system (Kannan, 2009), but also in all other greenhouse gas (GHG) producing sectors (such as tourism, which is a major user of fossil fuels, particularly through transport as well as heating, cooling and lighting (Becken & Hay, 2007).

Currently, tourism is estimated to contribute around 5% to the world’s total anthropogenic GHG emissions (Scott et al., 2008; World Economic Forum, 2009). However, it is the tourism sector’s growth potential that is giving reason for concern. Estimates show that tourism’s GHG emissions could grow by 161% by 2035 in a business as usual scenario (Scott, et al., 2008). In the context of global decarbonisation trends, such estimates highlight the need for climate change mitigation and adaptation in the tourism sector and emphazise the need to adopt a

M. Fuchs et al. (eds.), *Information and Communication Technologies in Tourism 2012*

more sustainable path with significant changes in policy and strategy. However, green economy planning in tourism is a complex process, characterized by high levels of uncertainty. For instance, tourism is not included as a sector in traditional emission inventories, and as such, little information is avaiable on sources and the magnitude of the sector's GHG emissions (Becken & Hay, 2007).

Another example of uncertainty for the tourism sector is the emergence of 'green demand', which remains difficult to quantify. While it is anticipated that climate change and environmental perceptions will alter destination choice and consequently influence tourism demand (i.e. Gössling, 2011; Gössling et al, 2008; Scott, et al., 2008; Simpson et al, 2008), there is a lack of information available for destination policymakers and planners to understand the dynamics behind these changes. For targeted mitigation and adaptation strategies, the relationship and interdependencies between the green economy drivers must be understood. However, a planning framework (of this type) for a green economy transition in tourism destinations does not currently exist. In this context, GETS is being developed to allow destination policymakers and planners investigate dynamic "what if" scenarios around their destination and green eocnomy developments.

The paper is organized as follows: project background is presented in the following section and the research approach is discussed in Section 3. The systems architecture is then outlined and this is followed by a DSS usage example. Concluding remarks are presented in Section 6.

2 Background

The development of a green economy DSS for tourism destinations requires a detailed analysis of the dynamic relationships that influence the behaviour of the system. While some information can be found in the academic and industry literature (see e.g. Georgantzas, 2003; Walker et al., 1999), little is available in the way of detailed planning guides, roadmaps and (probably most importantly) data. Consequently, much of this needs to be obtained in collaboration with a destination that is developing and implementing a tourism green economy strategy.

In 2009, the authors were part of a consultancy team to the Egyptian Government charged with developing strategies for a green economy transformation of the destination of Sharm El Sheikh on the Red Sea. The data and findings from this study allowed a systemic view on the drivers of change for a green economy transformation in tourism as well as an insight into the different stakeholder perspectives. Based on these findings a first holistic model for GETS was developed. The Sharm El Sheikh data highlighted four key elements for a successful green economy transformation in tourism:

1. GHG emission reductions
2. Growing the destinations market demand
3. Enhancing the destinations environments and ecosystems and
4. Sustainability of economic and socio-cultural trends.

The model (see Law et al., 2011 for more detail) highlights the complexity of the approach: all elements and factors are characterized by an integrative nature, reflecting that targeted and effective strategies rely on a holistic and systemic view (see Figure 1).

Fig. 1. GETS system requirements

One of the key challenges of developing and implementing GETS is the source, format and availability of data. The aim of GETS is to produce a system that can work for any destination, for example an island destination such as Bali, a whole country such as Australia, a city or a tourism region. This paper presents a system architecture (and usage examples) designed to demonstrate how this aim may be achieved.

3 Research Approach

As a relatively new field, information systems (IS) research borrows heavily from older disciplines; in particular, engineering and the design sciences. As Simon (1981) has noted, “design sciences do not tell us how things are done but how they ought to be to attain some ends”. Much the same applies to IS development and Gregor (2002, p. 12) has posed the question: what constitutes a contribution to knowledge when research is of this type (oftentimes with no hypotheses, no experimental design no data analysis per se)? Hasan (2003, p. 4) responds to this by claiming that IS development, in many cases, should be considered a legitimate research activity (and method) because, not only is knowledge created about the development process itself, but also because “a deeper understanding emerges about the organizational problem that the system is designed to solve". Markus et al. (2002) put forward a similar case in arguing that IS development is a particular instance of an *emergent knowledge process (EKP)* and that this constitutes original research where requirements elicitation, design and implementation are original and generate new knowledge on *how to proactively manage data and information in complex situations.* Hasan (2003: 6) contends that this often involves a staged approach, where "systems evolve through a series of prototypes" with results of each stage informing requirements for the next and subsequent iterations.

