UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

The private adoption of solar photovoltaic energy in Ekurhuleni Municipality, South Africa

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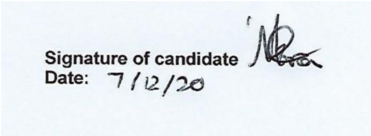
via coursework and research report

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



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Abstract

As a developing nation, South Africa has many responsibilities to the people living in its borders, including enabling access to clean, reliable and affordable electricity. The need for new energy resources becomes even more important in the context of a growing urban population. Due to the failures of the state-owned enterprise, Eskom, there has been a decrease in urban energy resilience. Thus, many electricity users are looking towards other sources for their power supply. As renewable energy becomes more affordable, individual households and small companies are adopting solar energy, via photovoltaic panels and solar hot water systems, to provide a portion of their energy needs. This mode of power generation takes advantage of the high quality South African solar resource, and its decentralised nature enhances energy resilience at the individual consumer level. This research quantifies the rate of uptake of photovoltaic panels and solar geysers over the period 2010 – 2019, in three contrasting neighbourhoods of the city of Ekurhuleni in South Africa: low-income suburbs, high-income suburbs and areas zoned for commercial or light industrial development. By comparing different variables to show significant differences between the three contrasting neighbourhoods, the extent of decentralisation can be mapped at different scales and rates. Different variables were found to have effects on the adoption of photovoltaic panels and solar geysers. Overall uptake of photovoltaic panels increased in all areas from 2010 to 2019.

Keywords

urban energy resilience, energy poverty, energy security, solar geysers, adaptation

Introduction

As the movement of people from rural to urban areas increases, so does the load upon the services that the city is called on to provide, including energy (Meerow *et al*., 2016). In a South African context, this is even more important due to the power shortage challenges that the country is currently experiencing (Lawrence, 2020). Urban planners and managers need to build more resilient settlements that can cope with changes to the climate and unforeseen power problems. As the cost of renewable technologies decreases, they become progressively more viable to implement than fossil fuels, where the cost of provision is rising, and are a far cleaner option from an air pollution and climate change perspective (Numbi and Malinga, 2017). The trend from fossil fuel-fired energy sources to renewable energy is seen throughout the world. Developing countries such as China and India are among the leaders in this field, as they move towards a cleaner, lower-carbon economy (Sasana and Ghozali, 2017). The transition has substantive benefits for the economy, the health of people and as a way of addressing past and future energy poverty (Alstone *et al*., 2015). As urban areas grow and provide economic opportunities for the economies of the world, it is important to make sure there is an unbroken production of power, so the economy may grow and the population prosper. In South Africa, power is currently being produced at a national scale (Lawrence, 2020). Decentralisation and localisation of power production make it easier to uplift those in rural areas and to provide basic power to the poor in both urban and rural contexts (Alstone *et al*., 2015). By using renewable energy on a smaller unit scale, power is consumed near to where it is produced, allowing for reduced losses in power in production and transmission. Potentially, excess power can be fed back into the national energy grid, generating income and contributing to broader-scale energy needs and resilience (Orehounig *et al*., 2015). The growth of decentralized systems seeks to enable urban environments to be more resilient to any changes in the environment, in the face of an ever-changing world, including risks like climate change that discourage against fossil fuel-based solutions, and where centralised systems may be vulnerable to extreme events. The adoption of renewable energy is not happening in South Africa at the requisite rate and scale by the government (Lawrence, 2020). This research seeks to quantify what is being done by private initiatives at a small scale, in the absence of a policy framework.

Aim

The aim of this research is to quantify the uptake between 2010 and 2019 of PV panels in poor, wealthy and industrial areas of the Ekurhuleni municipal area in Gauteng, South Africa, and to explore the factors which may be associated with the rate of adoption.

The following hypotheses will be tested:

H1: Adoption is most rapid in high-income areas.

H2: Large-scale installations are only found in industrial areas

H3: The size of individual installations in suburban areas scales with income per capita

Rationale

Energy is essential to any economy, especially a growing economy (Roege *et al*., 2014). Between 60% and 80% of the energy consumed globally is consumed within urban environments (Sharifi and Yamagata, 2016). This statistic along with the growing urban population especially in developing countries means that a large amount of energy will be needed and consumed within urban areas (Sharifi and Yamagata, 2016). Within South Africa, there are numerous energy-related issues leading to low growth within the economy and lowered resilience to climate change and load shedding (Menyah and Wolde-Rufael, 2010; Roege *et al*., 2014).

Resilience is a system's capacity to be able to recover from adversity according to Roege *et al.* (2014). Urban environments will need to be more resilient to be able to withstand changes in climate, socioeconomic and politics along with any other unforeseen changes (Boyd and Juhola, 2015; Meerow *et al*., 2016; Sharifi and Yamagata, 2016). Specifically, in a South African context, energy resilience is needed to mitigate the current load shedding crisis (Meerow *et al*., 2016; Lawrence, 2020). To reduce pollution and carbon emissions, it is assumed that South Africa will have to reduce heavy fossil-fuel economic growth by introducing more renewables which are generally seen as more expensive, to meet the carbon emission quotas that the country has agreed to, to mitigate climate change, as energy cannot be produced in the same method as before (Karekezi, 2002; Sasana and Ghozali, 2017).

By moving towards renewable sources, the economy may be preserved as well as lowering pollution and carbon emissions (Menyah and Wolde-Rufael, 2010). Hence power production within urban environments, using decentralised renewable technologies, solves the current issue of urban environments not being energy resilient, meaning they do not have the capacity to adequately maintain power production within a changing environment. Within other counties, such as Australia, which has a long relationship with solar technologies than South Africa, income is a factor on the rate of uptake of decentralized solar systems which would be a factor in which areas are more energy resilient to changes (Best *et al.,* 2019). Although within a South African context, there is little to no research done regarding the benefits of decentralized systems in urban areas, to the economy and resilience of urban areas.

I hypothesise that photovoltaic (PV) panels are first adopted by the wealthy. They install relatively large systems, to provide electricity for their appliances, lights, and other needs. The next adopters are businesses. They install even larger systems, as they need uninterrupted daytime power in order to increase their energy resilience. Those most in need of energy resilience, the poor, are often the last to adopt such methods. They use small installations, if at all, due to the high up-front expense of PV systems.

In South Africa, due to issues emanating from Eskom, power is currently intermittent, which decreases overall energy resilience. Load shedding has been causing issues to businesses and individuals, as power is now not stable. Thus, greater adoption of decentralised solar systems will increase urban energy resilience.

Literature Review

Urbanisation

Urbanisation has transformed the surface of the Earth. Only ten percent of people were urban two decades ago, now more than 50 percent are (Meerow *et al*., 2016). Urban resilience is defined by Meerow *et al*. (2016, p39) as: "urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity". Using this definition, urban resilience is defined as being active, actively changing, takes into account the different scales - temporal and spatial - and drives a generalised adaptivity for urban areas (Collier *et al*., 2013; Meerow *et al*., 2016). However, the issue of building resilience into future planning and implementation is challenging, since it must address past socio-economic and environmental issues whilst providing clean and sustainable energy which is assumed to have higher costs (Collier *et al*., 2013). Current energy security concerns only take into account the ability to procure sufficient oil supplies and do not take into account resilience, the adaptive abilities of the energy system, carbon emissions and other side issues (Bellos, 2018). Greenhouse gas emissions from cities are the largest single driver of climate change. Furthermore, urban structures absorb solar energy and transform it into heat, creating an urban heat island that can be exacerbated by climate change (Salat and Bourdic, 2012). Cityscapes need to be more resilient so as to mitigate these changes to the climate and be able to provide services to the population, especially electricity as the urban population grows, without compromising the ability to adapt to changes (Collier *et al*., 2013; Meerow *et al*., 2016). 'Progressive' approaches involve the integration of technology and the creation of the 'smart city'. However, these cities integrate certain technologies whilst leaving some critical technology for resilient structures such as Photovoltaic (PV) panels as they do not consider decentralization as a way forward (Viitanen and Kingston, 2014). This notion, in turn, has issues regarding resilience for the future and moving towards a low carbon city, as these types of smart cities do not include parts of the population, thus, leaving them unaccounted for (Viitanen and Kingston, 2014). These smart cities are therefore not resilient to the socio-economic and climatic changes in the future (Viitanen and Kingston, 2014). Thus, models need to be developed that provide guidelines for future cities (Hiremath *et al*., 2007). One-way forward is to create decentralized systems for power generation and transmission, located within urban environments. This would contribute to resilience as power would be created where it is consumed, which would allow for an uninterrupted flow of power without disrupting businesses and if there are issues with power supply, excess electricity can be sent back into the grid alleviating such issues (Meerow *et al*., 2016; Sharifi and Yamagata, 2016; Collier *et al*., 2013; Hiremath *et al*., 2007). Power systems can also be easily fixed and changed, and broken systems do not affect large areas of the urban population (Baruah and Enweremadu, 2019; Cox *et al.,* 2017).

Decentralized Systems

The reason for the emphasis on PV panels is that solar power is found to be the most viable current source of renewable energy within South Africa (Abubakr *et al.,* 2016). There are two main sources of solar electricity-generating technologies, concentrated solar power (CSP) and PV, although only PV is suitable for decentralized systems (Abubakr *et al.,* 2016). In addition, solar energy can be used to heat water, which is relatively simple and cheap, and thus suitable for distributed systems. There are a few problems associated with PV panels, such as that they have to be cleaned from dust and dirt regularly and depending on climatic conditions like cloud cover it can perform less than optimally (Abubakr *et al.,* 2016).

Decentralized systems have become popular within South Africa due to the rising cost of electricity (Numbi and Malinga, 2017). There are two main PV panel types, silicon and polymer (Ross and Anthony, 2016). Silicon systems are more resilient and work better under hotter climatic conditions making them suitable for South Africa but are more expensive (Ross and Anthony, 2016). South Africa has an abundant source of sunlight throughout the country making solar technologies viable and a good source to uplift communities via power production (Ross and Anthony, 2016).

One of the largest socio-economic issues occupying many developing nations is the issue of power generation and power transmission (Sharifi and Yamagata, 2015). By using a decentralized model for power generation, populations can consume power where it is created, allowing for disparities of the past to be addressed (Hiremath *et al*., 2007; Herran and Nakata, 2012). This way urban areas become more resilient whilst transitioning to a lower-carbon economy and providing the basis for future economic growth (Meerow *et al*., 2016; Alstone *et al*., 2015; Collier *et al*., 2013; Salat and Bourdic, 2012). This method would also be transferable to rural and lower-income areas, which would help provide electricity and start to address energy poverty (Alstone *et al*., 2015). Once the energy-poverty is alleviated, people in these lower-income areas will be able to focus their efforts on producing a sustainable income, goods and contribute to the economy (Alstone *et al*., 2015). Energy not only assists in daily necessities but in lighting and telecommunications which are essential for the improvements of daily life (Alstone *et al*., 2015). This method of decentralized power production would assist those without power even without the expansion of the power grid (Alstone *et al*., 2015). It would, therefore, be able to help urbanise areas quicker and increase development whilst reducing income and inequality disparities in the populations (Alstone *et al*., 2015; Herran and Nakata, 2012). Thus, using decentralized power sources, a country can develop rural and urban areas and solve power inequities without extending the grid, and in doing so will boost the economy as well (Khennas, 2012).

Approximately 40% of domestic power usage within households in South Africa is spent on water heating (Thobejane *et al.,* 2019). During 2007 there were many outages and so as a mitigation measure, South Africa implemented using solar water heaters (SH) or solar geysers to reduce the strain on the grid (Thobejane *et al.,* 2019). As such there were many initiatives around the uptake of solar geysers within low-income areas to reduce this strain (Thobejane *et al.,* 2019). However, due to poor planning and materials the initiative to use solar geysers to reduce the strain on the grid did not work as planned (Thobejane *et al.,* 2019). Even though there is great value in a mixture of energy sources which include solar geysers in reducing carbon emissions and shifting towards decentralized systems the failure of the project has skewed perceptions regarding solar geysers (Thobejane *et al.,* 2019).

Power production in South Africa

South Africa's economy and growth has historically been reliant on mineral sources, especially coal for power production and export (Baruah and Enweremadu, 2019). The relatively low historical cost of coal has been important in the development of an infrastructure that provides for the energy needs of South Africa. However, in recent decades there has not been sufficient infrastructure and power production to meet the needs of the whole country, and new-build coal-fired power stations have turned out to be both much more expensive, and unreliable (Baruah and Enweremadu, 2019). Approximately 5 million out of 55 million South Africans do not have adequate access to reliable electricity (Baruah and Enweremadu, 2019). Lack of access to basic amenities is one factor contributing to migration towards urban areas, which are assumed to have greater resources. This increases the stress on existing power production (Baruah and Enweremadu, 2019). The relationship between energy consumption and economic growth is synergistic, meaning that a growing economy needs greater energy production as it would be consumed in greater amounts (Sasana and Ghozali, 2017). Thus, by increasing the migration to urban areas, the consumption of energy is increased which also brings greater challenges in the form of energy production, especially clean energy production, as it is imperative to grow the economy as well (Baruah and Enweremadu, 2019). Although this is the case, due to the failure and aging infrastructure in South Africa, the economy has suffered major losses and power production has been hampered (Lawrence, 2020). Eskom is the eleventh-largest largest power utility in the world in terms of installed capacity, but this size seems to have led towards its downfall due to having a large workforce and salaries (Lawrence, 2020). Due to having a monopoly upon the electricity market, its failure has led to the failure of the entire country, costing the country about R1.4 trillion in a decade and is forecasted to lose even more than that in 2019 alone (Lawrence, 2020). Continued reliance on fossil-fuel-based power generation and lack of maintenance over the years has led to South Africa becoming fourteenth in total volumes of CO_2 produced (Lawrence, 2020). Further issues are due to South Africa's reliance on coal, as policies aimed to reduce CO_2 mean reducing growth in the country and so it is a precarious balance between growth and electricity production, along with the type of power production (Khobai and Le Roux, 2017). Evidence from other countries shows economic growth increases with the increased usage of renewables (Bhattacharya *et al.,* 2016). Losses within the economy mean that economic growth will be dampened and so will energy production (Sasana and Ghozali, 2017). Hence, decentralized power production can lead to more transparency, decreased CO_2, community ownership and competition, but it has yet to be realized in South Africa (Lawrence, 2020).

Benefits of decentralization

With the reduction of the cost of PV panels over time, the installed cost per kilowatt per hour (kWh) is much cheaper than new-build fossil fuel-fired generation options in many developing nations (Orehounig *et al*., 2015). However, the uptake of PV panels in developing nations is rather slow due to the pricing of the batteries, thus, by using hybrid systems, PV panels and fossil-fuel generated power, this issue can be resolved (Azoumah *et al.,* 2011). Although there have been a few successes in developing nations for electrifying rural areas by using decentralized systems it has not reached South Africa (Baruah and Enweremadu, 2019). The usage of decentralized systems in rural areas could have many benefits especially in a South African context at reducing the rural-urban migration and decreasing the strain on limited energy sources (Baruah and Enweremadu, 2019). By using systems such as PV and solar geysers in tandem with fossil fuel options (Thobejane *et al.,* 2019; Azoumah *et al.,* 2011). By doing this we can facilitate the movement towards renewable energy whilst making the most use of existing infrastructure for coal-powered power production (Lawrence, 2020; Azoumah *et al.,* 2011). This is also a more sustainable option as current batteries used currently are not made from sustainable materials, thus, making recycling very difficult and reducing the overall environmental benefits of PV panels (Larcher and Tarascon, 2014). By using an energy hub nexus network between neighbourhoods, the peak demand for electricity can be reduced even if the reliance on other means of energy is not completely removed (Schlor *et al*., 2018; Artioli *et al*., 2017; Orehounig *et al*., 2015). This type of design helps promote resilience and decreases the load on the grid and helps the transition between fossil fuel-fired coal plants towards cleaner power production (Orehounig *et al*., 2015; Ahern, 2013).

