

Institution: University of South Wales		
Unit of Assessment: B10 Mathematical Sciences		
Title of case study: Developing real time data analytics capability for energy management services – RUMM Ltd		
Period when the underpinning research was undertaken: 2002-2014		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof. Alan Ryley	Professor (now Prof Em.)	1992-2002
Dr. Hasan Al-Madfai	Senior Lecturer	2002-2010
Prof. Jamal Ameen	Professor (now Prof Em.)	1994-2011
Dr. Steve Lakin	Senior Lecturer	2004-2010
Period when the claimed impact occurred: 1st August 2013 - 31st December 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words) <p>Researchers from the University of South Wales (USW) created a suite of statistical tools that formed a central component of the intellectual property of a high-growth start-up company, RUMM Ltd. The company approached university statisticians to develop new real time data analysis methods to improve their energy management software and strengthen their competitive advantage. The USW research improved the data-analytics capability of the company, critically leading to new intellectual property which underpinned the acquisition of the company by a major British energy supplier, RWE npower Ltd in March 2015, generating significant economic and environmental impacts, through client cost savings and a reduction in carbon emissions across the UK. The research also contributed to economic regeneration in the deprived communities in the South Wales valleys through the training and upskilling of employees and the reinvestment of shareholder income into new start-up companies.</p>		
2. Underpinning research (indicative maximum 500 words) <p>The initial interest at the University in time series forecasting of energy usage began with a collaboration between the University of Glamorgan (now University of South Wales) and South Wales Electricity Board (SWALEC). SWALEC, one of the 12 electricity and supply distribution companies privatised in 1990 and serving the South Wales region, sought academic partners to assist in improving their understanding of patterns of electricity demand. Prof Alan Ryley and Prof Jamal Ameen, both based in Mathematical Sciences at the University, jointly supervised Dr. Hasan Al-Madfai's doctoral thesis on weather corrected electricity demand forecasting [3.1] which was supported by Senior Economists at SWALEC. The general approach involved the analysis of time series, specifically extracting patterns from energy demand measured at discrete moments in time and thus using them as forecasting tools. In particular, two novel time series modelling approaches were introduced and developed as part of this research project; profiles ARIMA (based on the widely used time series forecasting method AutoRegressive Integrated Moving Average) and a variability decomposition method, with the former utilizing an event-driven Hierarchical Profiling Approach (HPA) in which different elements of energy usage were divided into deterministic profiles and stochastic components.</p> <p>Al-Madfai was subsequently appointed as a Lecturer in Mathematics at the University in 2002 replacing Ryley within the Mathematical Sciences group, and in the following years, along with other co-authors, continued to develop the HPA method and its applications to numerous data sets, including crime forecasting [3.2], air pollution from carbon monoxide emissions [3.3] and further energy usages [3.4]. This expertise resulted in a collaboration with two engineers, Dr. Steve</p>		

Lloyd and Mr. Steve Thomas from the University whose interests in energy usage by medium-sized enterprises led to the establishment of RUMM Ltd (Remote Utility Monitoring and Management), a spin-out company from the University launched in 2005 to provide significant savings in energy, cost and carbon emissions to manufacturing and utility sectors. **AI-Madfai's** pre-existing interest in energy management enabled the identification of a weakness in the data analysis of RUMM. A comparison of the information needs of effective energy management against the existing and widely used methods identified a failure to detect irregular behaviour in datasets measured in a time domain rather than a frequency domain, partly due to then-current benchmark time series methods having been developed on the assumption that errors are homoskedastic (that is, the variance of the error term in the regression model is constant). The customer data obtained by RUMM revealed electricity demand time series that were heavily influenced by the presence of multiple seasonalities and heteroskedasticity, and therefore requiring a bespoke approach to the calculation of prediction limits for the detection of usage behaviour patterns for energy management.