Nunamaker et al. (1991) take an approach consistent with the above but draw on an alternative research tradition in case studies and, in particular, action research. Again, using 'replication' strategies, each new instance (case or action research activity) builds upon and refines knowledge gleaned from previous studies (Yin, 1994). Nunamaker et al. (op cit.), however, nominate two features of IS development that distinguish it from more general action research: first, the techniques of IS development, the properties of the system itself and the situation where the system is to be deployed may all generate important knowledge; and, second, IS research projects are both constrained by the limits that current IT place on the development of systems and are enabled by the uniqueness of the technology (which can, as a tool, mediate knowledge generation and the communication of same).

The latter feature has been studied extensively by scholars in 'activity theory' (Vygotsky, 1978). Notably, activity theorists emphasize the holistic nature of the IS development process and, in particular, the critical nature of the cultural and social context within which systems are developed (see, for example, Engestrom, 1987; Nardi, 1996). The socio-technical view of IS, where hardware, software, people and processes are integrated into a complex, purposeful whole, is one of the key features that make information and communication technologies "like no other in the history of mankind" (Hasan, 2003: 4). Thus, to summarize: the development of our GETS IS is a legitimate research activity in its own right, which draws on the more established, traditional research approaches of the design sciences and especially case study/action research. Each new application of GETS (e.g. to a new destination) produces a new version of our prototype and extends our knowledge of the green tourism economy research domain. This is akin to employing a multi-case (study) research strategy - with each new case refining and extending results of previous iterations - and finally, many research findings and outputs are actually inherent in the various conceptual models (and implementations of these) that constitute the GETS IS.

4 System Architecture

A high-level view of the GETS architecture is illustrated in Figure 2. A fundamental objective of the GETS project is to produce a system that is iterative, scalable and open. *Iterative* (in this instance) means that each application (e.g. to a new destination or aspect of a destination) produces a new prototype that increases or refines our knowledge of the green economy domain; *scalable* means that the system must be able to cope equally effectively with large and small destinations; and *open* means that GETS must be capable of handling any type of data, irrespective of source or format.

