



SELF-SUFFICIENT

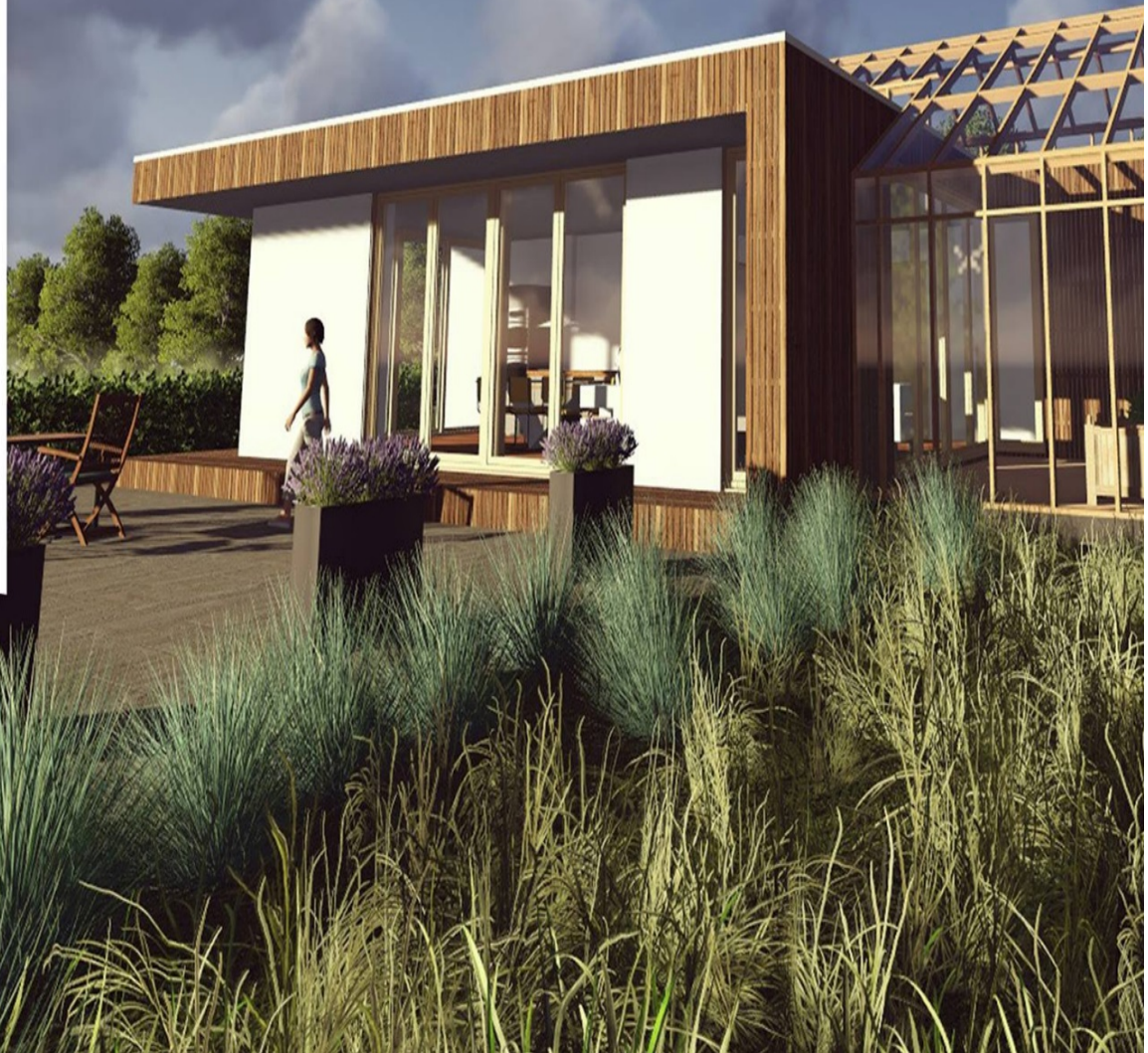


MODULAR SYSTEM



CIRCULAR ELEMENTS

Car vs Building Industry Comparison



June 4th 2018

Minor in Globalizing Business

**Authored by: Carl Abrahamsson & Brendan
O'Leary**



Contents

EXECUTIVE SUMMARY.....	3
Introduction	5
Findings.....	9
Appendix I.....	19
Appendix II.....	19
References	20

EXECUTIVE SUMMARY

This report was commissioned for Selficient to examine and compare the modular building industry to the car industry and to recommend what Selficient could learn from the car industry.