To develop the statistical tools necessary to analyse the large data sets obtained by RUMM Ltd, an EPSRC CASE award was granted and held between the University and RUMM [3a]. The award funded a PhD student, who was appointed in 2008 and based in the Mathematical Sciences group, resulting in the award of a doctoral degree in 2013 [3.5]. The doctoral study focussed on the development of an analytical technique capable of detecting irregular behaviour on half-hourly time series which were under the influence of multiple seasonalities and heteroskedasticities. These two goals were requirements of the data held by RUMM, where data from its business users were collected at discrete and regular moments in time and analysed to detect unusual patterns and identify a cause of any unusual activity. To achieve the project aims, the HPA method, which had not been developed to model heteroskedasticity nor previously been applied to time series having multiple seasonal components, was extended from forecasting to the field of process control, the novel Generalised HPA method. This modified time series method was incorporated into a procedure to detect irregular consumption before and after a change in use was made, determining the significance of the numbers of observations falling outside the prediction limits of the Generalised HPA, and thus leading a process control tool that improved RUMM's energy management methodology. Due to commercial sensitivity, this work was embargoed for a period of 2 years from its completion [5.3]. Thus, the statistical methodology, initially developed by **AI-Madfai** alongside **Ryley** and **Ameen**, and then later by a research student, formed a central component of RUMM's intellectual property.

3. References to the research (indicative maximum of six references)

[3.1] **AI-Madfai**, H (2002). Weather corrected electricity demand forecasting. PhD Thesis, University of Glamorgan. [https://pure.southwales.ac.uk/en/studentthesis/weather-corrected-electricity-demand-forecasting\(2e066cc4-58b1-4694-9937-ee8f57fbed02\).html](https://pure.southwales.ac.uk/en/studentthesis/weather-corrected-electricity-demand-forecasting(2e066cc4-58b1-4694-9937-ee8f57fbed02).html) [This is the first application of the time series HPA methodology to energy usage.]

[3.2] Ivaha, C., **AI-Madfai**, H., Higgs, G. and Ware, J.A. (2007). The simple spatial disaggregation approach to spatio-temporal crime forecasting. *International Journal of Innovative Computing, Information and Control*, **3**(3), p509-523. ISSN 1349-4198. [Use of HPA method used to model incidents of criminal damage in a metropolitan city.]

[3.3] **AI-Madfai**, H., Snelson, D. G. and Geens, A. J. (2008). Modelling the multi-year air quality time series in Edinburgh: an application of the Hierarchical Profiling Approach. In Air Pollution XVI, Eds. Brebbia, C.A. and Longhurst, J. W. S, WIT Press, Southampton, p49-56. <https://books.google.co.uk/books?id=CQQwv3nlhBwC&pg> [Use of HPA method to investigate air quality at sites in a city centre.]

[3.4] **AI-Madfai**, H., Akinwale, A., Lloyd, S., Thomas, S. and **Lakin**, S. (2009). Using hierarchical profiling approach (HPA) forecasts of multi-year half-hourly electricity consumption as a tool in energy management. 29th International Symposium on Forecasting,

https://isf.forecasters.org/pdfs/isf/ISF2009_Proceedings.pdf (page 130) [Conference: demonstration of HPA method applied to data of the form used by RUMM Ltd.]

[3.5] Akinwale, A. (2013). Detecting irregular energy consumption through analytical techniques. PhD Thesis, University of Glamorgan. (Director of studies Hasan **Al-Madfai**; supervisors Steve Thomas, Steve Lloyd & Steve **Lakin**) [https://pure.southwales.ac.uk/en/studentthesis/detecting-irregular-energy-consumption-through-analytical-techniques\(b8e99688-de4c-41f0-a40c-0a2a04e2895d\).html](https://pure.southwales.ac.uk/en/studentthesis/detecting-irregular-energy-consumption-through-analytical-techniques(b8e99688-de4c-41f0-a40c-0a2a04e2895d).html) [The work refined the techniques used by RUMM and due to commercial sensitivity was embargoed for 2 years during the acquisition of RUMM by RWE npower.]

Related research grant:

[3a] EPSRC SME Industrial Case Studentship Award. Detecting Irregular Energy Consumption through Analytical Techniques (DICTAT). University of Glamorgan in partnership with RUMM Ltd.

4. Details of the impact (indicative maximum 750 words)

Background to RUMM Ltd and collaboration with USW

RUMM Ltd [5.1] was a new company launched in South Wales by engineering lecturers, Dr Steve Lloyd and Mr Steve Thomas, as a spin-out company from the University in 2005 following a collaborative project with local companies to remotely monitor their energy consumption. The unique service offered by RUMM was aimed at medium-sized businesses, benchmarking their energy usage against critical parameters and the subsequent application of statistical process control techniques to reduce their energy bills and their carbon footprint. These savings aided the businesses in achieving targets in the wake of deregulation of the energy supply infrastructure in the UK and the increased political drivers for carbon reduction.