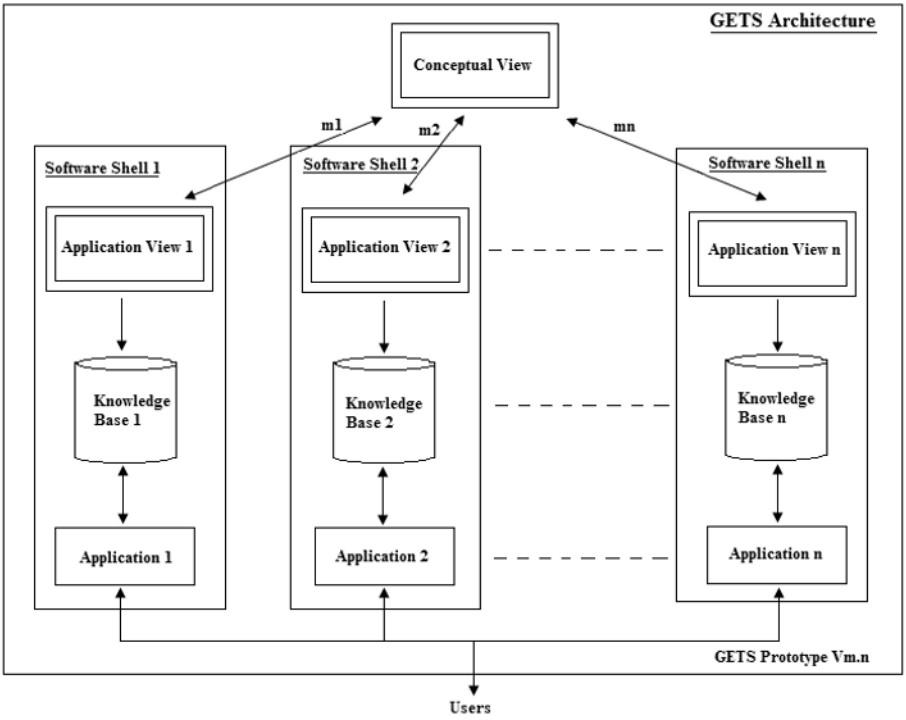


Fig. 2. GETS architecture – high-level view

One of the keys to realizing both an iterative and a scalable system is developing all code (and higher-order applications) around abstracted data models. Essentially, the aim is to allow new functionality to be added (e.g. as issues associated with a new destination introduce new system requirements) without having to revise existing applications. Similarly, development effort may be substantially reduced if large and small destinations (and sub-destinations) can be accommodated by the same applications without modification. Again, abstraction assists with this. We now illustrate how this is accomplished within GETS through a fairly simple (but realistic) example.

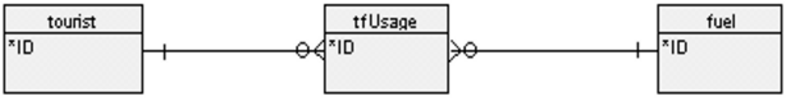
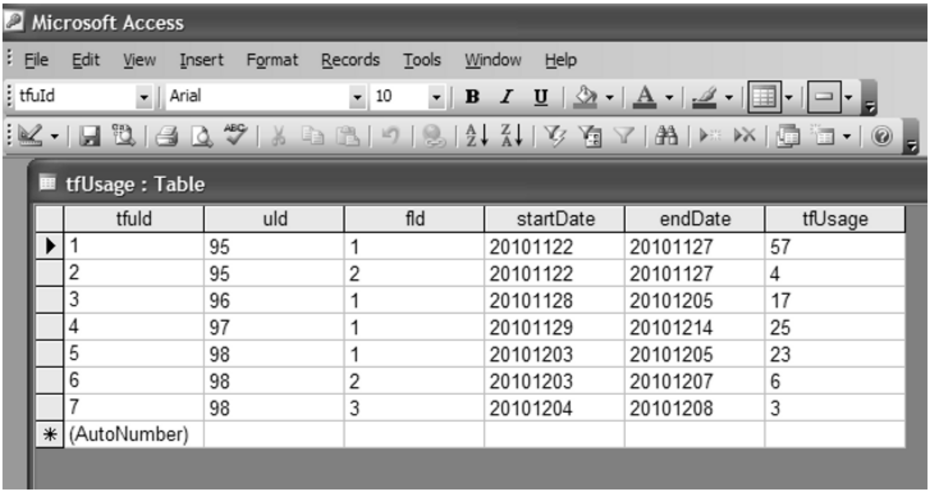


Fig. 3. E-R representation of tourist fuel usage

One indicator we are definitely interested in is tourist fuel usage, and a data model our application might employ is illustrated in entity-relationship (E-R) form (Chen, 1976) in Figure 3. Implemented as a relational database application, the intersecting entity, *tfUsage,* would translate to something like the *Access* table presented in Figure 4 (which has been populated with hypothetical test data). Pseudo-code constructed to calculate tourist gasoline usage (assuming the *fId* for gasoline is 1) might then read something like the following:

```
begin
    set totalTGUsage to 0.
    for each tfuId
      if fId = 1
        then add tfUsage to totalTGUsage
        else no action.
    display totalTGUsage.
end.
```



tfuId	uId	fId	startDate	endDate	tfUsage
1	95	1	20101122	20101127	57
2	95	2	20101122	20101127	4
3	96	1	20101128	20101205	17
4	97	1	20101129	20101214	25
5	98	1	20101203	20101205	23
6	98	2	20101203	20101207	6
7	98	3	20101204	20101208	3
(AutoNumber)					

Fig. 4. Fuel usage database table (hypothetical)

Assume now that, sometime after implementing the above, the need arises to track energy usage for all classes of visitors, plus locals and local businesses. Moreover, usage needs to be aggregated at many different levels and for many different categories (e.g. hotels, types of hotels, business and leisure visitors etc.). This will certainly demand extensions to our E-R model, plus amendments to our initial relational tables and the code constructed around these: in short, before even tackling the enhanced requirements, substantial (and costly) maintenance must be undertaken in order to ensure existing functionality continues to work correctly.