Resilience is increased as the system is not reliant on one system but many systems working in tandem, which allows for greater versatility as well, if one system is failing or fails, it can be replaced easily (Orehounig *et al*., 2015; Ahern, 2013). Individuals may earn from surplus electricity produced by their decentralized systems by feeding excess electricity back into the grid, which in turn allows for a surplus of clean electricity to be generated, further promoting a low carbon economy and providing relief to those that need the electricity (Orehounig *et al*., 2015). This method subsidises itself as it provides incentives to individuals who can convert their systems into decentralized systems and create a network to power others who may not have clean energy as well as providing an income which would further increase the economic benefits of decentralized systems (Orehounig *et al*., 2015). Although it is to be noted that residential areas may not be able to insert excess electricity into the grid as the size of the systems may not allow for that as the costs are offset by the electricity usage (Numbi and Malinga, 2017). Thus, energy nexus hubs may be the best option for residential areas (Schlor *et al*., 2018; Artioli *et al*., 2017; Numbi and Malinga, 2017; Orehounig *et al*., 2015). It has also been pointed out in previous literature that mini-grids using PV panels are the most economically viable option when compared with the expansion of the grid, diesel and individual PV panels (Szabo *et al*., 2011). Another option is using a combination of PV and solar water heaters to further reduce the costs associated with power production (Gerber *et al.,* 2019). Using a mixture of energy sources from PV and fossil fuel-fired options for urban structures such as schools, the daytime running costs are reduced as well as taking off the strain from the grid without the need for large systems and excess power can be stored or put back into the grid (Gerber *et al.,* 2019). Therefore, decentralized systems are cheaper as well as more resilient for future urban areas and rural areas (Orehounig *et al*., 2015; Szabo *et al*., 2011). By adopting a more decentralized system, city planning is more flexible to be able to adapt to changes in the future (Jha *et al*., 2013; Salat and Bourdic, 2012).

Policy and barriers for implementation

Photovoltaic panels within the urban landscape worsen the urban heat island effect by attracting more heat towards the panels (Orehounig *et al*., 2015; Salat and Bourdic, 2012). Mitigating such effects can involve including green spaces within the urban system, which also allows for a multitude of co-benefits (Orehounig *et al*., 2015; Salat and Bourdic, 2012; Evans, 2011). Therefore, a policy that is aimed to build a more resilient future for urban environments will have to consider these issues whilst promoting the move towards cleaner sources of power (Kreichbaum *et al.,* 2018). Although due to the uncertain nature of future risks, there should still be an addition to this policy to allow urban systems to be able to recover from changes or damage that are caused by climatic changes as these changes are uncertain and could have unforeseen consequences that have not been planned for, however, this would also allow for urban environments to be more energy resilient and flexible to changes and additions for the future which would further promote resilience (Sharifi and Yamagata, 2016; Jha *et al.,* 2013; Salat and Bourdic, 2012). Economic growth and stability of power production should also be considered as the relationship between power production and economic growth is part of building energy resilience within urban spaces especially considering South Africa's current power crisis (Baruah and Enweremadu, 2019; Lawrence, 2020). Although there are several barriers to the implementation of decentralized systems, within the Western Cape it can be seen that a major barrier towards implementation is municipalities themselves, as they oppose this due to loss of revenue (Kreichbaum *et al.,* 2018). Therefore, the policy will have to 'legitimize' the uptake of PV panels to allow for greater diffusion which would ultimately lead to greater resilience (Kreichbaum *et al.,* 2018).

The way forward is via renewable energy power systems, as they build resilience whilst promoting cleaner energy production. Decentralization via PV panels has become more popular due to rising energy costs. These rising costs, along with lowering costs of PV panels, mean that PV panels are now cheaper than new-build fossil-fuel-fired coal production. The increase in different systems allows for power generation to be spread over different sources increasing adaptability, creating greater resilience in the case of one source failing. New policies will have to incorporate the changes decentralised power systems bring to the urban landscape and changes in income creation for municipalities.

Differences between contrasting areas will help identify the ways decentralization is happening and compare the rates of uptake.

Methods

Description of the study area

The office for Environmental resource and waste management department, Corporate strategic planning division, in Ekurhuleni was contacted, to explain the research and ask for the aerial images and information to be shared. Ekurhuleni is a district municipality in South Africa, encompassing an area of 1975 km^2. The municipality is one of the most densely populated regions and accounts for nearly a quarter of Gauteng's economy. High-resolution aerial photography images were used to identify and quantify the presence of solar photovoltaic panels and solar geysers in 18 selected neighbourhoods in the Ekurhuleni Metropolitan Municipality. The imagery used was based on aerial photos, in which the smallest visible object is 1cm. The 18 demarcated areas consisted of 6 high-income areas, 6 industrial areas, and 6 low-income areas. The mean extent of the 18 selected sample locations was 2.7km^2 (range from 0.92 to 4.86km^2) (see appendix 30).

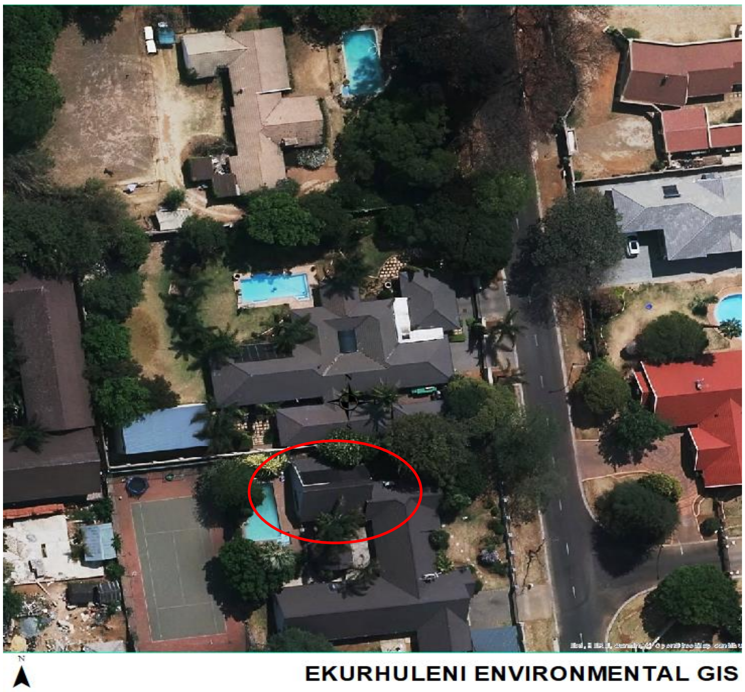


Figure 1: High-resolution image of a high-income neighbourhood.

Figure 2: High-resolution image of an industrial neighbourhood, showing a solar installation.

Figure 3: High-resolution image of a low-income neighbourhood.

Research design

The research followed a quantitative design, in which six replicate neighbourhoods of about 300 ha, in each of three different types of the suburb (low-income residential, high-income residential and commercial/light industrial) were assessed for the total number of installed photovoltaic panels and solar geysers, using high-resolution areal imagery for two time periods, 2010 and 2019.

Research methods

ArcGIS version 10 was used for selecting and delineating the neighbourhoods, and the different layers applied for the city to outline townships and suburbs (Ormsby *et al.,* 2010).

Data collection and sampling methods

The entire extent of each area was visually searched on the image, and every instance of a PV panel or solar geysers was recorded, both for 2010 and 2019. Each individual PV panel and solar geyser was counted for each neighbourhood. A subsample of 100 structures each in the high-income, low-income, and industrial- areas were used to score the number of viable north-facing rooftops, also by visual scanning and measurement. A sample of 30 installations each for high- and low-income areas used to estimate the mean size of the PV panels. The population density was obtained from the most recent census data (2011). Relative income data were estimated using mean house values in each of the areas as a proxy.

Data processing

The amount of power potentially generated per household was estimated from the number of panels installed. The mean PV panel size was 1.6 m^2, in both high- and low-income neighbourhoods, which at this latitude and climate translates to 320 watts produced per panel for peak illumination. For a standard 5 hours of peak sunlight, this is equivalent to 1.6 kWh (Centre for Renewable & Sustainable Energy Studies, 2014). Larger installations (ie multiple panels) were scaled accordingly as each individual panel was counted. Associations were explored between the rate of PV adoption, the income proxy, and the population density of the areas.

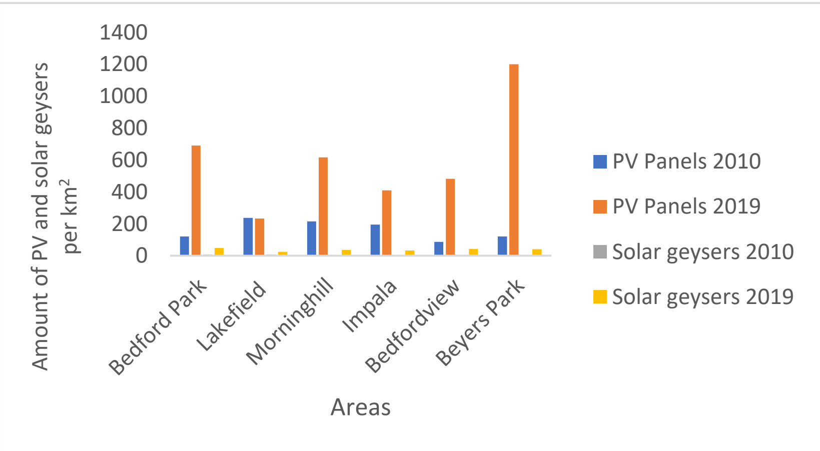
Data analysis and interpretation

Charts and graphs were used to present the data (Ehrenburg, 1978). The differences between uptake rates in the three types of area were tested using t-tests and ANOVA’s.

Results and discussion

All three hypotheses were supported. The first hypotheses being that adoption is most rapid in high-income areas, the second that large-scale installations are only found in industrial areas and the third being that the size of individual installations in suburban areas scales with income per capita. In relation to the third hypothesis, there is a significant difference in uptake rates between high- and low-income areas, within a neighbourhood type there were clear associations between property prices and PV installation rate. Although the proxy may not give an accurate view.

There has been an increase in installation of PV panels since 2010 in all neighbourhoods, which is expected as energy security becomes ever more important in South Africa (Bellos, 2018). The uptake could also be accounted for due to the falling costs of PV systems and rising costs of fossil fuel-fired coal power generation (Lawrence, 2020). This transition is very beneficial to economic development, as energy is needed to increase growth and so by having a secondary source of electricity, there is an uninterrupted flow of power that allows work to continue (Sasana and Ghozali, 2017).



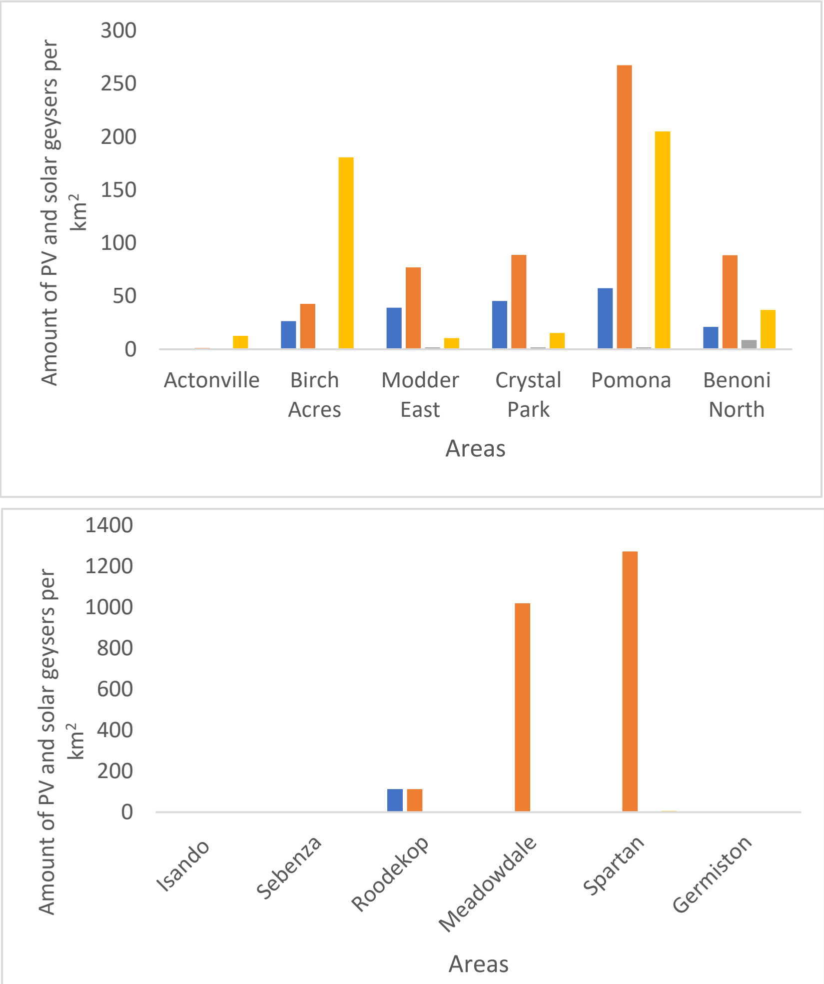


Figure 4: The increase in PV panels and solar geysers between 2010 and 2019 in high-income (top), low-income (middle) and commercial (bottom) neighbourhoods.

It is increasingly important to look after the energy needs of oneself due to the energy crisis being faced within the country (Lawrence, 2020), which is reflected in the data. Looking at figure 4 it is quite clear that the amount of private uptake of PV panels has increased in the last few years across all areas and income groups. Although there has been an uptake of PV panels, there has not been much of an energy mix or hybrid systems within high-income areas (Azoumah *et al.,* 2011). This is seen by a large number of PV panels, but the low uptake of solar geysers found in high-income areas.

Table 1: Summary table showing area, population density, size of area and number of PV panels and solar geysers for high- and low-income and industrial neighbourhoods for 2019.

Neighbourhood	The population of each neighbourhood	km^2 of each neighbourhood surveyed	The total number of individual PV panels per neighbourhood	The average number of individual PV panels per neighbourhood	Total number of individual solar geysers per neighbourhood
Bedford Park	1314	2.25	1556	8	108
Lakefield	1334	2.02	471	4	50
Morninghill	553	0.94	583	6	34
Impala	5271	2.45	1006	4	79
Bedfordview	13959	4.85	2340	9	205
Beyers Park	7364	4.16	4996	11	166
Actonville	10832	3.75	5	0	48
Birch Acres	6732	3.10	133	0	562
Modder East	4224	1.68	130	4	18
Crystal Park	3268	2.33	207	3	36
Pomona	6677	2.59	694	1	532
Benoni North	2501	4.84	429	2	179
Isando		4.27	0	414	1
Sebenza		1.06	0	0	0
Roodekop		2.37	268	268	0
Meadowdale		4.44	4537	206	3
Spartan		1.64	2091	232	10
Germiston		0.91	0	0	0

Table 2: Potential amount of power generated per household per day per area and the total potential amount of power generated per area for 2019.

Neighbourhoods	Power per household (kWh) per day	Number of PV installations in the neighbourhood	The total amount of power generated per neighbourhood, per day (kWh)
High income			
Beyers Park	13,06	363	4741
Bedford Park	8,57	146	1251
Bedfordview	13,21	173	2285
Morninghill	11,41	75	856
Lakefield	7,90	85	672

Impala Park	6,09	194	1182
Low income			
Pomona AH	2,17	112	243
Benoni North AH	4,44	69	306
Modder East	6,95	18	125
Actonville	0,26	2	0,52
Crystal Park AH	5,16	43	222
Birch Acres	0,52	31	16

Table 2 also shows that within high-income areas there is a greater absolute amount of electricity being produced per household, to the point where many of these households could be directly reliant on solar power only, with no reliance on Eskom provided power from the energy grid. Within low-income suburban areas, there are a great number of solar geysers due to government implementation and not due to private uptake as can be seen in the difference in the total number of solar geysers in table 1 (Thobejane *et al.,* 2019). It is difficult to know exactly how much power is being saved as a result of the installation of solar geysers as they may not be adequately maintained or have an optimal orientation but if it is assumed that they are working optimally, the amount would be approximately five kWh per day (Thobejane *et al.,* 2019). As seen in table 1 there has also been some uptake of solar geysers in industrial areas. Table 1 also shows that solar geysers are found in areas that already have PV panels, which adds to the resilience of industrial areas as they have an energy mix established. Many households have four or fewer PV panels across high- and low-income areas.

Figure 5: Showing a shopping centre, Eastgate, with solar panels found within a high-income area, Bedfordview, in 2019.

As seen in figure 5 there are also shopping centres found within high-income suburban areas and many have opted to establish PV panels on their rooftops, as they need a constant supply of power for their business (Khobai and Le Roux, 2017). Many businesses like shopping centres are opting for completely self-reliant sources of power as the instability of Eskom affects their income (Lawrence, 2020; Bellos, 2018; Khobai and Le Roux, 2017). Within industrial areas, due to the sizes of the PV panel systems implemented, there are not many other types of systems implemented besides PV systems that are in place as they need daytime running power and it could be argued that the large systems potentially provide enough daytime electricity (Azoumah *et al.,* 2011).