The research draws attention that compliancy and tradition in the building industry has led to it being less efficient, less environmentally friendly and having lower margins than the car industry by as much as 50%. These two problems (High costs and tradition) are the greatest problems Selficient faces. The research contained within this report highlights the possible use of offsite production, the platform concept, transportation/logistics and incentives as favorable as Selficient looks to begin mass production.

Studies have shown a 2.6% difference in productivity growth between the construction and manufacturing sectors with excessive waste and high labor turnovers being factors in reduced productivity within the construction sector. Productivity is shown to increase in a controlled offsite production facility (factory production) like what is used in the manufacturing industry ie auto manufacturers. Further investigations have identified times when modular building falls out of trend compared (ie during times of economic recession) compared to traditional construction and how this has limited offsite production in the construction industry in the past.

The platform concept used by auto manufacturers and how this allows manufacturers such as Toyota and Volkswagen to achieve a higher profit margin compared to the industry average and allowing the standardization achieved to be rolled out across product lines.. Investigation into consumer behaviors in the car industry with the platform concept have identified branding becoming less of a determining factor in car purchasing due to standardization.

Further investigations into the car industry have identified how shipment of parts compared to finished products can lead to cost savings in transportation and taxation. Moreover, the research has identified as positive correlation through incentives and benefits offered to consumers purchasing electric vehicles and how this has increased their adoption rate along with governmental regulation.

This report has evaluated the auto and construction industry and has identified ways in which Selficient can achieve cost reductions. However it is recommended that:

- Enter into a partnership to achieve finance/knowhow for sales negotiations with firms and to achieve mass production.
- The engineering team should conduct a technical analysis into the suitability of the report's findings to the Selficient concept.
- Establishing a continuous feedback system for Selficient homeowners/users to gain invaluable information on design improvements or problems.
- Establishment of production factories in strategic locations based on further research and roll out plans.
- Educating potential buyers on benefits of the modular home and to abolish stereotypes of the modular home.
- Conducting country analysis to establish incentives offered by countries around the world for the modular home.

Introduction

LOOKING INTO THE CAR INDUSTRY

Henry Ford revolutionized the car industry when in the 1920s he came up with mass production of cars. This mass production led to reduction in prices and more people were able to buy a car. His new innovative way of producing cars was through assembly lines. Assembly lines made it possible for people to specialize in one part of the production chain such as the engine or the wheel assembly instead of producing the whole car themselves. By working this way, only one skill per worker was necessary since they specialized in their part. This made it cheaper to produce cars and the cars could be sold at a lower price. This revolutionary way of producing cars also spread to other industries. ("Henry Ford and mass production", 2005)

ASSEMBLY LINES

A little more in depth of how an assembly line is working. An assembly line is an industrial arrangement of machines, equipment and workers in the right order for a continuous workflow when mass producing something. The design of an assembly line is well determined and planned regarding in which order everything comes. There should be no backtracking in an effective assembly line leading up to the final product. Everything in the line is compatible. For example, when using an assembly line in the car industry. The assembly line starts with the chassis of the car and then gets transported by a conveyor where more parts are added along the way such as engines and tires. As the conveyor moves, each worker performs a specific task. There are also automated assembly lines which consist of only machines, with little or no human interfering. Automated assembly lines are mostly used in the car industry where the output produced is very high. ("Assembly line", 2016)