Abstraction can alleviate these difficulties. One approach would be to replace the E-R schema presented in Figure 3 with that illustrated in Figure 5. In our revised schema, tourists, visitors, businesses etc. (plus their sub and super-types) all become *parties* of a particular *party type* and, where appropriate, these are all related to each other as *party-party involvement (ppi)* instances. *Resources* are treated in much the same way and *party-resource involvements (pris)* are used to link parties to their resource usage (at whatever level of granularity is required).

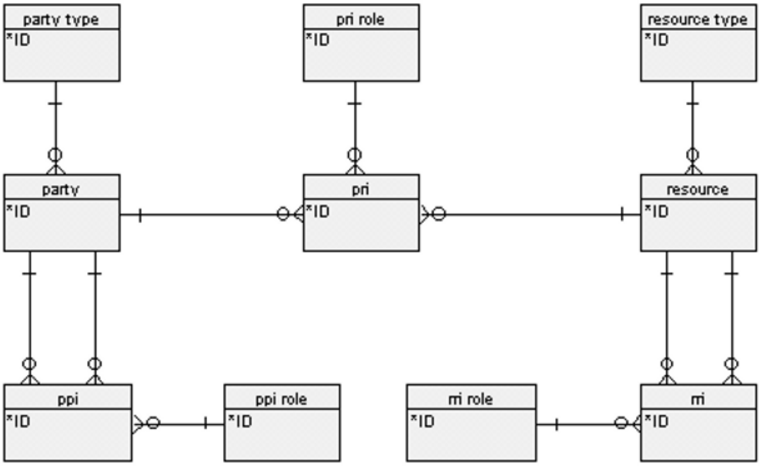


Fig. 5. Abstracted view of the original E-R model (see Fig. 3)

Two major benefits of this abstracted approach are: i) the same code can be used for multiple relationships (thus substantially reducing development costs and time); and ii) for the most part, application extensions do not require existing code and schema modifications – because new requirements can often be accommodated with simple revisions at the table level.

The history of software engineering has demonstrated that, in all but trivial systems, accurately capturing *all* requirements up-front is close to impossible (Somerville and Sawyer, 1997). In addition, there are other important benefits that result from abstraction and, for a detailed discussion of these, the reader is referred to the seminal work of Feldman and Miller (1986).

The open systems objective is realized by adopting a design for GETS consistent with ISO '3-Schema Architecture' principles (Griethuysen, 1982). Referring back again to Figure 2, the *Conceptual View* is a highly abstracted model of the total system, completely free of any implementation-level detail (hence, use of the term, 'conceptual'). *Application View 1, ----, Application View n* are information schemas developed for individual applications, implemented within specific software shells *(Software Shell 1, ----, Software Shell n).* Examples of these (used in applications implemented to date) are *Excel*™, *Access*™, a rule-based expert systems shell called *Flex*™ and the system dynamics simulator, *PowerSim*™. There is a third ISO 3-Schema level, the *Internal View,* which deals primarily with technical aspects of each application (relating to efficiency etc.) and is beyond the scope of this paper. Basically, in recognition of the fact that no one modelling or development method is best for all applications, we have adopted a 'horses for courses' approach. At the same time, no one application is truly stand-alone and, consequently, data must be shared between applications. Within GETS, this is accomplished through the *mappings, m1, ----,* m_n, which allow data within each application (irrespective of its form) to be mapped to and from the common, uniting conceptual view. This approach to application integration is far more efficient than the alternative of developing 1:1 interfaces between applications as required (McGrath, 1997).

5 System Usage: An Example

The following example is taken from a recent study into possibilities for introducing green tourism into the well-established coastal and water sports destination of Sharm el Sheikh in Egypt. This particular application is concerned with hotel energy usage and visitor goodwill, and was constructed using system dynamics (SD) models and principles. It was implemented using the software product, *PowerSim™.* SD has its origins in the work of Forrester (1961) and, more recently, has enjoyed something of a resurgence – largely due to Peter Senge's (1990) very influential work on 'the learning organization' and the development and release of easy-to-use, powerful, SD-based software modelling and simulation tools (such as *iThink™, Vensim™* and *Powersim™).* Recent examples of where SD has been used to good effect in tourism include the 'Tourism Futures Simulator' (Walker et al., 1999), the hotel value chain modelling work of Georgantzas (2003), and the tourism multipliers model of Loutif, Moscardini and Lawler (2000).