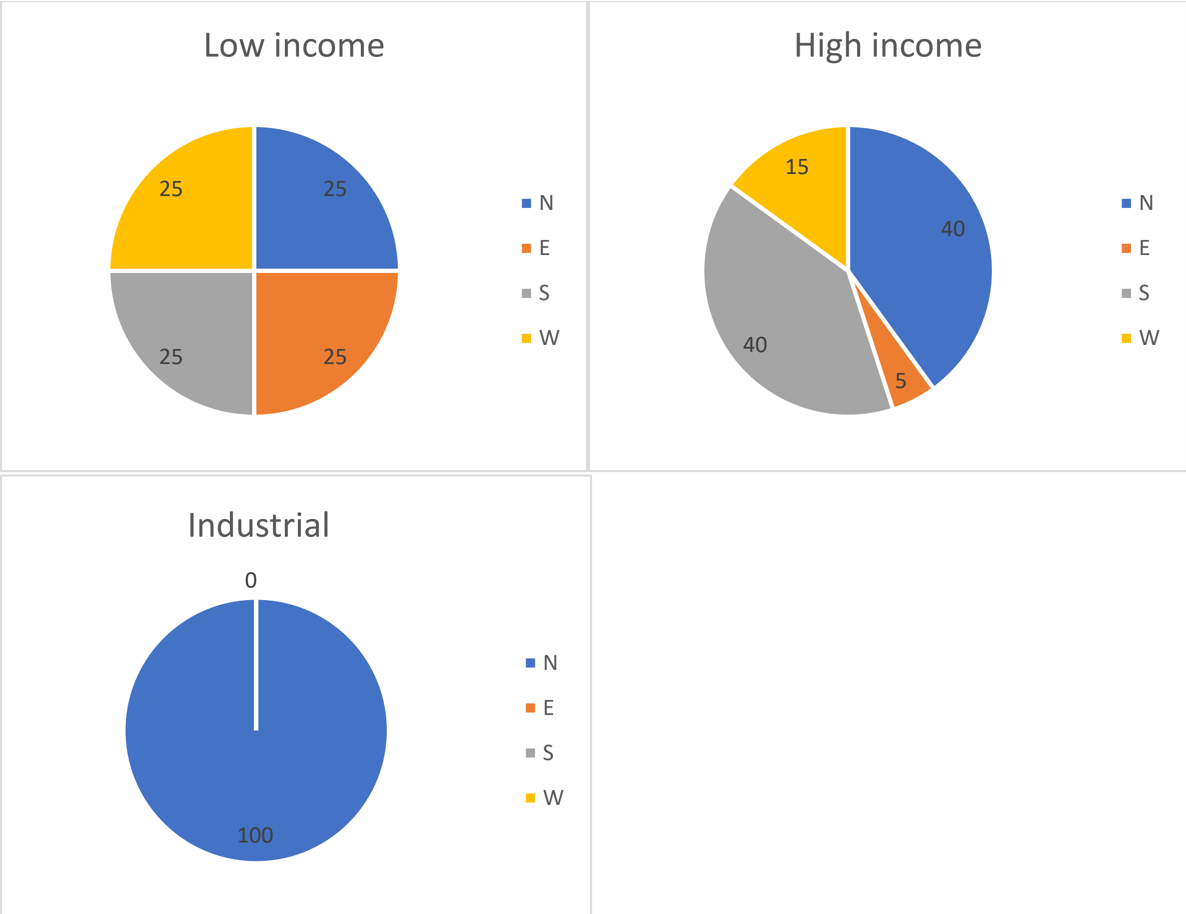


Figure 6: The distribution, in percentages, of rooftop orientations in a sample of 100 dwellings low-income areas (left panel), high-income areas (right panel) and Industrial areas (Bottom panel). The optimum orientation for PV panels is north-facing.

These areas also have the space to implement large battery systems to store their energy and due to optimal orientation as seen in figure 6, would garner the most amount of power (Larcher and Tarascon, 2014). The optimal size of battery systems would allow businesses to store excess power allowing for greater adaptability, making them more resilient (Cox *et al.*, 2017; Larcher and Tarascon, 2014). The largest PV panel penetration was found within industrial areas as can be seen in table 1, which shows that the number of PV panels installed within industrial areas far outstrips the number in either high- or low-income areas. Even if the number of PV panels found in both high- and low-income areas were added together, industrial areas still have the greatest concentration of PV panels.

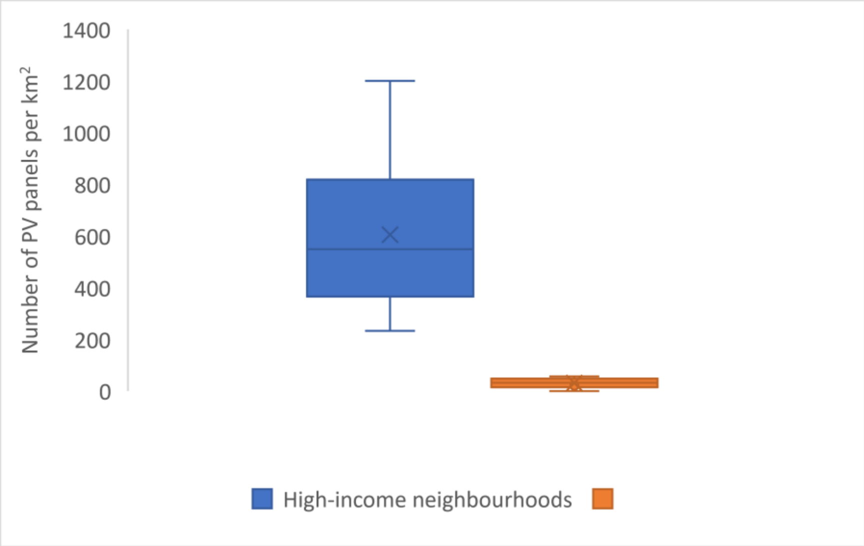


Figure 7: Comparing the number of individual PV panels per km^2 in high income and low-income neighbourhoods using a t-test shows a highly significant difference in the uptake rates ($t = 4.122$, $df = 5$, $p < 0,0091$).

Figure 8: Comparing the number of individual solar water heaters in high income and low-income neighbourhoods using a t-test shows a highly significant difference in the uptake rates based on income ($t = -1,04$, $df = 5$, $p < 0,343842026$).

The creation of a smart grid and energy nexus system, which allows households to share and power with one another and return excess power to the grid would most likely not be implemented yet due to governmental policies and municipality reluctance (Kreichbaum *et al.,* 2018; Schlor *et al*., 2018; Artioli *et al*., 2017; Orehounig *et al*., 2015). There is a significant difference between the uptake rates of PV panels and solar geysers in high- and low-income suburban areas can be seen in figures 7 and 8 where the uptake of PV is greater, as hypothesized in higher-income suburban areas, however, the number of solar geysers in low-income suburban areas far exceed high-income areas. This means that low-income suburban areas have greater diversity in terms of the energy mix that is available to them.

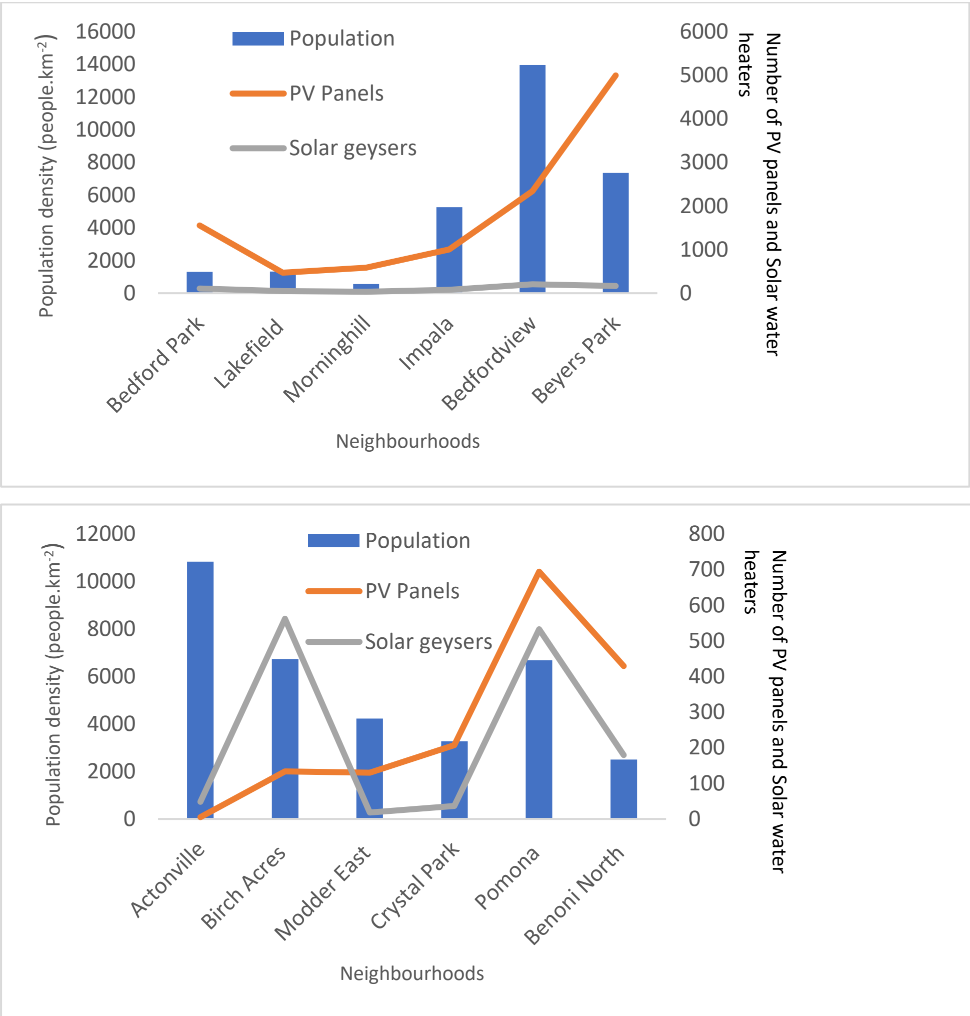
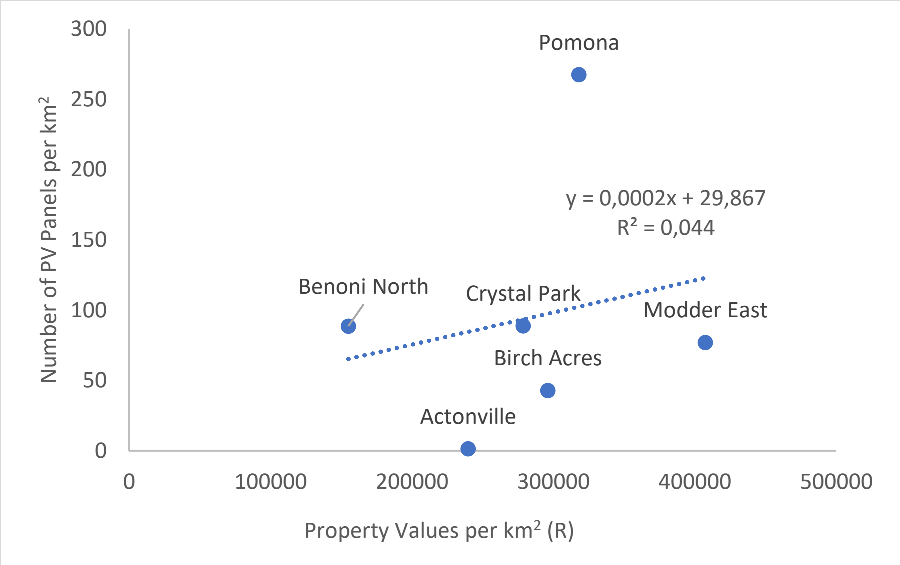


Figure 9: The observed number of PV panels and solar geysers in 2019 in six high-income residential neighbourhoods (top panel) and six low-income neighbourhoods (bottom panel), along with the population density as reported in the 2011 census.

In previous studies, income is a factor affecting the rate of uptake (Best *et al.,* 2019). I found a significant difference in uptake rates between high- and low-income areas (figures 7 and 8, tables 1 and 2). Within each of the broad income categories, the rate of uptake within the high- and low-income suburban areas bears a highly significant relationship with the household income of the area (figures 9 and 10).



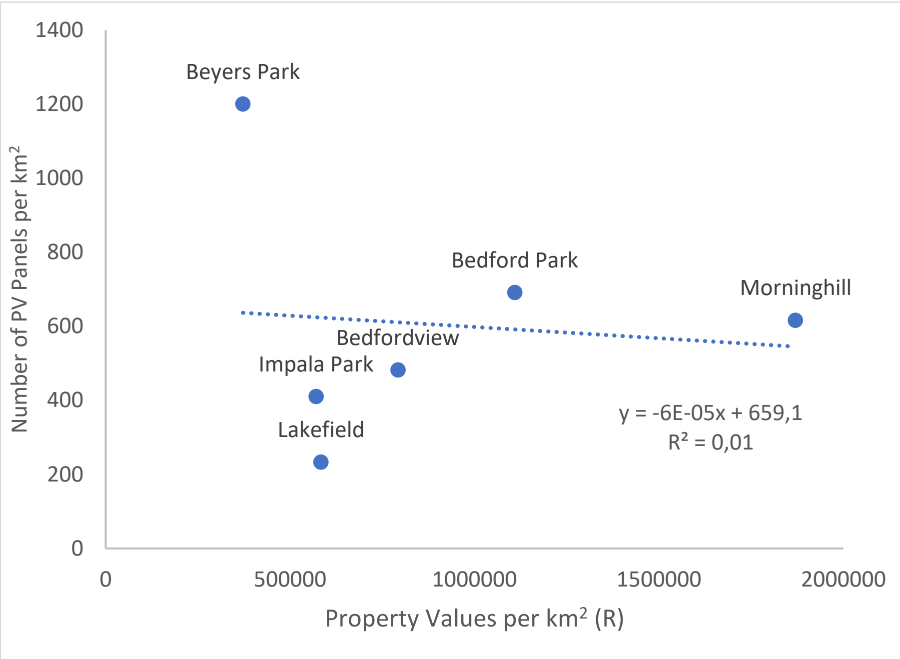


Figure 10: There is a clear association between PV adoption and property prices in both six low-income (P = 0,690115) (top panel) and six high-income neighbourhoods (P = 0,850833) (bottom panel).

Another variable that may affect the rate of uptake is the orientation of the building. Differences in building orientation can be a possible barrier for PV panel uptake as there needs to be sufficient space for the system to be able to work optimally and to receive the maximum amount of sunlight. High-income areas have a greater fraction of optimally north-facing roof facets; but it is unlikely that the equal distribution of orientations in low-income areas is a significant constraining factor since there are still sufficient suitable exposures. In figures 1, 2 and 3 orientation and size of systems can be seen. The difference in orientation between high-income, low-income and industrial areas is estimated in figure 4 and shows that high-income suburban areas have more buildings facing north than low-income suburban areas, and high-income suburban areas also have greater PV uptake, whilst industrial areas have an optimal orientation and greatest uptake due to large flat surface area (figure 11). The reason for the results in figure 6 for low-income suburban areas could be several and needs to be investigated in more detail. A working hypothesis is that in low-income housing, there is less awareness and priority given to optimal building orientation.

Figure 11: Comparing the number of individual PV panels of all the study areas using an ANOVA showing significance between uptake rates of PV panels within contrasting neighbourhoods ($F = 2{,}58$, $p < 0{,}108$).

Lawrence (2020) argues that due to rising costs of coal-fired energy production and logistical problems surrounding the current renewable energy independent power producer procurement program (REIPPPP), there are major social and economic gains to be had from decentralized means of power generation. The current issues surrounding the REIPPPP are partly due to the unbundling of the power parastatal Eskom into three separate entities (Lawrence, 2020). The reason for this split is due to multiple issues within Eskom including governance (Lawrence, 2020). Due to the many crises and governance failures surrounding the energy generated within the country, a decisive shift in perceptions regarding decentralized systems may be underway, meaning that a greater number of stakeholders will opt for own-generation as a means to protect their energy needs (Lawrence, 2020).

Thus, I believe that uptake rates may be dependent on perceptions regarding power production, concerns regarding climate change and energy security and the different uptake rates between high- and low-income areas may be dependent on building orientation as well (Lawrence, 2020; Bellos, 2018).

Income data does have a significant relationship with PV uptake rates within the broad income areas, thus, it is a variable that accounts for greater PV uptake in comparison to low-income suburban areas. PV panels are capital intensive. Industrial areas typically have large surface areas of mainly flat roofs, often well-orientated for PV panels. Even though two neighbourhoods in the industrial areas did not have any PV panels at all, the adoption of PV panels within industrial areas is still greater than in either high- and low-income areas. This is a significant factor for the future of energy production, as relatively large-scale power generation may be implemented within industrial areas. This could help alleviate the current energy crisis and provide much-needed energy security for the country (Lawrence, 2020; Bellos, 2018), but deprives municipalities and Eskom of a relatively reliable income source.