LOGISTICS IN AUTOMOTIVE INDUSTRY:

Instead of shipping finished cars all around the world, the automotive manufacturers prefer to send parts and components separately to the on-site manufacturing plants. This is because it is cheaper to send parts than to send finished cars and finished products in general. Mainly because the components occupy less weight and then reduces the freight costs. To make this possible, it requires flexible manufacturing. The challenge is to deliver every part right in time in the production and assembly line for when it is going to be used. If not delivered in time, the whole production and assembly lines must be changed. ("Supply Chain Management in Automotive Industry", 2016)

Car Industry manufacturing provided three main advantages over craft in the building industry (Gann, 1996)

- 1) Economies of Scale
- 2) Technical possibilities to develop and deploy capital equipment
- 3) The opportunity for tighter managerial control

Car industry keeps design standardised for as long as possible in order to keep costs of new equipment, training and R&D down.

CONDITIONS IN THE CAR INDUSTRY:

The car industry is doing well. The average car age is getting older. The new cars have longer time between services which means the quality is higher. Another side of the car industry that are doing very well is the automotive aftermarket. The older the cars gets the more service and care they need. This is where the industry flourishes. They need regular and emergency service, painting, replacement of parts and much more. This side of the industry is always going to stay strong even if the economy has a recession and the number of new cars being sold decreases. ("Automotive Industry Analysis 2018- Cost & Trends", 2018)

LOOKING INTO THE MODULAR HOME INDUSTRY

How long does it take to build a modular home? In general, it takes around 1-2 weeks but also depending on the design and the manufacturer. Modular homes are built in sections at a factory. A standard modular home is built to conform to all regional and local building codes in that region.

The design of a modular home could be like a normal house. Modular housing builders uses computer programs to build the houses and they can specify one of their standard houses to fit the owner's needs. The modular house can look so normal that you cannot tell the difference between a modular house and a regular house. The benefit with the modular house looking like a regular house though, is that it is much more cost efficient.

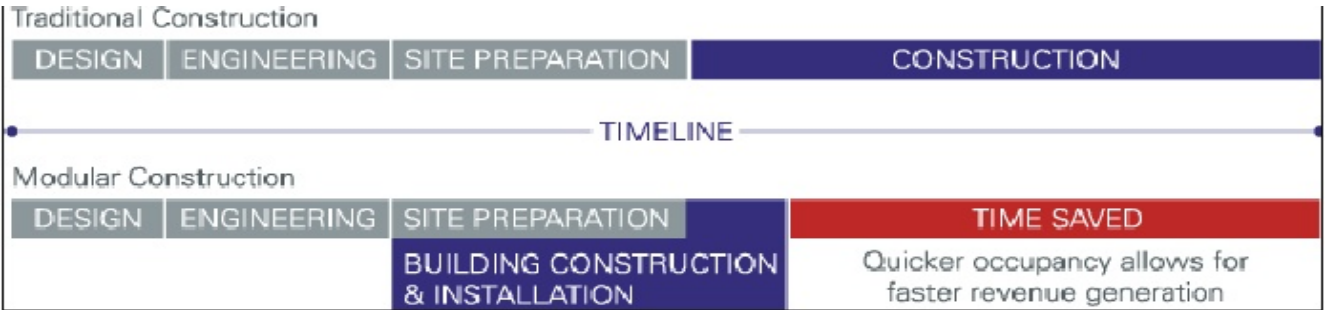
Do banks and other institutions finance modular homes? Yes, they do, and they treat it the same way as a regular home. Other benefits with modular homes are they are more energy sufficient. When you decide you want to stay in a modular home you could move into it much faster than if you would build a regular home from the ground up. This is because the production is faster for a modular house than a regular house. ("What Makes Modular Homes Different?", 2017), ("What Are Modular Homes vs Manufactured", 2017)