In this instance, the destination had decided to go green as part of its rejuvenation strategy and, consequently, was interested in possible impacts. Hotels[1] within this particular destination were divided into three categories: i) *non-green* – where almost no energy reduction initiatives had been implemented; ii) *moderate-green* - where most of the relatively easy (and cheap) initiatives had been implemented; and iii) *total-green* – where a significant number of capital-intensive initiatives had been implemented. The user is required to specify desired transformation rates (for example, 80% of hotels will be moderate-green within 5 years and 50% will be total-green within 8 years).

The user may test some social impacts of the energy reduction strategy; specifically, the impacts of visitor and local goodwill. Visitor goodwill, which manifests itself as the payment of premium prices for the accommodation, may be generated because there is some evidence that tourists (western tourists in particular) are tending to favour destinations that appear to be serious about environmental improvement (De Lacy and Lipman, 2010), while local goodwill, which manifests itself as community satisfaction may occur as a result of both environmental improvement and improved infrastructure and facilities that might result from more, higher-yielding visitors.

Baseline data gathered during the Sharm el Sheikh green tourism planning study was then used to instantiate SD models developed for scenario testing and to extend the basic SD model to include energy reduction impacts on visitor tariffs, revenue and yield. Referring back to Figure 2, this data represents an application view (derived

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[1] It was established that hotels within the destination were responsible for over 70% of tourism-related energy usage and CO2 emissions, exclusive of energy used in travel to and from the destination – hence the accommodation focus.

from the conceptual view and associated knowledge bases) for evaluating various scenarios related to energy usage in the accommodation sector. Implemented in *Excel™*, this is a GETS application in its own right and deals with much of the basic data analysis that must be conducted in any green tourism planning study. Here though, we are primarily concerned with the SD energy reduction scenario generation exercise introduced above. This has its own application view but much of the data it uses is sourced from the *Excel™* application.

As previously noted, hotels move from a status of non-green (NG) to moderate-green (MG) and, finally, to total-green (TG) and the user may set and test target transfer rates. The SD 'stock-flow' model employed here is presented in Figure 6 and, without going into detail on how these models are used to underpin SD simulation (for a comprehensive treatment see, for example, Maani and Cavana (2000)), the flow of destination energy through the three phases is fairly apparent from the model.

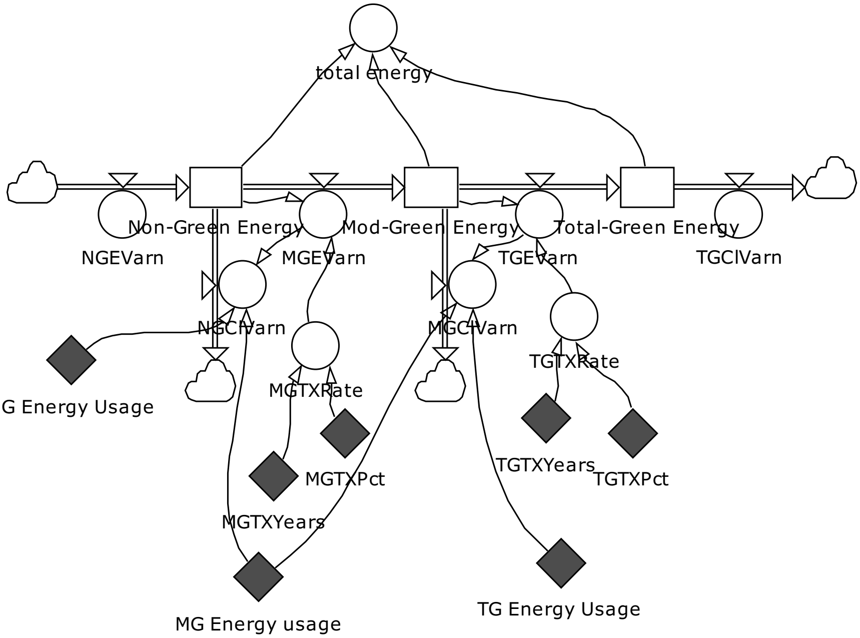

Fig. 6. Hotel energy usage – SD core process model

Each of the 'stocks', 'flows' and 'converters' (the latter represented by circles) represent simulation variables and the diamonds represent constants. All of these must be initialized prior to simulation commencing and data from Table 1 is used here. For example, with an initial NG-MG-TG split of 70-30-0, the initial values for the *Non-Green Energy, Mod-Green Energy* and *Total-Green Energy* stocks are 2,047.9 million, 761.8 million and 0 MJ/year respectively. Some key simulation constants are initialized from slider values set by the user and sample simulation run output is presented in Figure 7 below. In this instance it can be seen that the Sharm destination's total annual accommodation sector energy usage is predicted to drop from 2.9 million to around 1.4 million MJ/year over a 10-year period.