RUMM's technology provided a remote assessment of each client's energy use, typically using between 20-60 meters per site that measured energy consumption at key locations. Time series data from each meter was transmitted to RUMM's server in 30-minute intervals where it was automatically analysed using RUMM's proprietary software package, Internet Based Analytical Software Suite (IBASS). IBASS provided the client with a visualisation of energy consumption and targets of energy consumption using data analytics. Automatic alarms were sent to the users whenever a meter identified an abnormally high energy use. For example, an alarm would be triggered by a machine being left on outside of normal operating hours. However, the analysis of the time series data in IBASS, which was central to the RUMM model's ability to detect inconsistent behaviour was identified by the company as basic; it simply compared energy usage in successive half-hourly intervals in a rudimentary manner and lacked any sophistication to deal with changes in demand due, for example, to seasonal differences. To generate the greatest possible savings in energy consumption and carbon emissions, the company sought a collaboration with the University to improve its energy management methodology.

Pathway to impact

In 2006 RUMM approached Al-Madfai to develop the advanced statistical tools they needed to improve the analysis of their clients' energy and utility data, and management of usage. Following the identification of the presence of multiple seasonalities and heteroskedasticity in RUMM's clients' data, Al-Madfai and the company submitted a collaborative bid for funding from the EPSRC for an Industrial CASE PhD Studentship [3a] (titled Detecting Irregular Energy Consumption Through Analytical Techniques (DICTAT)), which was awarded in 2008. Akinbami Akinwale was recruited to the project as the research student, to build on **Al-Madfai**'s own PhD work [3.1] to develop an analytical technique that could be used as an energy management tool in detecting irregular behaviour of a time series [3.5]. To achieve this, the Hierarchal Profiling Approach (HPA) originally developed by **Al-Madfai**, **Ryley** and **Ameen** and extended from 2002 by **Al-Madfai** and co-workers, was extended further. Process control techniques were developed to detect abnormalities extracted from RUMM's time series data that identified "non-standard" consumption profiles, while accounting for the seasonalities and variabilities embedded within the data

(<https://youtu.be/xs1YboaQhT8>). This enabled development of a remote monitoring and alarming system for the detection of irregular consumption patterns. With research outcomes having contributed to continuous upskilling of RUMM staff and to upgrades to IBASS, the statistical tools utilising HPA completed by **Al-Madfai** and co-workers formalised the toolkit as a key component of RUMM Ltd's intellectual property and its competitive advantage from 2013 onwards. The intellectual property in the results of this research project were assigned to the company on the 31st March 2015 in a legal agreement [5.2a] to allow the company to incorporate them into IBASS Version 6 [5.2b] as a key part of a commercial deal with a major energy provider RWE npower. RUMM continued to deliver services supported by IBASS until 2019 when the company was fully subsumed into the new parent company.

Impact: Acquisition of RUMM by RWE npower

By the end of year trading on 31st August 2014, RUMM Ltd had an annual turnover of approximately £1.3 million, generating £200 000 pre-tax profit [5.3]. On 31st March 2015, RUMM was purchased by RWE npower Ltd [5.4], known as one of the “Big Six UK Energy Suppliers” and a subsidiary of E.ON UK from January 2019. The statistical analysis and control tools developed by **Al-Madfai** and co-workers formed a central component of the company's intellectual property. To quote Mr. Steve Thomas (the commercial director of RUMM Ltd) on its sale to npower, “If Hasan [**Al-Madfai**] wasn't there, it couldn't have been done” [5.5].

At the point of acquisition, RUMM was reported to have saved its customers £43 million in energy costs, reduced energy consumption by 600 million kWh with a concomitant reduction of carbon emissions by almost 300 000 tonnes [5.1, 5.6]. RWE npower paid [text removed for publication] for RUMM [5.7], and immediately began rolling out RUMM's energy-saving approaches to its customers in the second quarter of 2015.

Impact: ongoing benefits of RUMM to RWE npower and its UK clients

Following the acquisition of RUMM by RWE npower, RUMM became part of npower's Business Solutions suite of packages, under its “Energy HQ” umbrella [5.8], which continues to be offered to its customers. Later in 2015, RWE npower became the first power utility to be awarded the Carbon Trust triple standard for significant reduction measures across energy, waste and water, with the acquisition of RUMM cited as one of “[two] key developments that led to certification” [5.9]. Npower's Low Carbon & Behaviour Change EMS Manager reported of RUMM a year after acquisition: “It's already produced clear and proven benefits for firms, big and small, saving businesses we have worked with over £26m” [5.10], demonstrating the value to npower of the IP purchased. It was anticipated by npower's Chief Executive that by rolling out RUMM's technology across its customers, £4 billion could be saved from the UK's annual fuel bill for businesses across its 23 000 commercial customers [5.6]. Npower targeted savings of between 3-15% for each of its customers through its focus on “RUMM's behavioural approach to energy” [5.10].