TRANSPORTATION OF MODULAR HOMES

Load dimensions and travel distances are the two most important factors to consider when transporting a modular home or building to determine the cost. Also, the height plays a role in transporting since a lot of bridges are not higher than 4,6m. The length of the modules is going to affect the size of the truck. A small module can be moved by a truck where as a bigger module must be delivered by a semi-trailer. ("How much will it cost to transport and crane my modular home?", 2017)

Modular building can also solve the problem of labor shortage in the building industry. There is less of a need for a skilled workforce with the modules delivered pre-assembled from a factory meaning anyone could construct them in that controlled environment

Here we see how modular construction vs traditional construction. Site preparation can happen simultaneously to construction when using the modular method.



CONDITIONS IN THE HOUSING INDUSTRY:

As reported in 2018, housing prices continue to climb, interest rates rise, and the financial part of buying a house is the biggest challenge for many potential new homebuyers. (“5 Market Conditions to Impact the Housing Industry”, 2017)

Findings

The Selficient concept for modular building exists to revolutionize the building industry via its sustainable endeavours using a circular economy approach. An increasing demand and lack of supply of materials (Potemans, 2017) puts pressure on the building industry to change to reduce waste and be more environmentally friendly. The Selficient concept solves these problems.

However, it isn't that easy. The prototype of the Selficient house is expensive and time consuming to produce and is more expensive than the competition. So today we look towards the car industry (a beacon for lean and efficient production) to help Selficient create a sustainable business model regarding production, transportation and logistics, before entering mass production.

The largest building in the world (the Jeddah Tower) is due to open in 2020 (Lo, 2018) as mankind competes to outperform but not in terms of efficiencies. The building industry is slow to change or adapt to newer technologies and way of doing things unlike the car industry. The car industry is efficient, lean and keeps costs low as companies like Toyota adapt to only work on endeavors that add value to reduce waste (Felxoconcepts, 2015). Therefore, it is recommended that Selficient use a lean approach towards managing and manufacturing like what is used in the car industry. Particular attention should be paid to the following:

OFFSITE PRODUCTION (FACTORY PRODUCTION)

The construction industry is held as one of the world's largest being worth an estimated \$10 trillion per annum (McKinsey, 2017). However, the construction industry has only grown in labour productivity by 1% compared to 3.6 % productivity growth in manufacturing over the past two decades (McKinsey, 2017). The construction industry is facing labour shortages and quality issues for example while

the demand for newer constructions are increasing with countries having escalating housing shortages (Whyte, 2014). There are little margins being made in traditional construction meaning companies are at deadlock with each other (McKinsey, 2017). With labour shortages and increasing regulations including environmental in the construction sector, a change to traditional ways of construction is needed to ensure the sustainability of the worldwide construction sector.

This report views the ideal solution is offsite production using the modular approach. Modular construction is defined by the Modular building institute as *“a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standards as conventionally built facilities”* (Institute, 2018). Here, modules are constructed in a factory like environment in a shorter time period with the goal of minimizing onsite times and assembly.

The research has identified times that there is greater demand for construction of modular units such as after natural disasters, during homeless crises and could be the solution to Olympic villages that are abandoned afterwards. As (Whyte, 2014) suggested, there are certain times where modular construction falls out of fashion/trend. It is important that Selficient examines what trends will directly impact demand for their modular buildings and be able to ramp up supply to meet these demands which could be achieved by off-site production. The adoption rate of buyers to modular houses can also be influenced by government regulations and incentives, it is important to conduct a country analysis into incentives to identify suitable countries to sell the modular homes.

There is a stigma that also exists that modular constructions are of lesser quality (REDS10). Modular constructions are viewed in Eastern Countries like Dubai as being desirable and something lived in by richer people therefore giving the modular construction a higher brand image. However, in Western countries modular constructions are seen as cheaper construction that has a lower re-sale value and lived in by less well-off people due to their common design. Selficient needs to look at changing perceptions of possible buyers of their modular homes into the future.