Many other possible scenarios may be evaluated using the SD models developed as part of the Sharm strategic planning process. A key outcome of this exercise was the development of a marketing and branding strategy for the destination based around the 'Green Sharm' concept. The belief was that green tourism would attract fewer, higher-yielding visitors and that this would help to alleviate many of the serious environmental and social problems confronting the destination. While this may sound simple enough (in concept, if not in implementation), it is actually underpinned by many assumptions and a great deal of complexity. With the example presented, we have demonstrated how an interactive, sophisticated model such as GETS can be operationalized by using advanced decision support techniques such as SD. In this situation, SD can be employed: i) to expose and clarify much of this underlying complexity; ii) to model key aspects of the green tourism domain in a formal, precise and rigorous manner; iii) to use the models to generate and evaluate possible future scenarios; and iv) to, hopefully, prevent the unintended consequences of policy decisions that frequently bedevil complex decision-making settings of this type (Vennix, 1996).

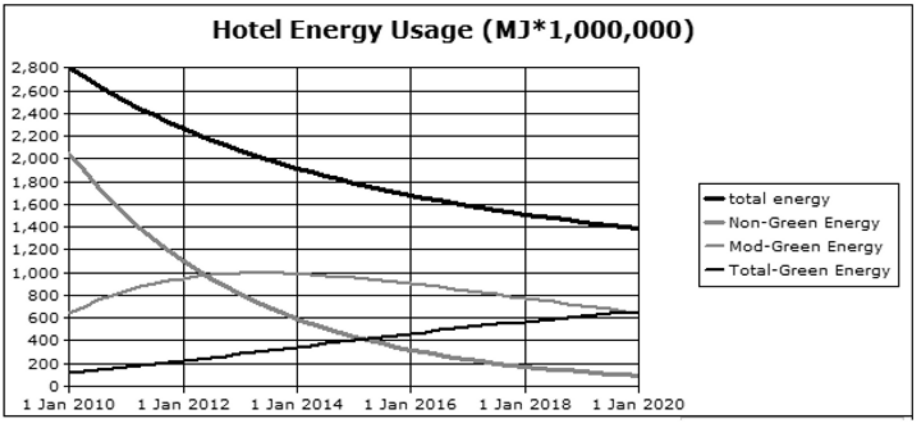

Fig. 7. Hotel energy usage – sample SD simulation output

6 Conclusion

This work adds to an increasing body of applied research concerned with green economy strategic planning. In this particular paper, we outlined a DSS implementation designed to support this activity and were primarily concerned with the architecture of this system. In particular, the paper focused on data abstraction and the benefits that flow from that – specifically: i) a reduction in DSS development and maintenance costs; ii) a reduction in control flow complexity through data-driven programming techniques; iii) an improved capability to cope with business environment volatility; and iv) the ability to more effectively integrate application schemas.

One area we have not covered in this paper is the issue of how our DSS might be employed to advise on green-based destination rejuvenation strategies. A prototype component of this type, based on Butler's (1980) 'Tourism Area Life Cycle' (TALC) has been developed (Pornphol & McGrath, 2011) and is due to be field-tested in Phuket, Thailand in late-2011. In this application, the knowledge base contains instances of TALC cases taken from the literature, with particular emphasis on instances of destinations in stagnation/decline where rejuvenation strategies (often green economy-based) have been applied. Users enter details (e.g. information on the current status of the destination environment, tourism enterprises, types of current visitors and significant problems as search parameters) and a case-based reasoning component retrieves those knowledge base cases that most closely match the new case as a 'Best Match Report'. The user may then review these cases to ascertain whether they provide pointers to actions, strategies or policies that might assist the destination with its current (or potential) problems.

An example might be the Waikiki environmental quality enhancement initiatives adopted by the City and County of Honolulu during the 1990s (Patoskie, 1992). If adoption of a particular initiative is under serious consideration, the user may then perform some ”what if” analysis using the type of SD module outlined in this paper. It is our view that this type of functionality would constitute a very useful enhancement to the current GETS system.

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