Impact: upskilling of employees

A key philosophy of RUMM Ltd was the upskilling of its employees. Based in Ystrad Mynach, Caerphilly County Borough, RUMM's 30 employees [5.6] were predominantly drawn from local communities that display poor educational achievements and high overall deprivation, and the majority of staff were appointed to positions requiring high technical skill sets. The 2019 Welsh Index of Multiple Deprivation ([Welsh Index of Multiple Deprivation \(WIMD\) 2019: results report \(gov.wales\)](https://gov.wales)) identified Caerphilly County as the 4th most education deprived and 5th most employment deprived local authority of 22 in Wales (by percentage of Lower Layer Super Output Areas in the 50% most deprived such areas). As a result of the development of the HPA method and its incorporation into IBASS, a number of RUMM's staff were upskilled in their statistical knowledge [5.5], adding further commercial value to the company (as evidenced by RUMM Ltd's sale price [5.7]) and reducing both employment and educational deprivation in the region. Further, a former research student working within RUMM subsequently became a director, and post-sale developed Blue Sky Equity Ltd (see below), exemplifying, through the collaboration, the research-driven development at USW of entrepreneurship skills of students and staff.

Impact: investments from profit generation

Shareholders' income from the sale of RUMM Ltd has led to further new company starts and investments in start-up companies from 2015 to 2020. One example is the bio-technology company Blood Line Ltd [5.11], founded in 2017 by two of the ex-RUMM directors to develop technological aids for people with diabetes, making use of statistical techniques to model relationships between food intake, exercise, and key biometric parameters. Further examples include investments in the four companies by another ex-director of RUMM, including Blue Sky Equity Ltd which was established to specifically invest in start-up companies [5.12].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] RUMM website (historical). Contains list of clients with testimonials. Available on web archive: <https://web.archive.org/web/20190224011638/http://rumm.co.uk/>

[5.2] RUMM IP Transfer Agreements March 2015: [5.2a] Deed of Variation; [5.2b] RUMM request to University of Glamorgan to embargo outcomes of EPSRC SME Industrial Case Studentship Award: DICTAT while the outcomes were incorporated into IBASS6. **CONFIDENTIAL**

[5.3] Full accounts for year ending 31st August 2014 [Companies House: RUMM Ltd](#) (Turnover £1.3million. Pre-tax profit £0.2 million.)

[5.4] Statement from npower on purchase of RUMM Ltd.

<https://web.archive.org/web/20190728082129/http://www.npowermediacentre.com/releases/ReleaseDetailPage.aspx?releaseId=5180>

[5.5] Letter from Mr Steve Thomas (former director, shareholder and company secretary of RUMM Ltd.) confirming Al-Madfa'i's contribution.

[5.6] Details on purchase of RUMM by npower <https://www.ft.com/content/c9a96ace-d79a-11e4-94b1-00144feab7de>

[5.7] Letter confirming sale price of RUMM to npower (Head of Commercial Client Services, USW Commercial Services Ltd.). **CONFIDENTIAL**

[5.8] Npower's business solution packages (Energy HQ), into which the IP of RUMM was incorporated since 2015 <https://energy-hq.co.uk/>

[5.9] "Npower earns energy sector's first Carbon Trust Carbon Trust triple certification", edie: empowering sustainable business, Faversham House, 17 September 2015

<https://www.edie.net/news/5/npower--leading-by-example--as-energy-sector-s-first-triple-standard-company/>

[5.10] "Save Energy the RUMM Way!", Energy Management: Energy Savings Solutions, 8 April 2016 <https://companysuggestion.wordpress.com/category/energy-saving-solutions/>

[5.11] Blood Line Ltd Companies house records:

<https://beta.companieshouse.gov.uk/company/10596269>

[5.12] Companies house records for RUMM ex-director:

<https://beta.companieshouse.gov.uk/officers/nGXLmAWr61ryEBRT2hH9DQHIA7w/appointments>