In previous decades, manufacturers weren't convinced that the offsite production of houses warranted huge investment (Gann, 1996) as construction was viewed as a craft industry. Longevity and durability meant that innovations and newer manufacturing methods weren't implemented unlike in the car industry where cars have a shorter lifespan compared to houses. Henry Ford changed the car industry with mass production assembly in the 1920s reducing the cost of production (Hardcastle., 2005) so it is comparable that a similar move in the construction industry would have similar cost savings.

Larger scale construction projects such as re-developments of large areas like which is common in the Netherlands offer a greater potential for off-site modular construction as mass construction shares commonalities in parts (McKinsey, 2017). These areas already share a common design and there is less of a desire for persons to customised constructions. However, contracts for larger construction projects normally are awarded to larger companies by local governments or owners. It is extremely important for Selficient to enter a partnership with a larger construction company to tender for projects to ensure the roll-out on a large scale. Offsite construction requires high initial investment which is not something that Selficient can achieve on its own at first making a partnership an ideal choice (Institute, 2018).

Advantages of using off-site modular construction:

1. **Time Savings:** Off-site modular construction can lead to time-savings over traditional construction as much as 50% (Institute, 2018). With construction taking place in a factory, onsite construction time is reduced which would be favourable in urban areas to avoid nuisance and keeping within planning permission noise regulations. There can be less site upset during construction and time savings can be achieved with on-site preparations taking place simultaneously to off-site modular construction. Construction projects are notorious for surpassing deadlines, so these time-savings means projects can be delivered on-time or ahead of schedule.

2. **More environmentally friendly:** This fits into the Selficient approach of using the circular economy model. Less waste is produced in production in the controlled off-site

environment, greener materials can be increased into the assembly and parts are often re-used and recycled reducing the need for more materials or new construction (Institute, 2018).

3. **Eliminating/Reducing weather delays:** With greater amounts of construction taking place within the controlled factory environment, the construction project is subjected to less delays due to weather events. Delays increase costs, and this is something companies like Selficient want to reduce not increase

4. **Reducing Costs:** This is the main reason that Selficient should adopt a modular construction approach offsite. This will allow them to achieve Economies of Scale by having continuous standardised production in which many modules are produced at once. However, there is a downside to this as many people want their home to be unique, so the value created in the modular construction process has to be great enough to off-set the disadvantage of a standardised home. However, it is suggested Selficient could position itself as a premium manufacturer who constructs unique modular homes at a premium price in areas where there is demand for this eg in Dubai.

(Continued in Appendix I)

PLATFORM CONCEPT

The age old problem of ‘how do we create a product that meets the needs of each consumer but at an affordable price’ is something that companies worldwide face including Selficient. Looking at the car industry, the industry has benefited from the platform concept for years so in theory it could be used across any industry.

The platform concept is where a car manufacturer uses a common base design to construct cars from and this base is used across different models and series and thus creates economies of scale (Danilovic Mike, n.d.) It is a common model used by major manufacturers such as Toyota and Volkswagen. These companies have benefited from reliability, reduced lead times and development costs in particular (Mahmoud-Jouini & Lenfle, 2010)

However, the platform concept is not just the physical platform (chassis) that the car is built on, it is also a managerial concept and strategic way of thinking (Danilovic Mike, n.d.). For example, how can the common base suit the needs of different target markets?

Like Selficient has already experienced with Suteki, the platform concept has a flaw. Having a common platform design sees limitations (rigidity) and to change/add something might mean a complete redesign immediately raises costs due to the changes. Suteki is reluctant to change the base design due to costs of changing equipment, upskilling etc. However, the Selficient model requires flexibility to add or remove modular elements so in effect if Selficient was to use a platform concept a great deal of planning and design would be needed to ensure the platform can be somewhat adaptable. It would be highly recommended in a cost sense to have all parts and materials manufactured as close to Selficients manufacturing site to reduce costs in transportation and environmental impact.