The uptake of PV panels from 2010 to 2019 in urban spaces has led to increased energy security for these urban areas (Cox *et al.,* 2017). The PV panels are versatile and able to survive a variety of different types of climate and weather (Cox *et al.,* 2017). Even though the panels require some level of constant care, mainly cleaning, for these relatively modest systems the effort is not great (Abubakr *et al.,* 2016). As the panels are rather small in scale, they are easy to fix if there are problems or breaks, which lead to increased energy resilience (Cox *et al.,* 2017). The modular easy-to-replace nature of PV panels makes them optimal for adapting to changing environments (either due to climate change, or a shifting energy supply environment), which further increased their resilience (Aliyu *et al.,* 2016). As can be seen in figures 4, 7, 8 and 11 there has been a large uptake of PV panels in all the study areas since 2010. This is probably partly due to dropping costs and improving energy-efficiency of solar-based systems, but a key driver is likely worries regarding energy security and the desire to become more energy resilient (Bellos, 2018; Cox *et al.,* 2017; Fan and Xia, 2017). The rapid uptake of PV panels has already initiated a transition towards a cleaner and more sustainable power production (Bellos, 2018). The deepening crisis of energy stability within South Africa has made stakeholders look elsewhere for their power production, which has had multiple benefits for these areas (Lawrence, 2020). One such benefit is more resilient urban areas, more likely to be able to adapt to changes in climate and energy supply (Lawrence, 2020; Cox *et al.,* 2017).

Study limitations

The limitations of the study are as follows. First was the inadequate database regarding household income in each of the suburbs. Since there is no such publicly available database (the census results conceal income data at this resolution for purposes of privacy protection), it was necessary to use proxy data, based on housing prices, which may give a biased or inaccurate result. A limitation was the date of the available census data, which was 2011 and may no longer give an accurate view of whether the population density has an effect on the uptake rate of PV panels. Another limitation is not knowing whether the PV panels used are monocrystalline or polycrystalline. Normally they can be differentiated by the different colours, however, some polycrystalline panels are created with a darker hue, so it becomes difficult to differentiate between them (Energysage, 2019). The different types have different efficiency levels, and this affects the potential amount of power produced. To fix these issues, a simple approach could be created for collecting and collating data of the areas for income and types and sizes of PV panels leading to more accurate data and better results. This could require asking homeowners what systems and PV panels are being used, rather than using high-resolution images.

Implications of the study

The energy crisis has decreased overall energy resilience. Energy consumers, at the level of individual households or small businesses, are opting for full PV systems to provide themselves with adequate power. This furthers the crisis for centralised electricity suppliers, as revenue is lost for Eskom and the municipal retailers (Lawrence, 2020; Azoumah *et al.,* 2011). The amount of power potentially generated by these areas is something that can be used by energy planners to help supplement the current energy grid, and the potential for large scale power generation from all areas is something that can be explored in the future as a way of transitioning to a more sustainable way of generating electricity. The greatest immediate potential probably exists in industrial areas, as they have the largest surface area suitable for large PV installations (and the accompanying batteries) and are able to mobilise the necessary capital.

Conclusion

The urban energy resilience of the neighbourhoods studied was increased by the private uptake of PV panels between 2010 to 2019. There was a large increase in installed capacity in all areas, but the greatest increase was in high-income residential and commercial areas. The size of individual installations also increased in the order low-income residential, high-income residential and commercial neighbourhoods.

The reasons for the differences in uptake rates are likely to be multiple and were not definitively established by this study. It is suggested that perceptions regarding the stability of the grid and the ability for Eskom to be able to provide uninterrupted power are changing, so stakeholders are starting to look elsewhere for their electricity needs. They look especially towards decentralized systems (in other words, the kind of highly localised, small systems under individual owner control that were observed in this study). The private uptake of PV panels is not a negative feature, although it could be a challenge to the business model of municipalities and centralised power generators, as it has increased the energy resilience of all the areas and increased adaptability to changing climates and to the current uncertainties in energy provision (Bellos, 2018). It points to a future of cleaner, decentralized and more resilient energy production.

Greater uptake of PV panels within the study areas may occur with better financing structures from private or governmental entities to allow greater access to PV panels for all income groups. Recommendations on future research is to find and understand the potential benefits to human health and environmental health greater uptake of PV would have on the study area and surrounding areas along with more focus on the impacts of decentralized power generation.

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Appendices

In the following tables, the column headings have the same meaning.

FID Record identification number

ID Record ID

No Solar the number of solar panels on the building in the record

Heat number of solar geyser installations on the building

Type Type of solar panel, 1= moncrystraline 2=polycrystalline

Appendix 1 - Morninghill 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	16	0	1
1	2	3	0	1
2	3	0	1	2
3	4	8	0	1
4	5	8	0	1
5	6	4	0	1
6	7	6	0	1
7	8	4	0	1
8	9	0	1	2
9	10	6	0	1
10	11	3	0	1
11	12	14	0	1
12	13	4	0	1
13	16	3	0	1
14	14	4	0	1
15	15	3	0	1
16	17	3	0	1
17	18	8	0	1
18	21	12	0	1
19	20	16	0	1
20	19	3	0	1
21	22	5	0	1
22	23	16	0	1
23	24	3	0	1
24	25	2	0	1
25	26	4	0	1
26	27	2	0	1
27	28	4	0	1
28	29	0	1	2
29	30	6	0	1
30	31	3	0	1
31	32	5	0	1
32	33	10	0	1
33	34	3	0	0
34	35	7	0	1
35	36	2	0	1
36	37	3	0	1

Appendix 2 - Impala Park 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	4	0	1
1	2	0	1	2
2	4	4	0	1
3	3	10	0	1
4	6	4	0	1
5	5	10	0	1
6	7	8	0	1
7	8	0	1	2
8	9	4	0	1
9	11	4	0	1
10	10	4	0	1
11	14	10	0	1
12	12	16	0	1
13	13	8	0	1
14	16	3	0	1
15	15	5	0	1
16	17	4	0	1
17	18	0	1	2
18	20	3	0	1
19	19	3	0	1
20	22	3	0	1
21	23	10	0	1
22	21	4	1	3
23	24	10	0	1
24	29	4	0	1
25	28	4	0	1
26	27	4	0	1
27	26	4	0	1
28	25	5	0	1
29	33	6	0	1
30	32	4	0	1
31	31	5	0	1
32	30	4	0	1
33	34	4	0	1
34	35	0	1	2
35	36	6	0	1
36	37	4	0	1
37	38	3	0	1
38	39	3	0	1
39	43	6	0	1
40	42	5	0	1
41	41	4	0	1

42	40	6	0	1
43	44	7	0	1
44	45	14	0	1
45	46	3	0	1
46	49	10	0	1
47	48	4	0	1
48	47	14	0	1
49	50	0	1	2
50	51	3	0	1
51	52	3	0	1
52	53	4	0	1
53	54	3	0	1
54	55	15	0	1
55	56	4	0	1
56	57	3	0	1
57	59	8	0	1
58	58	4	0	1
59	60	0	2	2
60	61	0	2	2
61	65	4	0	1
62	64	14	0	1
63	63	3	0	1
64	62	3	0	1
65	66	12	0	1
66	67	8	0	1
67	68	0	1	2
68	69	4	0	1
69	71	8	0	1
70	70	4	0	1
71	72	4	0	1
72	74	4	0	1
73	73	3	0	1
74	75	3	0	1
75	76	5	0	1
76	77	4	0	1
77	78	10	0	0
78	79	0	1	2
79	80	3	0	1
80	81	4	0	1
81	82	6	0	1
82	85	6	0	1
83	84	8	0	1
84	83	3	0	1
85	86	4	0	1
86	89	3	1	3
87	88	3	0	1

88	87	6	0	1
89	90	3	0	1
90	91	4	0	1
91	92	3	0	1
92	94	6	0	1
93	93	6	0	1
94	95	4	0	1
95	96	4	0	1

Appendix 3 - Beyers Park 2010 - Raw counts

FID	ID	No_solar	Heat	Type
0	1	5	0	1
1	2	4	0	1
2	3	3	0	1
3	4	2	0	1
4	6	3	0	1
5	5	4	0	1
6	7	4	0	0
7	8	12	0	1
8	9	0	1	2
9	10	7	0	1
10	11	7	0	1
11	12	8	0	1
12	14	3	0	1
13	13	4	0	1
14	15	3	0	1
15	16	0	2	2
16	17	0	1	2
17	18	3	0	1
18	21	2	0	1
19	20	3	0	1
20	19	0	2	2
21	22	2	0	1
22	23	4	0	1
23	24	9	0	1
24	25	9	0	1
25	26	6	0	1
26	27	6	0	1
27	28	15	0	1
28	29	6	0	1
29	33	0	1	2
30	32	3	0	1
31	31	3	0	1
32	30	3	0	1
33	34	5	0	1

34	37	4	0	1
35	36	0	1	2
36	35	0	1	2
37	38	3	0	1
38	39	3	0	1
39	40	4	1	3
40	41	0	1	2
41	42	5	0	1
42	43	3	0	1
43	44	3	0	1
44	48	0	1	2
45	47	4	0	1
46	46	3	0	1
47	45	3	0	1
48	49	6	0	1
49	50	3	0	1
50	54	4	0	1
51	53	2	0	1
52	52	4	0	1
53	51	4	0	1
54	59	6	0	1
55	58	4	0	1
56	57	2	0	1
57	56	2	0	1
58	55	3	0	1
59	60	4	0	1
60	61	0	1	2
61	62	4	0	1
62	63	3	0	1
63	64	0	1	2
64	66	6	0	1
65	65	6	0	1
66	67	3	0	1
67	69	6	0	1
68	68	4	0	1
69	71	2	0	1
70	70	3	0	1
71	72	8	0	1
72	73	0	1	2
73	74	2	0	1
74	76	3	0	1
75	75	3	0	1
76	77	4	0	1
77	78	4	0	1
78	81	3	0	1
79	80	2	0	1

80	79	3	0	1
81	83	2	1	3
82	82	2	0	1
83	85	4	0	1
84	84	3	0	1
85	86	3	0	1
86	87	5	0	1
87	88	3	0	1
88	89	3	0	1
89	90	5	0	1
90	91	4	0	1
91	92	4	0	1
92	93	10	0	1
93	94	6	0	1
94	95	6	0	1
95	96	3	0	1
96	97	0	1	2
97	98	6	1	3
98	99	3	0	1
99	100	0	1	2
100	101	7	0	1
101	102	4	0	1
102	103	3	0	1
103	104	5	0	1
104	107	4	0	1
105	106	2	0	1
106	105	4	0	1
107	108	6	0	1
108	109	7	0	1
109	110	3	0	1
110	112	5	0	1
111	111	6	0	1
112	113	0	1	2
113	114	4	0	1
114	115	5	0	1
115	116	4	0	1
116	117	8	0	1
117	119	3	0	1
118	118	4	0	1
119	120	3	0	1
120	121	4	0	1
121	122	0	2	2
122	123	8	0	1
123	127	3	0	1
124	126	3	0	1
125	125	4	0	1

126	124	3	0	1
127	129	3	0	1
128	128	2	0	1
129	130	3	0	1
130	132	4	0	1
131	131	4	0	1
132	133	3	0	1

Appendix 4 - Lakefield 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	6	0	1
1	2	6	0	1
2	3	0	1	2
3	4	0	1	2
4	5	3	0	1
5	11	4	0	1
6	10	5	0	1
7	9	4	0	1
8	8	4	0	1
9	7	2	0	1
10	6	4	0	1
11	12	6	0	1
12	13	3	0	1
13	14	0	1	2
14	15	6	0	1
15	16	6	0	1
16	18	3	0	1
17	17	4	0	1
18	19	6	0	1
19	20	8	0	1
20	21	10	0	1
21	22	0	1	2
22	23	8	0	1
23	24	3	0	1
24	25	8	0	1
25	26	4	0	1
26	27	4	0	1
27	28	8	0	1
28	29	8	0	1
29	30	14	0	1
30	31	4	0	1
31	34	4	0	1
32	33	3	0	1
33	32	3	0	1
34	35	2	0	1

35	36	0	1	2
36	37	3	0	1
37	38	5	0	1
38	39	12	0	1
39	40	5	0	1
40	41	6	0	1
41	44	0	1	2
42	45	4	0	1
43	46	4	0	1
44	47	0	1	2
45	48	0	1	2
46	49	0	1	2
47	50	4	0	1
48	51	8	0	1
49	52	6	0	1
50	53	18	0	1
51	54	14	0	1
52	55	10	0	1
53	56	8	0	1
54	57	3	0	1
55	58	3	0	1
56	59	3	0	1
57	60	6	1	3
58	61	0	1	2
59	62	4	0	1
60	63	0	1	2
61	64	5	0	1
62	65	6	0	1
63	66	4	0	1
64	67	6	0	1
65	68	4	0	1
66	69	4	0	1
67	70	4	0	1
68	71	4	0	1
69	72	4	0	1
70	73	4	0	1
71	74	10	0	1
72	79	10	0	1
73	78	4	0	1
74	77	8	0	1
75	75	6	0	1
76	76	6	0	1
77	81	4	0	1
78	80	6	0	1
79	82	4	0	1
80	85	4	0	1

81	84	4	0	1
82	83	6	0	1
83	87	5	0	1
84	86	5	0	1
85	88	10	0	1
86	89	6	0	1
87	90	0	1	2
88	91	6	0	1
89	92	12	0	1
90	93	22	0	1
91	94	6	0	1

Appendix 5 - Bedfordview 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	2	0	1
1	2	3	0	1
2	3	8	0	1
3	5	4	0	1
4	4	5	0	1
5	6	4	0	1
6	8	4	0	1
7	7	6	0	1
8	9	0	1	2
9	10	6	0	1
10	11	6	0	1
11	12	4	0	1
12	13	12	0	1
13	14	6	0	1
14	15	0	1	2
15	16	4	0	1
16	20	6	0	1
17	19	4	0	1
18	18	4	0	1
19	17	3	0	1
20	21	0	1	2
21	22	6	0	1
22	23	4	0	1
23	26	8	0	1
24	25	12	0	1
25	24	6	0	1
26	27	3	0	1
27	28	8	0	1
28	29	4	0	1
29	30	10	0	1
30	31	6	2	3

31	35	6	0	1
32	34	3	0	1
33	33	3	0	1
34	32	4	0	1
35	36	3	0	1
36	39	4	0	1
37	38	3	0	1
38	37	4	0	1
39	40	8	0	1
40	42	4	0	1
41	41	3	0	1
42	43	4	0	1
43	45	3	0	1
44	44	4	0	1
45	46	3	0	1
46	47	4	0	1
47	48	4	0	1
48	49	0	1	2
49	50	10	0	1
50	52	3	0	1
51	51	4	0	1
52	54	8	0	1
53	53	10	0	1
54	55	6	0	1
55	56	8	0	1
56	57	6	0	1
57	60	0	1	2
58	59	5	0	1
59	61	10	0	1
60	62	6	0	1
61	63	6	0	1
62	64	0	1	2
63	65	0	1	2
64	66	4	0	1
65	67	5	0	1
66	68	0	1	2
67	58	3	1	3
68	69	2	0	1
69	70	10	0	1
70	71	8	0	1
71	72	5	0	1
72	73	8	0	1
73	74	0	1	2
74	75	6	0	1
75	76	9	0	1
76	77	8	0	1

77	78	6	0	1
78	79	4	0	1
79	80	5	0	1
80	81	3	0	1
81	82	7	0	1
82	83	10	0	1
83	82	4	0	1
84	84	0	2	2
85	85	5	0	1
86	86	6	0	1

Appendix 6 - Bedford Park 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	3	0	1
1	2	4	0	1
2	3	2	0	1
3	4	0	1	2
4	5	0	1	2
5	6	6	0	1
6	7	4	0	1
7	8	0	1	2
8	9	6	0	0
9	10	4	0	0
10	11	0	1	2
11	12	17	0	1
12	13	0	2	2
13	14	9	0	1
14	16	4	0	1
15	15	2	0	1
16	17	8	0	1
17	18	8	0	1
18	19	12	1	3
19	20	12	0	1
20	21	0	3	2
21	22	0	2	2
22	23	8	0	1
23	24	16	0	1
24	25	4	0	1
25	26	3	0	1
26	27	4	0	1
27	28	4	0	1
28	29	3	0	1
29	30	4	0	1
30	31	3	0	1
31	32	6	0	1

32	33	3	0	1
33	34	8	0	1
34	35	14	0	1
35	37	3	0	1
36	36	3	0	1
37	38	3	0	1
38	39	10	0	1
39	40	8	0	1
40	41	12	0	1
41	42	6	0	1
42	43	3	0	1
43	44	3	0	1
44	45	6	0	1
45	46	4	0	1
46	47	5	0	1
47	48	3	0	1
48	49	5	0	1
49	50	2	0	1
50	51	6	0	1
51	52	3	0	1
52	53	3	0	1
53	54	4	0	1
54	55	0	1	2