The standardisation achieved in the car industry by having a common platform and parts is enviable for all industries and often repeated. It also allows for maintenance workers to be able to work across a large variety of automobiles. However, if a common defect were to exist this could be disastrous for brand image and extremely expensive for the company.

However, even with a common platform or parts there still needs to be differentiating features. Why would you buy a BMW when you could buy a cheaper Volkswagen which has the same platform and/or parts? If Selficient wanted to some premium aspects to their modular homes, a platform type model might not be suitable as

people would realize. In this sense, lower costs might actually lead to consumer dissatisfaction if Selficient was positioned as a premium provider of modular homes.

Selficient business model is still in a prototype phase and with changes with self-efficient technologies ever changing a platform system can be difficult for new ways of thinking or technologies to be implemented which is a major drawback. These new develops and quick implementations into the design of a Selficient model might be a form of differentiation or a unique selling point (USP). Selficient itself wants to revolutionize the way of building so this requires making changes and redefining value, so would a platform concept be a limiting factor?

The car industry also has to adapt their platforms to local markets ie in Ireland cars drive on the left while in the Netherlands cars drive on the right. Also, different countries requires changes to the strength of the platform, clutch, axels and so on. This would apply to Selficient with having to adapt their modular buildings for climates for example and this might reduce the lifecycle depending on where the modular home is situated.

The average profit margin for the construction industry globally is 4% (EY, 2017) compared to industry average of 8% for the car industry (Kallstrom, 2015). However, looking at Toyota or Volkswagen who have both excelled in using the platform concept, their profit margins are both over 13% indicating the profitability of such a concept (Kallstrom, 2015).

Advantages of the Platform Concept:

1. Economies of Scale: A switch from the traditional make-to-order to engineer-to-order (platform concept) allows Selficient to gain economies of scale with the repeat use of components and ordering in large volumes (Jansson, 2018) which is achieved with increased production. Production is increased by the lack of need for upskilling of staff, common design and a select few suppliers.

2. **Development of a product family:** This is commonly used in the car industry to meet different consumer needs/wants. The platform concept is seen as a starting point for which to form the basis of a product family (Siddique, 2001). The resources and inputs necessary to produce the modular home could become common across a product family or adapted for different target markets in materials used, product positioning and location. This would allow Selficient to target people across continents with adapted modular homes given their needs and allows them to concept in more than one market.

Disadvantages of the Platform concept:

1. Defective components: For Selficient to use the platform concept, it is advisable to conduct extensive testing into components and the manufacturing process. In the case of Toyota, a potentially defective airbag design and other flaws required them to recall millions of cars worldwide. This damaged their brand image and cost billions.

2. Legislation: The platform concept works well across the EU and the world with common legislation for the auto industry. Countries within the EU set different building standards at which construction must adhere to. An example of which is the material used in the Grenfell Tower in London. This material is banned in some countries within the EU and not the UK. Selficient therefore has to either design the modular home to meet as many countries regulations as possible or adapt each house to a countries regulation. However, this would in effect reduce the cost savings achieved with economies of scale.

(Continued in Appendix II)

TRANSPORT AND LOGISTICS

Instead of shipping finished cars all around the world, the automotive manufacturers prefer to send parts and components separately to the on-site manufacturing plants. This is because it is cheaper to send parts than to send finished cars and finished products in general. This is something that the modular housing industry and Selficient has to learn from. You cannot send modular houses all around the world as it is going to be too costly and requires too much work. The modular houses have to be built close to where they are going to be used preferably. There is no point in setting up a modular housing factory in an area which not have surrounding attractive areas for the houses to be at. So, what is an attractive area to begin with? Attractive areas for modular housing are student areas, areas just outside a big city, an area which is not sensitive for a natural disaster and Olympic villages (could be hard to tell in advance though). This is areas to consider before setting up a modular housing factory. Take these into account to reduce the later transportation and logistics costs. Areas which is not good places to set up factories are areas such as far away countryside with a lot of narrow roads. This is going to make the transportation of the modular houses even harder.