Appendix 7 - Impala Park 2019 – Raw counts

FID	No_of_sola	Heat	Type	ID
0	2	0	1	1
1	3	0	1	2
2	4	0	1	3
3	9	0	1	4
4	9	0	1	5
5	2	0	1	6
6	6	0	1	8
7	2	0	1	7
8	6	0	1	9
9	0	1	2	10
10	0	1	2	11
11	3	0	1	12
12	9	0	1	13
13	2	0	1	14
14	4	0	1	15
15	0	1	2	16
16	0	1	2	18
17	4	0	1	17
18	2	0	1	19

19	8	2	3	20
20	4	0	1	21
21	3	0	1	22
22	2	0	1	23
23	4	1	3	24
24	2	1	3	25
25	8	0	1	26
26	9	0	1	27
27	0	1	2	28
28	6	0	1	29
29	5	0	1	30
30	0	1	2	31
31	5	0	1	32
32	5	0	1	33
33	4	0	1	34
34	3	0	1	35
35	0	2	2	36
36	2	0	1	37
37	10	1	3	38
38	6	0	1	39
39	38	1	3	40
40	0	1	2	41
41	11	0	1	42
42	16	0	1	42
43	5	0	1	43
44	0	2	2	44
45	0	1	2	45
46	0	1	2	46
47	0	1	2	47
48	2	1	3	46
49	5	0	1	47
50	6	0	1	48
51	4	0	1	49
52	6	0	1	50
53	0	1	2	51
54	2	0	1	52
55	8	0	1	53
56	4	0	1	54
57	6	0	1	55
58	5	0	1	56
59	5	0	1	57
60	4	0	1	58
61	0	1	2	59
62	4	0	1	60
63	5	0	1	61
64	12	1	3	62

65	5	0	1	63
66	3	0	1	64
67	0	1	2	64
68	5	0	1	65
69	4	0	1	66
70	4	0	1	67
71	6	0	1	68
72	19	0	1	68
73	7	0	1	69
74	4	0	1	69
75	2	0	1	70
76	8	0	1	71
77	3	0	1	72
78	4	0	1	73
79	5	0	1	74
80	4	0	1	75
81	4	0	1	76
82	4	0	1	77
83	4	0	1	78
84	5	0	1	79
85	0	1	2	80
86	7	1	3	81
87	6	0	1	82
88	4	0	1	83
89	4	0	1	84
90	4	0	1	85
91	7	0	1	86
92	3	0	1	87
93	2	0	1	88
94	6	0	1	89
95	2	1	3	90
96	2	1	3	91
97	3	0	1	92
98	3	0	1	93
99	12	0	1	94
100	3	0	1	95
101	0	2	2	96
102	0	2	1	97
103	4	0	1	98
104	0	1	2	99
105	5	0	1	100
106	5	0	1	101
107	4	0	1	102
108	4	0	1	103
109	0	2	2	104
110	4	2	3	105

111	2	0	1	106
112	6	0	1	107
113	4	1	3	108
114	4	0	1	109
115	4	0	1	110
116	4	0	1	111
117	6	0	1	112
118	2	0	1	113
119	3	0	1	114
120	5	0	1	115
121	0	1	2	116
122	4	0	1	117
123	8	0	1	118
124	4	0	1	119
125	6	0	1	120
126	2	0	1	121
127	2	0	1	122
128	2	0	1	123
129	5	0	1	124
130	6	1	3	125
131	5	0	1	126
132	3	0	1	127
133	12	0	1	128
134	0	1	2	129
135	7	0	1	130
136	6	0	1	131
137	10	0	1	132
138	4	0	1	133
139	3	0	1	134
140	3	0	1	135
141	0	1	2	136
142	7	0	1	137
143	7	0	1	138
144	8	0	1	139
145	3	0	1	140
146	7	0	1	141
147	0	1	2	142
148	3	0	1	143
149	1	0	1	144
150	8	0	1	145
151	0	1	2	146
152	3	0	1	147
153	0	1	2	148
154	0	2	2	149
155	2	0	1	150
156	4	0	1	151

157	0	1	2	152
158	0	1	2	153
159	6	0	1	154
160	2	0	1	155
161	3	0	1	156
162	6	0	1	157
163	5	0	1	158
164	0	1	2	159
165	9	0	1	160
166	0	1	2	161
167	0	1	2	163
168	0	1	2	162
169	6	1	3	164
170	10	0	1	165
171	24	2	3	166
172	5	0	1	167
173	4	0	1	168
174	3	0	1	169
175	0	1	2	170
176	7	0	1	171
177	0	2	2	172
178	2	0	1	173
179	0	1	2	174
180	7	0	1	175
181	2	0	1	176
182	4	0	1	177
183	3	0	1	178
184	10	0	1	179
185	2	1	3	180
186	10	0	1	181
187	0	1	2	182
188	4	1	3	183
189	3	0	1	184
190	3	0	1	185
191	4	0	1	186
192	4	0	1	187
193	6	1	3	188
194	4	0	1	189
195	3	0	1	190
196	0	1	2	192
197	2	0	1	191
198	2	0	1	193
199	6	0	1	194
200	12	0	1	195
201	0	2	2	196
202	4	1	3	197

203	4	0	1	198
204	2	0	1	199
205	2	0	1	200
206	0	1	2	201
207	8	0	1	202
208	9	0	1	203
209	3	0	1	204
210	12	0	1	205
211	5	1	3	206
212	0	1	2	207
213	4	0	1	208
214	2	0	1	209
215	4	0	1	210
216	3	0	1	211
217	0	1	2	212
218	4	0	1	213
219	7	0	1	214
220	4	0	1	215
221	3	0	1	216
222	4	1	3	217
223	4	0	1	218
224	0	1	2	219
225	3	0	1	220
226	9	0	1	221
227	4	0	1	222
228	2	0	1	223
229	3	0	1	224
230	8	1	3	225
231	7	0	1	226
232	3	0	1	227
233	4	0	1	228
234	0	1	2	229
235	3	0	1	230
236	5	0	1	231
237	4	0	1	232
238	0	2	2	233

Appendix 8 - Bedford Park 2019 – Raw counts

FID	No_solar	Heat	Type	ID
0	0	1	2	1
1	4	0	1	2
2	4	0	1	3
3	4	0	1	4
4	0	1	2	5
5	0	1	2	6

6	2	0	1	7
7	4	0	1	8
8	5	0	1	9
9	32	0	1	10
10	26	0	1	11
11	2	0	1	12
12	4	0	1	13
13	11	0	1	14
14	3	0	1	15
15	4	0	1	16
16	4	1	3	17
17	5	0	1	18
18	6	0	1	19
19	4	0	1	20
20	10	0	1	21
21	6	0	1	22
22	4	0	1	23
23	0	1	2	24
24	0	1	2	25
25	6	0	1	26
26	6	0	1	27
27	2	0	1	28
28	0	2	2	29
29	4	0	1	30
30	4	0	1	31
31	5	0	1	32
32	0	2	2	33
33	8	2	3	34
34	0	1	2	35
35	8	0	1	36
36	4	0	1	37
37	5	0	1	38
38	4	0	1	39
39	8	0	1	40
40	9	0	1	41
41	4	0	1	42
42	6	0	1	43
43	0	2	2	44
44	0	1	2	45
45	6	2	3	46
46	0	2	2	47
47	2	0	1	48
48	4	0	1	49
49	10	0	1	50
50	8	2	3	51
51	60	2	3	52

52	35	0	1	53
53	0	4	2	54
54	5	0	1	55
55	0	3	2	58
56	0	3	2	57
57	0	3	2	56
58	46	0	1	59
59	9	0	1	60
60	0	3	2	61
61	9	0	1	62
62	9	1	3	63
63	0	1	2	64
64	6	0	1	65
65	44	0	1	66
66	21	3	3	67
67	0	2	2	68
68	0	1	2	69
69	0	3	2	70
70	14	0	1	71
71	7	0	1	72
72	0	1	2	73
73	6	2	3	74
74	3	0	1	75
75	10	0	1	76
76	4	0	1	77
77	7	0	1	78
78	21	2	3	79
79	55	1	3	80
80	9	0	1	81
81	6	2	3	82
82	15	0	1	83
83	14	0	1	84
84	6	1	3	85
85	20	2	3	86
86	36	0	1	87
87	0	1	2	88
88	0	1	2	89
89	4	0	1	90
90	10	0	1	91
91	120	0	1	92
92	14	3	3	93
93	4	0	1	95
94	2	0	1	96
95	8	3	3	94
96	6	1	3	97
97	36	0	1	98

98	3	0	1	99
99	3	0	1	100
100	6	0	1	101
101	11	0	1	102
102	24	0	1	103
103	6	0	1	104
104	0	2	2	105
105	5	0	1	106
106	5	1	3	107
107	6	0	1	108
108	6	0	1	109
109	4	0	1	110
110	3	0	1	111
111	0	4	2	112
112	4	0	1	113
113	0	1	2	114
114	0	1	2	115
115	3	0	1	116
116	3	0	1	117
117	4	0	1	118
118	56	0	1	119
119	0	2	2	122
120	0	1	2	121
121	0	1	2	120
122	0	2	2	123
123	120	0	1	124
124	6	1	3	126
125	0	1	2	130
126	18	1	3	127
127	8	0	1	129
128	0	3	2	125
129	0	2	2	131
130	6	0	1	132
131	8	0	1	133
132	7	0	1	134
133	10	0	1	135
134	5	0	1	136
135	5	0	1	137
136	10	1	3	138
137	9	0	1	139
138	6	1	3	140
139	14	0	1	141
140	5	0	1	142
141	6	0	1	143
142	0	3	2	144
143	12	0	1	145

144	2	0	1	146
145	0	1	2	147
146	2	0	1	148
147	2	0	1	149
148	4	0	1	150
149	5	0	1	151
150	3	0	1	152
151	4	0	1	153
152	4	0	1	154
153	8	0	1	155
154	0	2	2	156
155	5	0	1	157
156	10	0	1	158
157	5	0	1	159
158	0	1	2	160
159	5	0	1	161
160	6	0	1	162
161	0	2	2	163
162	37	0	1	164
163	3	0	1	173
164	3	0	1	172
165	4	0	1	171
166	2	0	1	170
167	3	0	1	169
168	4	0	1	168
169	3	0	1	167
170	4	0	1	166
171	4	0	1	165
172	2	0	1	174
173	10	0	1	175
174	3	0	1	176
175	4	0	1	177
176	4	0	1	178
177	5	0	1	179
178	5	0	1	180
179	0	1	2	181
180	2	0	1	182
181	6	0	1	183
182	4	0	1	184
183	6	0	1	185
184	0	2	2	186
185	24	0	1	187
186	4	0	1	188

Appendix 9 – Morninghill 2019 – Raw counts

FID	No_solar	Heat	Type	ID
0	0	1	2	1
1	5	0	1	2
2	12	0	1	3
3	0	1	2	4
4	3	0	1	5
5	5	0	1	7
6	5	0	1	6
7	4	0	1	8
8	6	0	1	9
9	7	0	1	10
10	6	0	1	11
11	6	0	1	12
12	9	0	1	13
13	6	0	1	14
14	40	0	1	15
15	6	1	3	16
16	5	0	1	17
17	17	0	1	18
18	4	0	1	19
19	0	1	2	20
20	3	0	1	21
21	8	0	1	22
22	6	0	1	24
23	30	0	1	23
24	0	1	2	25
25	10	0	1	26
26	0	1	2	27
27	10	0	1	28
28	0	1	2	29
29	8	2	3	30
30	0	4	2	31
31	16	0	1	32
32	3	0	1	33
33	4	0	1	34
34	12	0	1	35
35	12	0	1	36
36	0	1	2	37
37	0	1	2	38
38	0	1	2	39
39	10	0	1	40
40	7	1	3	41
41	8	0	1	42
42	4	0	1	43
43	3	0	1	44
44	2	0	1	45

45	8	0	1	46
46	8	3	3	47
47	0	1	2	48
48	6	0	1	49
49	2	0	2	50
50	7	0	1	51
51	0	1	2	52
52	11	0	1	53
53	8	0	1	54
54	10	0	1	55
55	2	0	1	56
56	7	0	1	57
57	4	0	1	58
58	12	0	1	59
59	6	0	1	61
60	6	0	1	60
61	0	2	2	62
62	0	1	2	63
63	0	1	0	64
64	0	1	0	65
65	0	1	0	66
66	0	1	0	67
67	0	1	2	68
68	4	0	1	69
69	3	0	1	70
70	3	0	1	71
71	15	0	1	72
72	9	0	1	73
73	6	0	1	74
74	9	0	1	75
75	3	0	1	76
76	0	1	2	77
77	2	0	1	78
78	3	0	1	79
79	42	0	1	80
80	0	1	2	81
81	2	1	3	82
82	6	0	1	83
83	2	0	1	84
84	0	1	2	85
85	4	0	1	86
86	9	0	1	87
87	6	0	1	88
88	2	0	1	89
89	3	0	1	90
90	3	0	1	91

91	4	0	1	92
92	6	0	1	93
93	14	0	1	94
94	12	0	1	95
95	7	0	1	96
96	5	0	1	97

Appendix 10 – Lakefield 2019 – Raw counts

FID	Id	No_panels	Solar_type	Heat
0	2	4	1	0
1	1	15	1	0
2	3	8	1	0
3	4	7	1	0
4	5	0	2	1
5	6	10	3	2
6	7	12	1	0
7	8	6	1	0
8	9	0	2	1
9	10	0	2	1
10	11	6	1	0
11	13	7	1	0
12	12	7	1	0
13	16	7	1	0
14	14	10	1	0
15	19	0	2	1
16	15	0	2	2
17	18	0	0	0
18	17	3	1	0
19	20	6	1	0
20	21	8	1	0
21	22	6	1	0
22	23	5	1	0
23	24	4	1	0
24	26	4	1	0
25	27	0	2	1
26	29	6	1	0
27	25	4	1	0
28	30	8	1	0
29	28	0	2	1
30	31	0	2	1
31	32	6	1	0
32	33	0	2	1
33	34	0	2	1
34	35	6	1	0
35	36	0	2	1

36	37	4	1	0
37	38	8	1	0
38	39	7	1	0
39	40	0	2	1
40	41	4	1	0
41	42	0	2	1
42	43	6	1	0
43	44	7	1	0
44	45	5	1	0
45	46	9	1	0
46	46	6	3	1
47	47	0	2	1
48	48	3	1	0
49	49	4	1	0
50	49	2	1	0
51	50	5	3	1
52	50	5	3	1
53	51	5	1	0
54	52	3	1	0
55	53	4	1	0
56	54	4	1	0
57	55	0	2	1
58	55	3	1	0
59	57	4	1	0
60	56	9	1	0
61	58	8	1	0
62	59	0	2	1
63	60	6	1	0
64	61	6	1	0
65	62	0	2	1
66	63	0	2	2
67	64	5	1	0
68	65	7	1	0
69	66	5	1	0
70	67	0	2	1
71	68	4	1	0
72	68	4	1	0
73	69	7	1	0
74	70	0	2	1
75	71	0	2	1
76	72	0	2	1
77	73	4	1	0
78	73	5	1	0
79	74	2	1	0
80	75	0	2	1
81	76	2	1	0

82	77	2	1	0
83	78	0	2	1
84	79	6	1	0
85	80	5	1	0
86	81	5	3	1
87	82	0	2	1
88	83	0	2	1
89	83	4	1	0
90	84	6	3	1
91	85	4	1	0
92	86	8	3	1
93	86	3	1	0
94	87	4	1	0
95	87	4	1	0
96	88	0	2	1
97	89	0	2	1
98	90	3	1	0
99	91	4	1	0
100	92	3	1	0
101	92	0	2	1
102	93	7	1	0
103	94	4	1	0
104	94	8	1	0
105	95	3	1	0
106	95	3	1	0
107	96	2	1	0
108	96	10	1	0
109	97	0	2	1
110	98	2	1	0
111	99	4	1	0
112	100	8	1	0
113	101	12	1	0
114	102	0	2	1
115	102	7	1	0
116	103	0	2	2
117	104	0	2	2
118	105	0	2	1
119	106	0	2	1
120	107	0	2	1
121	107	0	2	1
122	108	0	2	1
123	108	3	1	0

Appendix 11 – Bedfordview 2019 – Raw counts

FID	no__solar	ID	Heat	Type

0	122	1	0	1
1	10	2	0	1
2	4	3	0	1
3	7	4	0	1
4	18	5	2	3
5	0	6	2	2
6	6	7	0	1
7	606	8	0	1
8	5	9	0	1
9	0	10	1	2
10	0	11	1	2
11	9	12	0	1
12	0	13	2	2
13	8	14	0	1
14	0	15	1	2
15	10	16	2	3
16	0	18	2	2
17	0	17	1	2
18	8	19	1	3
19	6	20	0	1
20	3	21	0	1
21	21	22	0	1
22	3	28	0	1
23	0	27	1	2
24	0	26	1	2
25	0	25	1	2
26	0	24	1	2
27	0	23	1	2
28	0	29	1	2
29	9	30	0	1
30	4	31	1	3
31	3	32	0	1
32	0	33	3	2
33	5	34	0	1
34	0	35	1	2
35	5	36	0	1
36	0	37	2	2
37	8	38	2	3
38	0	39	3	2
39	2	40	0	1
40	0	41	2	2
41	0	42	2	2
42	5	43	0	1
43	0	44	2	2
44	4	45	0	1
45	8	46	1	3

46	12	47	0	1
47	7	48	0	1
48	7	49	0	1
49	0	65	1	2
50	0	64	1	2
51	0	63	1	2
52	0	62	1	2
53	0	61	1	2
54	0	60	1	2
55	0	59	1	2
56	0	58	1	2
57	0	57	1	2
58	0	56	1	2
59	0	55	1	2
60	0	54	1	2
61	0	53	1	2
62	0	52	1	2
63	0	50	1	2
64	0	51	1	2
65	4	66	0	1
66	8	67	0	1
67	0	68	1	2
68	3	69	2	3
69	0	70	1	2
70	18	71	0	1
71	11	72	3	3
72	31	73	0	1
73	23	74	0	1
74	6	75	0	1
75	2	76	1	3
76	0	77	2	2
77	4	78	0	1
78	3	79	0	1
79	0	80	1	2
80	2	81	0	1
81	0	82	1	2
82	0	83	1	2
83	0	84	1	2
84	0	85	1	2
85	4	86	0	1
86	0	88	3	2
87	4	87	0	1
88	3	89	0	1
89	0	90	2	2
90	0	91	5	2
91	7	92	1	3

92	6	93	0	1
93	4	94	0	1
94	8	95	0	1
95	8	96	1	3
96	0	97	1	2
97	4	98	0	1
98	4	99	0	1
99	0	100	1	2
100	3	101	0	1
101	0	102	1	2
102	4	103	0	1
103	4	104	0	1
104	3	105	0	1
105	0	106	2	2
106	0	107	2	2
107	0	108	2	2
108	8	109	0	1
109	3	110	0	1
110	3	111	0	1
111	5	112	0	1
112	0	113	1	2
113	6	114	0	1
114	4	115	0	1
115	6	116	1	3
116	3	117	0	1
117	0	118	1	2
118	0	119	1	2
119	4	120	0	1
120	5	121	0	1
121	0	122	1	2
122	0	123	1	2
123	0	124	1	2
124	2	125	0	1
125	3	126	0	1
126	0	127	1	2
127	0	128	5	2
128	0	129	4	2
129	0	130	8	2
130	0	131	1	2
131	0	132	1	2
132	0	133	1	2
133	2	134	2	3
134	0	135	1	2
135	7	136	1	3
136	6	137	0	1
137	4	138	0	1

138	0	139	1	2
139	2	140	1	3
140	0	141	1	2
141	0	142	1	2
142	0	143	1	2
143	29	144	0	1
144	3	145	0	1
145	4	146	0	1
146	4	147	0	1
147	4	148	0	1
148	4	149	0	1
149	2	150	0	1
150	0	151	2	2
151	8	152	0	1
152	2	153	0	1
153	0	154	1	2
154	6	155	0	1
155	24	156	0	1
156	6	157	0	1
157	5	158	0	1
158	6	159	0	1
159	2	160	0	1
160	0	161	1	2
161	21	162	0	1
162	44	163	0	1
163	10	164	0	1
164	15	166	0	1
165	35	167	2	3
166	0	165	2	2
167	6	168	0	1
168	4	169	0	1
169	2	170	0	1
170	12	171	0	1
171	0	172	1	2
172	0	173	1	2
173	4	174	0	1
174	2	175	1	3
175	0	176	1	2
176	215	177	0	1
177	3	178	0	1
178	3	179	0	1
179	6	180	0	1
180	0	181	2	2
181	0	182	2	2
182	3	183	0	1
183	3	184	1	2

184	0	185	2	2
185	0	186	2	2
186	8	187	0	1
187	8	188	0	1
188	11	189	0	1
189	8	190	0	1
190	0	191	1	2
191	15	192	0	1
192	8	193	0	1
193	7	194	0	1
194	4	195	0	1
195	3	196	0	1
196	0	197	1	2
197	2	198	0	1
198	7	199	0	1
199	3	200	0	1
200	5	201	0	1
201	3	202	0	1
202	4	203	0	1
203	8	204	0	1
204	6	205	0	1
205	4	206	2	3
206	4	207	0	1
207	32	208	3	3
208	6	209	0	1
209	6	210	0	1
210	9	211	0	1
211	6	212	2	3
212	6	213	0	1
213	6	214	0	1
214	18	215	1	3
215	8	216	0	1
216	0	217	2	2
217	6	218	4	3
218	0	219	2	2
219	0	220	2	2
220	6	221	0	1
221	8	222	1	3
222	4	223	1	3
223	4	224	0	1
224	12	225	0	1
225	6	226	2	3
226	3	227	0	1
227	4	228	0	1
228	2	229	0	1
229	6	230	0	1

230	36	231	0	1
231	0	232	1	2
232	0	233	3	2
233	0	234	1	2
234	0	235	1	2
235	6	236	0	1
236	12	237	1	3
237	4	238	0	1
238	6	239	1	3
239	6	240	0	1
240	8	241	2	3
241	0	242	1	2
242	0	243	1	2
243	0	244	2	2
244	0	245	2	2
245	0	246	3	2
246	2	247	0	1
247	25	248	3	3
248	5	249	0	1
249	0	250	2	2
250	0	251	1	2
251	5	252	0	1
252	0	253	1	2
253	5	254	0	1
254	3	255	0	1
255	9	256	0	1
256	4	257	0	1
257	6	258	0	1
258	12	259	0	1
259	6	260	1	3
260	114	261	0	1
261	0	262	2	2
262	0	263	1	2
263	4	264	0	1
264	20	265	0	1
265	9	266	0	1
266	9	267	0	1
267	6	268	0	1
268	5	269	0	1
269	12	270	0	1
270	32	271	1	3
271	4	272	0	1
272	5	273	0	1
273	8	274	0	1

Appendix 12 - Beyers Park 2019 – Raw counts

FID	No_solar_p	ID	Heat	Type_of_pa
0	155	1	1	3
1	8	2	0	1
2	5	3	0	1
3	24	4	0	1
4	5	5	0	1
5	2	6	0	1
6	0	7	1	2
7	4	8	0	1
8	0	9	1	2
9	0	10	3	2
10	2	11	0	1
11	4	12	1	3
12	8	13	0	1
13	0	14	1	2
14	4	15	0	1
15	3	16	0	1
16	7	17	0	1
17	4	19	0	1
18	5	18	0	1
19	4	20	0	1
20	5	21	0	1
21	4	22	0	1
22	0	31	1	2
23	0	30	1	2
24	0	29	1	2
25	0	28	1	2
26	0	27	1	2
27	0	26	1	2
28	0	25	1	2
29	0	24	1	2
30	0	23	1	2
31	8	32	0	1
32	3	33	0	1
33	5	34	0	1
34	10	35	0	1
35	7	36	1	3
36	0	37	1	2
37	6	38	0	1
38	2	39	0	1
39	0	40	1	2
40	3	41	0	1
41	5	42	0	1
42	5	43	0	1

43	3	44	0	1
44	5	45	2	3
45	3	46	0	1
46	3	47	0	1
47	0	48	1	2
48	21	49	0	1
49	0	50	1	2
50	9	51	0	1
51	3	52	0	1
52	6	53	0	1
53	0	54	1	2
54	3	55	0	1
55	4	56	0	1
56	3	57	0	1
57	4	58	0	1
58	0	59	1	2
59	7	60	1	3
60	0	61	2	2
61	8	62	1	3
62	4	63	0	1
63	6	64	0	1
64	12	65	0	1
65	4	66	0	1
66	4	67	0	1
67	3	68	0	1
68	10	69	0	1
69	0	70	1	2
70	5	71	0	1
71	0	73	1	2
72	0	72	1	2
73	6	74	0	1
74	6	75	0	1
75	4	76	0	1
76	0	77	1	2
77	0	78	1	2
78	2	79	0	1
79	6	80	0	1
80	0	81	1	2
81	0	82	1	2
82	3	83	0	1
83	0	84	1	2
84	4	85	0	1
85	5	86	0	1
86	5	87	0	1
87	4	88	0	1
88	7	89	0	1

89	4	90	1	3
90	7	91	1	3
91	7	92	0	1
92	6	93	0	1
93	4	94	0	1
94	3	95	0	1
95	3	96	0	1
96	0	97	1	2
97	3	98	0	1
98	4	99	1	3
99	30	100	0	1
100	0	101	1	1
101	12	102	1	3
102	2	103	0	1
103	4	104	0	1
104	10	105	0	1
105	0	106	2	2
106	0	107	1	2
107	0	108	1	2
108	0	109	1	2
109	0	110	1	2
110	8	111	0	1
111	0	113	1	2
112	0	112	1	2
113	7	114	0	1
114	8	115	0	1
115	0	116	1	2
116	3	117	1	3
117	7	118	0	1
118	4	119	0	1
119	5	120	0	1
120	0	121	2	2
121	6	122	1	3
122	9	123	0	1
123	4	124	0	1
124	6	125	0	1
125	10	126	0	1
126	4	127	0	1
127	6	128	2	3
128	24	129	1	3
129	4	130	0	1
130	4	131	0	1
131	4	132	0	1
132	4	133	0	1
133	0	134	1	2
134	5	135	0	1

135	5	136	0	1
136	0	137	1	2
137	5	138	0	1
138	4	139	0	1
139	0	140	3	2
140	3	141	0	1
141	3	142	0	1
142	3	143	1	3
143	12	144	2	3
144	3	145	0	1
145	0	146	2	2
146	3	147	0	1
147	18	148	0	1
148	0	149	1	2
149	4	150	0	1
150	7	151	0	1
151	19	152	1	3
152	0	153	1	2
153	2	155	0	1
154	2	154	0	1
155	13	156	2	3
156	8	157	0	1
157	4	158	0	1
158	4	159	0	1
159	0	160	1	2
160	5	161	0	1
161	0	162	2	2
162	2	163	0	1
163	2	164	0	1
164	2	165	0	1
165	2	166	0	1
166	2	167	0	1
167	2	168	0	1
168	2	169	0	1
169	2	170	0	1
170	0	171	1	2
171	0	172	1	2
172	9	173	1	3
173	0	174	1	2
174	0	175	1	2
175	3	176	0	1
176	4	177	0	1
177	1	178	0	1
178	3	179	0	1
179	2	180	0	1
180	12	181	0	1

181	7	182	0	1
182	4	183	0	1
183	0	184	1	2
184	5	185	0	1
185	4	186	0	1
186	0	187	1	2
187	6	188	0	1
188	0	189	1	2
189	4	190	0	1
190	3	191	1	3
191	0	192	1	2
192	3	193	0	1
193	6	194	0	1
194	5	195	0	1
195	0	196	1	2
196	7	197	0	1
197	10	198	0	1
198	3	199	0	1
199	0	200	2	2
200	3	201	0	1
201	2	202	0	1
202	4	203	0	1
203	3	204	0	1
204	4	205	0	1
205	5	206	0	1
206	5	207	0	1
207	4	208	1	3
208	2	209	1	3
209	0	210	1	2
210	4	211	0	1
211	2	212	0	1
212	5	213	0	1
213	6	214	0	1
214	0	215	1	2
215	5	216	0	1
216	2	217	0	1
217	11	218	0	1
218	0	220	1	2
219	10	219	0	1
220	4	221	0	1
221	6	222	0	1
222	5	223	0	1
223	4	224	0	1
224	5	225	0	1
225	3	226	0	1
226	5	227	2	3

227	0	228	2	2
228	3	229	0	1
229	7	230	0	1
230	4	231	0	1
231	16	232	1	3
232	5	233	0	1
233	8	234	1	3
234	3	235	0	1
235	5	236	0	1
236	9	237	1	3
237	7	238	1	3
238	4	239	0	1
239	5	240	0	1
240	6	241	0	1
241	6	242	0	1
242	2	243	0	1
243	3	244	0	1
244	5	245	0	1
245	4	246	0	1
246	3	247	0	1
247	4	248	0	1
248	0	249	1	2
249	4	250	1	3
250	6	251	0	1
251	0	252	2	2
252	0	253	1	2
253	2	254	0	1
254	8	255	0	1
255	5	256	0	1
256	0	257	1	2
257	5	258	0	1
258	3	259	0	1
259	4	260	0	1
260	5	261	0	1
261	0	262	2	2
262	0	265	1	2
263	6	263	0	1
264	6	264	1	3
265	0	266	2	2
266	0	267	1	2
267	2	268	0	1
268	6	269	1	3
269	3	270	0	1
270	2717	271	0	1
271	2	272	0	1
272	2	273	0	1

273	2	274	0	1
274	2	275	0	1
275	2	276	0	1
276	2	277	0	1
277	2	278	0	1
278	2	279	0	1
279	2	280	0	1
280	2	281	0	1
281	2	282	0	1
282	2	283	0	1
283	2	284	0	1
284	2	285	0	1
285	2	286	0	1
286	2	287	0	1
287	2	288	0	1
288	2	289	0	1
289	2	290	0	1
290	2	291	0	1
291	2	292	0	1
292	2	293	0	1
293	2	294	0	1
294	2	295	0	1
295	2	296	0	1
296	2	297	0	1
297	2	298	0	1
298	2	299	0	1
299	2	300	0	1
300	2	301	0	1
301	2	302	0	1
302	2	303	0	1
303	2	304	0	1
304	2	305	0	1
305	2	306	0	1
306	2	307	0	1
307	2	308	0	1
308	2	309	0	1
309	2	310	0	1
310	2	311	0	1
311	2	312	0	1
312	2	313	0	1
313	2	314	0	1
314	2	315	0	1
315	2	316	0	1
316	2	317	0	1
317	2	318	0	1
318	2	319	0	1

319	2	320	0	1
320	2	321	0	1
321	2	322	0	1
322	2	323	0	1
323	2	324	0	1
324	2	325	0	1
325	2	326	0	1
326	2	327	0	1
327	2	328	0	1
328	2	329	0	1
329	2	330	0	1
330	2	331	0	1
331	2	332	0	1
332	2	333	0	1
333	2	334	0	1
334	2	335	0	1
335	2	336	0	1
336	2	337	0	1
337	2	338	0	1
338	2	339	0	1
339	2	340	0	1
340	2	341	0	1
341	2	342	0	1
342	2	343	0	1
343	2	344	0	1
344	2	345	0	1
345	2	346	0	1
346	2	347	0	1
347	2	348	0	1
348	2	349	0	1
349	2	350	0	1
350	2	351	0	1
351	2	352	0	1
352	2	353	0	1
353	2	354	0	1
354	2	355	0	1
355	2	356	0	1
356	2	357	0	1
357	2	358	0	1
358	5	359	0	1
359	4	360	0	1
360	9	361	3	3
361	16	362	0	1
362	8	363	0	1
363	0	364	1	2
364	0	365	1	2

365	0	366	1	2
366	0	367	1	2
367	4	368	0	1
368	14	369	1	3
369	9	370	0	1
370	8	371	0	1
371	10	372	2	3
372	0	373	1	2
373	7	374	0	1
374	0	375	1	2
375	2	376	0	1
376	32	377	0	1
377	0	378	1	2
378	4	379	0	1
379	104	380	0	1
380	27	381	0	1
381	2	382	0	1
382	0	383	1	2
383	0	384	1	2
384	6	385	2	3
385	10	386	0	1
386	3	387	0	1
387	2	388	0	1
388	5	389	0	1
389	4	390	0	1
390	8	391	0	1
391	2	392	0	2
392	0	393	2	2
393	2	394	0	1
394	4	395	0	1
395	0	396	1	2
396	60	397	0	1
397	6	398	0	1
398	0	399	1	2
399	2	400	0	1
400	9	401	0	1
401	0	402	1	2
402	6	403	0	1
403	10	404	6	3
404	3	405	0	1
405	6	406	0	1
406	0	407	1	2
407	3	408	0	1
408	0	409	1	2
409	3	410	0	1
410	2	411	0	1

411	3	413	0	1
412	2	412	0	1
413	4	414	0	1
414	0	415	1	2
415	4	416	1	3
416	0	417	1	2
417	0	418	1	2
418	2	419	0	1
419	2	420	0	1
420	0	421	1	2
421	3	422	0	1
422	0	423	1	2
423	4	424	0	1
424	0	425	1	2
425	0	426	1	2
426	3	427	0	1
427	4	428	1	3
428	0	429	1	2
429	5	430	0	1
430	4	431	0	1
431	3	432	0	1
432	5	433	0	1
433	2	434	0	1
434	3	435	0	1
435	3	436	0	1
436	3	437	0	1
437	296	438	0	1
438	3	439	0	1
439	23	440	1	3
440	2	441	0	1
441	0	442	1	2
442	4	443	0	1
443	2	444	1	3
444	4	445	0	1
445	2	446	0	1
446	2	447	0	1
447	3	448	0	1
448	2	449	0	1
449	2	450	0	1
450	4	451	0	1
451	6	452	1	3
452	0	456	1	2
453	0	455	1	2
454	2	454	0	1
455	3	453	0	1
456	5	457	0	1

457	0	459	1	2
458	0	458	1	2
459	13	460	0	1

Appendix 13 – Roodekop 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	268	0	1

Appendix 14 – Spartan 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	0	2	2
1	2	0	4	2

Appendix 15 – Isando 2019 – Raw counts

FID	No_Solar	Heat	ID	Type
0	80	0	1	1
1	373	0	2	1
2	1307	0	3	1
3	660	0	4	1
4	20	0	5	1
5	45	1	6	3

Appendix 16 – Roodekop 2019 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	268	0	1

Appendix 17 – Meadowdale 2019 – Raw counts

FID	No_solar_p	Heat	ID	Type_of_so
0	78	0	1	1
1	160	0	2	1
2	160	0	3	1
3	160	0	4	1
4	9	0	5	1
5	474	0	6	0
6	4	0	7	1
7	194	0	8	1
8	0	2	9	2
9	0	1	10	2

10	28	0	11	1
11	6	0	12	1
12	20	0	13	1
13	8	0	14	1
14	4	0	15	1
15	1158	0	16	1
16	751	0	17	1
17	52	0	18	1
18	256	0	19	1
19	20	0	20	1
20	935	0	21	1
21	60	0	22	1

Appendix 18 – Spartan 2019 – Raw counts

FID	No_solar	ID	Heat	Type
0	228	1	0	1
1	760	2	0	1
2	0	3	2	2
3	12	4	0	1
4	0	5	4	2
5	0	6	4	2
6	180	7	0	1
7	387	8	0	1
8	524	9	0	1

Appendix 19 – Birch Acres 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	3	0	1
1	3	5	0	1
2	2	6	0	1
3	4	3	0	1
4	5	6	0	1
5	6	6	0	1
6	7	3	0	1
7	9	4	0	1
8	8	6	0	1
9	11	3	0	1
10	10	4	0	1
11	12	3	0	1
12	13	4	0	1
13	14	2	0	1
14	15	4	0	1
15	17	3	0	1
16	16	8	0	1

17	18	9	0	1

Appendix 20– Benoni North 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	5	0	1
1	15	0	1	2
2	14	0	1	2
3	13	0	1	2
4	12	0	1	2
5	11	0	1	2
6	10	0	3	2
7	9	0	1	2
8	8	6	0	1
9	7	4	0	1
10	6	3	0	1
11	5	12	3	3
12	4	12	0	1
13	3	2	0	1
14	2	0	0	1
15	16	3	0	1
16	17	0	1	2
17	18	6	0	1
18	19	0	1	2
19	20	0	1	2
20	21	4	1	3
21	22	3	2	3
22	23	0	1	2
23	24	4	0	1
24	25	4	0	1
25	26	3	1	3
26	27	3	0	1
27	28	0	1	2
28	29	0	4	2
29	30	6	0	1
30	31	0	1	2
31	32	4	0	1
32	33	0	1	2
33	34	6	0	1
34	35	0	3	2
35	36	4	0	1
36	38	4	0	1
37	37	4	0	1
38	39	0	12	2

Appendix 21 – Crystal Park 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	4	0	1
1	2	4	0	1
2	3	3	0	1
3	4	4	0	1
4	5	5	0	1
5	6	3	0	1
6	7	4	0	1
7	8	6	0	1
8	9	4	0	1
9	10	6	0	1
10	11	4	0	1
11	13	4	0	1
12	12	6	0	1
13	14	12	0	1
14	15	4	0	1
15	16	4	0	1
16	17	4	0	1
17	18	3	0	1
18	19	3	0	1
19	20	0	1	2
20	21	0	1	2
21	22	0	1	2
22	23	5	0	1
23	24	3	0	1
24	25	3	0	1
25	26	4	0	1
26	27	0	1	2
27	28	4	0	1

Appendix 22 – Modder East 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	0	1	2
1	2	14	0	1
2	3	6	0	1
3	4	1	0	1
4	5	0	1	2
5	6	0	1	2
6	7	5	0	1
7	8	6	0	1
8	9	6	0	1
9	11	6	0	1
10	10	4	0	1

11	12	7	0	1
12	13	4	0	1
13	14	4	0	1
14	15	3	0	1

Appendix 23 – Pomona 2010 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	6	0	1
1	2	6	0	1
2	3	4	0	1
3	4	4	0	1
4	5	5	0	1
5	6	4	0	1
6	7	4	0	1
7	8	4	0	1
8	9	3	0	1
9	10	3	0	1
10	11	3	0	1
11	12	3	0	1
12	13	0	1	2
13	14	0	1	2
14	15	4	0	1
15	16	3	0	1
16	17	6	0	1
17	18	6	0	1
18	19	12	0	1
19	22	12	0	1
20	21	4	0	1
21	20	3	0	1
22	26	7	0	1
23	25	8	0	1
24	24	4	0	1
25	23	4	0	1
26	27	6	0	1
27	28	12	0	1
28	29	4	0	1
29	30	0	1	2
30	31	5	2	3

Appendix 24 – Actonville 2019 – Raw counts

FID	Name	No_ofSolar	Heat	Solar_type
0	2	0	1	2
1	1	0	1	2
2	3	2	0	1

3	5	0	1	2
4	4	0	1	2
5	6	3	0	1
6	7	0	1	2
7	8	0	1	2
8	9	0	1	2
9	10	0	1	2
10	11	0	1	2
11	12	0	1	2
12	12	0	1	2
13	13	0	1	2
14	14	0	1	2
15	15	0	1	2
16	16	0	1	2
17	17	0	1	2
18	18	0	1	2
19	19	0	1	2
20	20	0	1	2
21	21	0	1	2
22	22	0	1	2
23	23	0	1	2
24	23	0	1	2
25	24	0	1	2
26	25	0	1	2
27	26	0	1	2
28	27	0	1	2
29	28	0	1	2
30	29	0	1	2
31	30	0	1	2
32	31	0	1	2
33	32	0	1	2
34	33	0	1	2
35	34	0	1	2
36	35	0	1	2
37	36	0	1	2
38	37	0	1	2
39	38	0	1	2
40	39	0	1	2
41	40	0	1	2
42	41	0	1	2
43	42	0	1	2
44	43	0	1	2
45	44	0	1	2
46	45	0	1	2
47	46	0	1	2
48	47	0	1	2

49	48	0	1	2

Appendix 25 – Birch Acres 2019 – Raw counts

FID	No_solar	ID	Heat	Type
0	0	1	1	2
1	0	2	1	2
2	0	3	1	2
3	4	4	0	1
4	2	5	0	1
5	4	6	1	3
6	0	21	1	2
7	0	20	1	2
8	0	19	2	2
9	0	18	1	2
10	0	17	1	2
11	0	16	1	2
12	0	15	1	2
13	0	14	1	2
14	0	13	1	2
15	0	12	1	2
16	0	11	1	2
17	0	10	1	2
18	0	9	1	2
19	0	8	1	2
20	0	7	1	2
21	0	22	1	2
22	0	23	1	2
23	0	28	1	2
24	0	27	1	2
25	0	26	1	2
26	0	25	1	2
27	0	24	1	2
28	0	47	1	2
29	0	46	1	2
30	0	45	1	2
31	0	44	1	2
32	0	43	1	2
33	0	42	1	2
34	0	41	1	2
35	0	40	1	2
36	0	39	1	2
37	0	37	1	2
38	0	36	1	2
39	0	32	1	2
40	0	31	1	2

41	0	29	1	2
42	0	30	1	2
43	0	33	1	2
44	0	34	1	2
45	0	35	1	2
46	0	38	1	2
47	0	53	1	2
48	0	52	1	2
49	0	51	1	2
50	0	50	1	2
51	0	49	1	2
52	0	48	1	2
53	0	54	1	2
54	0	55	1	2
55	0	56	1	2
56	0	57	1	2
57	0	58	1	2
58	0	59	1	2
59	0	60	1	2
60	0	61	1	2
61	0	62	1	2
62	0	63	1	2
63	0	64	1	2
64	0	65	1	2
65	0	66	1	2
66	0	67	1	2
67	0	68	1	2
68	0	69	1	2
69	0	70	1	2
70	0	72	1	2
71	0	73	1	2
72	0	74	1	2
73	0	75	1	2
74	0	76	1	2
75	0	77	1	2
76	0	78	1	2
77	0	79	1	2
78	0	80	1	2
79	0	81	1	2
80	0	82	1	2
81	0	83	1	2
82	0	84	1	2
83	0	85	1	2
84	0	86	1	2
85	0	71	1	2
86	0	87	1	2

87	0	88	1	2
88	0	89	1	2
89	0	90	1	2
90	0	91	1	2
91	0	92	1	2
92	0	93	1	2
93	0	94	1	2
94	0	95	1	2
95	0	96	1	2
96	0	97	1	2
97	0	98	1	2
98	0	99	1	2
99	0	100	1	2
100	0	101	1	2
101	0	102	1	2
102	0	103	1	2
103	0	104	1	2
104	0	105	1	2
105	0	106	1	2
106	0	107	1	2
107	0	108	1	2
108	0	109	1	2
109	0	110	1	2
110	0	111	1	2
111	0	112	1	2
112	0	113	1	2
113	0	114	1	2
114	0	117	1	2
115	0	115	1	2
116	0	116	1	2
117	0	118	1	2
118	0	119	1	2
119	0	121	1	2
120	0	120	1	2
121	0	122	1	2
122	0	123	1	2
123	0	124	1	2
124	0	125	1	2
125	0	126	1	2
126	0	127	1	2
127	0	130	1	2
128	0	128	1	2
129	0	129	1	2
130	0	131	1	2
131	0	132	1	2
132	0	133	1	2

133	0	134	1	2
134	0	135	1	2
135	0	136	1	2
136	0	137	1	2
137	0	139	1	2
138	0	138	1	2
139	0	140	1	2
140	0	141	1	2
141	0	142	1	2
142	0	143	1	2
143	0	144	1	2
144	0	145	1	2
145	0	146	1	2
146	0	147	1	2
147	0	148	1	2
148	0	149	1	2
149	0	150	1	2
150	0	151	1	2
151	0	152	1	2
152	0	153	1	2
153	0	154	1	2
154	0	155	1	2
155	0	156	1	2
156	0	157	1	2
157	0	158	1	2
158	0	159	1	2
159	0	160	1	2
160	0	161	1	2
161	0	162	1	2
162	0	163	1	2
163	0	164	1	2
164	0	165	1	2
165	0	166	1	2
166	0	167	1	2
167	0	168	1	2
168	0	169	1	2
169	0	170	1	2
170	0	171	1	2
171	0	172	1	2
172	0	173	1	2
173	0	174	1	2
174	0	175	1	2
175	0	176	1	2
176	0	177	1	2
177	0	178	1	2
178	0	179	1	2

179	0	180	1	2
180	0	181	1	2
181	0	182	1	2
182	0	184	1	2
183	0	185	1	2
184	0	183	1	2
185	0	186	1	2
186	0	187	1	2
187	0	189	1	2
188	0	188	1	2
189	0	190	1	2
190	0	191	1	2
191	0	192	1	2
192	0	193	1	2
193	0	194	1	2
194	0	195	1	2
195	0	196	1	2
196	0	197	1	2
197	0	198	1	2
198	0	199	1	2
199	0	200	1	2
200	0	201	1	2
201	0	202	1	2
202	0	203	1	2
203	0	204	1	2
204	0	205	1	2
205	0	206	1	2
206	0	207	1	2
207	0	208	1	2
208	0	209	1	2
209	0	210	1	2
210	0	212	1	2
211	0	213	1	2
212	0	211	1	2
213	0	214	1	2
214	0	215	1	2
215	0	216	1	2
216	0	217	1	2
217	0	218	1	2
218	0	219	1	2
219	0	220	1	2
220	0	221	1	2
221	0	222	1	2
222	0	224	1	2
223	0	225	1	2
224	0	223	1	2

225	0	226	1	2
226	0	227	1	2
227	0	228	1	2
228	0	229	1	2
229	0	230	1	2
230	0	231	1	2
231	0	232	1	2
232	0	233	1	2
233	0	234	1	2
234	0	235	1	2
235	0	236	1	2
236	0	237	1	2
237	0	238	1	2
238	0	239	1	2
239	0	240	1	2
240	0	241	1	2
241	0	242	1	2
242	0	243	1	2
243	0	244	1	2
244	0	246	1	2
245	0	247	1	2
246	0	245	1	2
247	0	248	1	2
248	0	249	1	2
249	0	250	1	2
250	0	251	1	2
251	0	252	1	2
252	0	253	1	2
253	0	254	1	2
254	0	255	1	2
255	0	257	1	2
256	0	258	1	2
257	0	259	1	2
258	0	260	1	2
259	0	261	1	2
260	0	262	1	2
261	0	263	1	2
262	0	264	1	2
263	0	265	1	2
264	0	266	1	2
265	0	267	1	2
266	0	268	1	2
267	0	269	1	2
268	0	270	1	2
269	0	271	1	2
270	0	272	1	2

271	0	273	1	2
272	0	274	1	2
273	0	275	1	2
274	0	276	1	2
275	0	277	1	2
276	0	278	1	2
277	0	280	1	2
278	0	279	1	2
279	0	281	1	2
280	0	282	1	2
281	0	283	1	2
282	0	284	1	2
283	0	285	1	2
284	0	286	1	2
285	0	287	1	2
286	0	288	1	2
287	0	289	1	2
288	0	290	1	2
289	0	291	1	2
290	0	292	1	2
291	0	293	1	2
292	0	294	1	2
293	0	295	1	2
294	0	296	1	2
295	0	297	1	2
296	0	298	1	2
297	0	299	1	2
298	0	300	1	2
299	0	301	1	2
300	0	302	1	2
301	0	303	1	2
302	0	304	1	2
303	0	305	1	2
304	0	306	1	2
305	0	307	1	2
306	0	308	1	2
307	0	309	1	2
308	0	310	1	2
309	0	311	1	2
310	0	312	1	2
311	0	313	1	2
312	0	314	1	2
313	0	315	1	2
314	0	316	1	2
315	0	317	1	2
316	0	318	1	2

317	0	319	1	2
318	0	320	1	2
319	0	321	1	2
320	0	322	1	2
321	0	325	1	2
322	0	324	1	2
323	0	326	1	2
324	0	327	1	2
325	0	328	1	2
326	0	329	1	2
327	0	331	1	2
328	0	332	1	2
329	0	333	1	2
330	0	330	1	2
331	0	323	1	2
332	2	334	0	1
333	0	335	1	2
334	0	336	1	2
335	0	337	1	2
336	0	338	1	2
337	0	339	1	2
338	0	340	1	2
339	0	341	1	2
340	0	342	1	2
341	0	343	1	2
342	0	344	1	2
343	0	345	1	2
344	0	346	1	2
345	0	347	1	2
346	0	348	1	2
347	2	362	0	1
348	0	349	1	2
349	0	350	1	2
350	0	351	1	2
351	0	352	1	2
352	0	353	1	2
353	0	354	1	2
354	0	355	1	2
355	0	356	1	2
356	0	357	1	2
357	0	358	1	2
358	0	359	1	2
359	0	360	1	2
360	0	361	1	2
361	0	363	1	2
362	0	364	1	2

363	0	365	1	2
364	0	366	1	2
365	0	367	1	2
366	0	368	1	2
367	0	369	1	2
368	0	370	1	2
369	0	371	1	2
370	0	372	1	2
371	0	373	1	2
372	0	374	2	2
373	0	375	2	2
374	0	376	2	2
375	0	377	1	2
376	0	378	1	2
377	0	379	1	2
378	0	380	1	2
379	0	381	2	2
380	0	382	2	2
381	0	383	2	2
382	0	384	2	2
383	0	385	2	2
384	0	386	2	2
385	0	387	2	2
386	0	388	2	2
387	0	389	2	2
388	0	390	1	2
389	0	391	3	2
390	0	401	1	2
391	0	400	1	2
392	0	399	1	2
393	0	398	1	2
394	0	397	1	2
395	0	396	1	2
396	0	395	1	2
397	0	394	1	2
398	0	393	1	2
399	0	392	1	2
400	0	402	1	2
401	0	403	1	2
402	0	404	1	2
403	0	405	1	2
404	0	406	1	2
405	0	407	1	2
406	0	408	1	2
407	0	409	1	2
408	0	410	1	2

409	0	411	1	2
410	0	412	1	2
411	0	413	1	2
412	0	414	1	2
413	0	415	1	2
414	0	416	1	2
415	0	417	1	2
416	0	418	1	2
417	0	419	1	2
418	0	420	1	2
419	0	421	1	2
420	0	422	1	2
421	0	423	1	2
422	0	424	1	2
423	0	425	1	2
424	0	426	1	2
425	0	427	1	2
426	0	428	1	2
427	0	429	1	2
428	0	430	1	2
429	0	431	1	2
430	0	432	1	2
431	0	33	1	2
432	0	434	1	2
433	0	435	1	2
434	0	436	1	2
435	0	438	1	2
436	0	437	1	2
437	0	439	1	2
438	0	440	1	2
439	0	441	1	2
440	0	442	1	2
441	0	443	1	2
442	0	444	1	2
443	0	445	1	2
444	0	446	1	2
445	0	447	1	2
446	0	448	1	2
447	0	449	1	2
448	0	450	1	2
449	0	451	1	2
450	0	452	1	2
451	0	453	1	2
452	0	454	1	2
453	0	455	1	2
454	0	456	1	2

455	0	457	1	2
456	0	458	1	2
457	0	459	1	2
458	0	460	1	2
459	0	461	1	2
460	0	462	1	2
461	0	463	1	2
462	0	464	1	2
463	0	465	1	2
464	0	466	1	2
465	0	467	1	2
466	0	468	1	2
467	0	469	1	2
468	0	470	1	2
469	0	471	1	2
470	0	472	1	2
471	0	473	1	2
472	0	474	1	2
473	0	475	1	2
474	2	476	0	1
475	0	477	1	2
476	0	478	1	2
477	0	479	1	2
478	0	480	1	2
479	0	483	1	2
480	0	484	1	2
481	0	481	1	2
482	0	482	1	2
483	0	485	1	2
484	4	486	1	3
485	0	487	1	2
486	0	488	1	2
487	0	489	1	2
488	5	490	0	1
489	5	492	0	1
490	0	491	1	2
491	4	493	0	1
492	0	494	1	2
493	0	495	1	2
494	0	496	1	2
495	0	499	1	2
496	0	498	1	2
497	0	497	1	2
498	7	500	0	1
499	5	501	0	1
500	5	502	0	1

501	5	503	0	1
502	5	504	0	1
503	3	505	0	1
504	0	506	1	2
505	2	507	0	1
506	0	508	1	2
507	5	509	0	1
508	4	510	0	1
509	0	511	1	2
510	4	512	0	1
511	0	513	1	2
512	0	514	1	2
513	0	515	1	2
514	0	516	1	2
515	0	517	1	2
516	0	518	1	2
517	0	519	1	2
518	0	520	1	2
519	0	521	1	2
520	0	522	1	2
521	0	523	1	2
522	0	524	1	2
523	0	525	1	2
524	0	526	1	2
525	0	527	1	2
526	0	528	1	2
527	0	529	1	2
528	0	530	1	2
529	0	531	1	2
530	0	532	1	2
531	0	533	1	2
532	0	534	1	2
533	0	535	1	2
534	0	536	1	2
535	0	537	1	2
536	0	538	1	2
537	0	539	1	2
538	0	540	1	2
539	0	541	1	2
540	0	542	1	2
541	0	543	1	2
542	0	544	1	2
543	0	545	1	2
544	0	546	1	2
545	0	547	1	2
546	0	548	1	2

547	0	549	1	2
548	0	550	1	2
549	0	552	1	2
550	0	551	1	2
551	0	553	1	2
552	0	555	1	2
553	0	554	1	2
554	4	556	0	1
555	9	557	0	1
556	0	558	1	2
557	0	559	1	2
558	5	560	0	1
559	2	561	0	1
560	3	562	0	1
561	0	563	1	2
562	0	564	1	2
563	0	565	1	2
564	0	566	1	2
565	2	567	0	1
566	0	568	1	2
567	6	569	0	1
568	4	570	0	1
569	6	571	0	1
570	0	572	1	2
571	4	573	0	1
572	0	574	1	2
573	3	575	0	1
574	0	576	2	2
575	6	577	0	1

Appendix 26– Benoni North 2019 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	0	3	2
1	2	14	0	1
2	3	8	0	1
3	4	7	0	1
4	5	4	0	1
5	6	0	2	2
6	7	2	0	1
7	13	0	1	2
8	14	0	3	2
9	12	0	2	2
10	11	0	2	2
11	8	0	1	2
12	9	0	1	2

13	10	0	2	2
14	15	6	0	1
15	16	0	1	2
16	17	0	1	2
17	18	0	1	2
18	19	0	1	2
19	20	0	3	2
20	21	9	0	1
21	22	0	3	1
22	23	8	1	3
23	24	0	2	2
24	25	5	2	3
25	26	5	0	1
26	27	0	1	2
27	28	7	0	1
28	29	6	0	1
29	30	5	0	1
30	31	0	2	2
31	32	31	1	3
32	33	2	0	1
33	34	2	0	1
34	35	2	0	1
35	36	2	0	1
36	37	2	0	1
37	38	2	0	1
38	39	2	0	1
39	40	2	0	1
40	41	2	0	1
41	42	2	0	1
42	43	2	0	1
43	44	2	0	1
44	45	2	0	1
45	46	2	0	1
46	47	2	0	1
47	48	0	1	2
48	49	0	1	2
49	50	2	0	1
50	51	2	0	1
51	52	2	0	1
52	53	2	0	1
53	54	2	0	1
54	55	3	0	1
55	56	3	0	1
56	58	2	0	1
57	57	2	0	1
58	59	2	0	1

59	60	0	1	2
60	61	0	1	2
61	62	3	0	1
62	63	0	1	2
63	64	0	1	2
64	65	0	1	2
65	66	0	1	2
66	67	4	0	1
67	71	0	1	2
68	70	0	1	2
69	69	0	1	2
70	68	0	1	2
71	72	2	0	1
72	74	0	1	2
73	76	0	1	2
74	75	0	1	2
75	77	8	1	3
76	73	4	1	3
77	78	0	1	2
78	79	0	1	2
79	80	0	1	2
80	81	0	1	2
81	82	0	1	2
82	83	0	1	2
83	84	0	1	2
84	86	12	0	1
85	85	65	2	3
86	87	0	1	2
87	88	5	0	1
88	89	4	0	1
89	90	3	0	1
90	91	0	1	2
91	92	4	0	1
92	93	0	1	2
93	94	0	3	2
94	95	0	1	2
95	96	0	1	2
96	97	0	1	2
97	98	0	1	2
98	100	0	2	2
99	99	0	1	2
100	101	3	0	1
101	105	0	1	1
102	104	0	1	1
103	103	0	1	1
104	106	3	0	1

105	107	0	1	2
106	108	3	0	1
107	109	0	1	2
108	110	2	0	1
109	111	4	0	1
110	112	8	0	1
111	113	0	1	2
112	114	0	1	2
113	116	0	1	2
114	115	0	1	2
115	119	0	2	2
116	118	0	1	2
117	117	0	1	2
118	102	0	5	1
119	120	6	0	1
120	121	0	2	2
121	122	0	1	2
122	123	0	1	2
123	124	0	1	2
124	125	0	1	2
125	127	0	1	2
126	128	0	1	2
127	126	0	1	2
128	129	0	1	2
129	130	0	1	2
130	131	0	1	2
131	132	0	1	2
132	133	0	1	2
133	134	0	1	2
134	135	0	1	2
135	136	0	1	2
136	138	0	1	2
137	139	0	1	2
138	137	0	1	2
139	140	0	1	2
140	141	0	1	2
141	142	0	1	2
142	143	2	0	1
143	144	0	1	2
144	145	0	2	2
145	146	0	2	2
146	147	0	1	2
147	148	0	1	2
148	149	13	3	3
149	150	35	0	1
150	151	0	1	2

151	152	7	0	1
152	153	0	2	2
153	154	7	1	3
154	158	0	2	2
155	157	0	1	2
156	156	0	2	2
157	155	0	1	2
158	163	0	1	2
159	161	0	1	2
160	160	0	2	2
161	159	0	1	2
162	162	6	1	3
163	164	4	0	1
164	165	25	0	1
165	166	3	0	1
166	167	0	8	2
167	168	0	1	2
168	170	0	1	0
169	171	0	1	0
170	169	0	24	1
171	172	0	1	2
172	173	3	0	1
173	174	4	0	1
174	175	8	1	3

Appendix 27 – Crystal Park 2019 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	2	0	1
1	2	0	1	2
2	3	3	0	1
3	4	6	0	1
4	5	0	2	2
5	6	4	0	1
6	7	4	0	1
7	8	5	0	1
8	10	0	1	2
9	9	0	1	2
10	11	7	0	1
11	12	7	0	1
12	13	0	2	2
13	14	5	0	1
14	15	7	0	1
15	16	3	0	1
16	17	0	1	2
17	18	6	0	1

18	20	0	1	2
19	19	0	1	2
20	21	6	0	1
21	22	6	0	1
22	23	6	0	1
23	24	0	1	2
24	25	5	0	1
25	26	2	2	3
26	27	4	0	1
27	28	4	0	1
28	29	4	0	1
29	30	4	0	1
30	31	0	1	2
31	32	0	1	2
32	33	3	0	1
33	34	0	1	2
34	35	6	0	1
35	36	6	0	1
36	37	5	0	1
37	38	0	1	2
38	39	5	0	1
39	40	3	0	1
40	41	2	0	1
41	42	4	0	1
42	43	0	1	2
43	44	0	1	2
44	45	0	2	2
45	46	0	1	2
46	47	0	1	2
47	48	8	1	3
48	49	3	0	1
49	50	4	0	1
50	51	4	0	1
51	52	6	0	1
52	53	0	1	2
53	54	12	0	1
54	55	0	1	2
55	56	5	0	1
56	57	0	2	2
57	58	0	1	2
58	59	0	1	2
59	60	0	1	2
60	61	0	1	2
61	62	3	0	1
62	63	0	1	2
63	64	3	0	1

64	65	2	0	1
65	66	0	1	2
66	67	8	0	1
67	68	0	1	2
68	69	4	0	1
69	70	0	1	2
70	71	8	0	1
71	72	3	0	1

Appendix 28 – Modder East 2019 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	6	0	1
1	2	0	1	2
2	3	8	0	1
3	5	0	1	2
4	6	0	1	2
5	4	5	0	1
6	7	4	0	1
7	8	2	0	1
8	9	27	1	3
9	10	0	1	2
10	11	11	0	1
11	12	0	1	2
12	13	3	0	1
13	14	0	1	2
14	15	10	0	1
15	16	0	1	2
16	17	14	0	1
17	18	0	1	2
18	19	4	1	3
19	20	0	1	2
20	21	6	1	3
21	22	0	1	2
22	23	0	1	2
23	24	0	1	2
24	25	5	0	1
25	26	7	0	1
26	27	8	0	1
27	28	0	1	2
28	29	6	0	1
29	30	4	0	1
30	31	0	1	2
31	32	0	1	2

Appendix 29 – Pomona 2019 – Raw counts

FID	ID	No_solar	Heat	Type
0	1	6	0	1
1	2	6	0	1
2	3	3	0	1
3	4	15	3	1
4	5	0	2	2
5	6	12	0	1
6	7	0	1	2
7	8	0	1	2
8	9	0	1	2
9	11	0	1	2
10	12	0	1	2
11	10	0	1	2
12	13	0	1	2
13	14	0	1	2
14	15	0	1	2
15	16	0	1	2
16	17	0	1	2
17	18	0	1	2
18	19	0	1	2
19	20	0	1	2
20	21	0	1	2
21	22	0	1	2
22	23	0	1	2
23	24	0	1	2
24	25	0	1	2
25	26	0	1	2
26	27	0	1	2
27	28	0	1	2
28	29	0	1	2
29	31	0	1	2
30	30	0	1	2
31	32	0	1	2
32	33	0	1	2
33	43	3	1	3
34	34	4	0	1
35	35	0	1	2
36	36	0	1	2
37	37	0	1	2
38	38	0	1	2
39	39	0	1	2
40	40	0	1	2
41	41	0	1	2
42	42	0	1	2

43	99	2	1	3
44	44	0	1	2
45	45	0	1	2
46	46	0	1	2
47	47	0	1	2
48	48	0	1	2
49	49	0	1	2
50	50	0	1	2
51	51	0	1	2
52	52	0	1	2
53	53	0	1	2
54	54	0	1	2
55	55	0	1	2
56	56	0	1	2
57	57	0	1	2
58	58	0	1	2
59	59	0	1	2
60	60	0	1	2
61	61	0	1	2
62	62	0	1	2
63	63	0	1	2
64	64	0	1	2
65	65	0	1	2
66	66	0	1	2
67	67	0	1	2
68	68	0	1	2
69	69	0	1	2
70	70	0	1	2
71	71	0	1	2
72	72	0	1	2
73	73	0	1	2
74	74	0	1	2
75	75	0	1	2
76	76	0	1	2
77	77	0	1	2
78	80	0	1	2
79	78	0	1	2
80	79	0	1	2
81	81	0	1	2
82	82	0	1	2
83	83	0	1	2
84	84	0	1	2
85	85	0	1	2
86	86	0	1	2
87	87	0	1	2
88	88	0	1	2

89	89	0	1	2
90	97	0	1	2
91	98	0	1	2
92	96	0	1	2
93	95	0	1	2
94	94	0	1	2
95	93	0	1	2
96	92	0	1	2
97	91	0	1	2
98	90	0	1	2
99	100	4	0	1
100	101	0	1	2
101	102	0	1	2
102	103	0	1	2
103	104	0	1	2
104	105	0	1	2
105	106	0	1	2
106	107	0	1	2
107	108	0	1	2
108	109	0	1	2
109	110	0	1	2
110	111	0	1	2
111	112	0	1	2
112	113	0	1	2
113	114	3	0	1
114	115	6	1	3
115	116	6	2	3
116	117	0	1	2
117	118	0	1	2
118	119	0	1	2
119	120	0	1	2
120	121	0	1	2
121	122	0	1	2
122	123	0	1	2
123	124	0	1	2
124	125	0	1	2
125	126	0	1	2
126	127	0	1	2
127	128	0	1	2
128	129	0	1	2
129	130	0	1	2
130	131	10	0	1
131	132	12	2	3
132	138	4	0	1
133	137	6	1	3
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449	451	0	1	2
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452	456	0	1	2
453	457	0	1	2
454	458	0	1	2
455	459	0	1	2
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462	466	4	0	1
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465	469	0	1	2
466	470	0	1	2
467	471	5	0	1
468	472	4	0	1
469	473	3	0	1
470	474	4	0	1
471	475	3	0	1
472	476	3	0	1
473	478	2	0	1
474	477	3	0	1
475	479	0	1	2
476	481	0	1	2
477	480	4	0	1
478	482	10	0	1
479	483	10	0	1
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481	485	2	0	1
482	486	2	0	1
483	487	16	0	1
484	488	3	0	1
485	489	3	0	1
486	490	2	0	1
487	491	2	1	3
488	492	8	0	1
489	493	2	0	1
490	494	6	0	1
491	495	5	0	1
492	496	10	0	1
493	497	4	0	1
494	498	4	0	1
495	499	12	0	1
496	500	4	0	1
497	501	0	1	2
498	502	6	1	3
499	503	6	0	1
500	504	8	0	1
501	505	12	0	1
502	506	2	0	1

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514	518	4	0	1
515	519	6	0	1
516	520	2	0	1
517	521	0	1	2
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576	580	2	0	1
577	581	3	0	1
578	582	4	0	1
579	583	4	0	1
580	584	0	1	2
581	585	0	1	2
582	586	4	0	1
583	587	0	1	2
584	588	8	0	1
585	589	10	0	1
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587	591	2	0	1
588	592	0	1	2
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590	594	0	1	2
591	596	3	0	1
592	595	0	1	2
593	597	2	0	1
594	598	4	0	1

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597	601	4	0	1
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613	617	4	0	1
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615	619	0	1	2
616	620	0	1	2
617	621	0	1	2
618	622	0	1	2
619	623	0	1	2
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623	627	0	1	2
624	628	0	1	2
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Appendix 30 – Map of study area with polygon shapes for specific neighbourhoods