COMPARING DEMAND FOR ELECTRIC CARS TO MODULAR BUILDING

Electric cars have changed the car industry with the use of electric compared to traditional fuels therefore redefining the value chain of the automotive industry (Electric Vechicle Outlook , 2017). The adopt rate as in the below figures has been low and this is comparable to the modular building industry with lower numbers building using the modular method. Below is examined how electric car adoption rates have been encouraged and how a similar move could be used for the modular building industry.

Electric cars have a relatively low adaption rate with 2016 sales figures being just 750'000 of the 77.5 million new cars sold worldwide (Electric Vechicle Outlook ,

2017).The Netherlands holds a 6.4% market share of electric cars currently (Electric Vehicle Outlook , 2017) and the worldwide sales are expected to form 54% of new cars sales in 2040.

The adaption rate of Electric cars would not have happened without incentives on consumers to switch from conventional engines like Petrol and Diesel to Electric vehicles. This has been seen in Norway with the highest EU market share of electric cars with incentives including no VAT on sales of electric vehicles (Kristin Ystmark Bjerkan, 2016) A similar move with implementing incentives could encourage greater demand for modular building in the building industry and more sales would lead to greater Economies of Scale (reducing costs).

So what has incentivised consumers to switch from conventional fuels to electric vehicles? The world would like to think it is because of the need to reduce greenhouse gases since road transport has contributed 80% of gases in the last 45 years (Kristin Ystmark Bjerkan, 2016). This is not the case. The main reason sales are due to increase is due to countries like The Netherlands, France, UK and Ireland banning the sale of Petrol and Diesel cars beyond 2030. Here we can see some similarities with the housing industry. Since modular housing means in general less energy consumption and less co2 emissions could this happen in the future? Maybe not within the near future since housing still is not the biggest co2 and environment threat, but maybe in a far future. This certainly would not even be considered an option until a higher adoption rate of modular building was achieved worldwide.

So looking at other incentives that governments and manufacturers are using to encourage electric car sales, can Selfciant and governments use similar approaches to encourage modular building sales?

Other incentives to buy a modular home could be because of the environment. Because of the off-site production the production uses less vehicles than when building on-site. This means lower co2 emissions. It is beyond the context of this report to

research the incentives individual countries offer but could include no property fees and free water rates.

The idea of owning a car for most people is for getting where they want to go on demand. An electric vehicle has a certain range in which it can drive before it needs to be recharged and is dependent on weather conditions, speed and many other variable factors. It takes Tesla's supercharger 90 minutes to charge from 20-100% battery life (Tesla, 2018) while a conventional vehicle would take minutes to refuel at a gas station. For a consumer to change their current habits, there needs to be benefits of changing which in the case of the electric car is cheaper fuel and being environmentally friendly.

Most modular building providers do not take care of installation (Modular House prices, n.d.) which leaves uncertainty for the consumer on the actual price including site works. Consumers need certainty when applying for finance and other pre-development arrangements, so this is where Selficient could step in. Like traditional construction firms, Selficient could provide development schemes in which they buy the land, construction and install the home and sell it to potential buyers then.

Appendix I

Advantages of offsite production	Disadvantages of offsite production
Reduced construction costs	Transport Risk/Costs
Eliminating/Reducing weather delays	Lack of consumer knowledge/bad perception
More environmentally friendly	Land costs still exist
Time savings	Time consuming to source finance
Safer construction (reducing deaths)	Differing building regulations across the world from site of manufacturing to installation
Greater productivity	Not designing towards users specific needs in cases
Overall cost reduction	Initial high investment

Appendix II

Advantages of the Platform Concept	Disadvantages of the Platform Concept
Economies of Scale	Commonality (lack of differentiation)
Reduced Lead time	Meant for a low life-cycle industry
Reduced Development Costs	Organisation Resistance
Mass Customization	Limits innovation
Product Family	Increases imitation

References

- B, D. (2017, 10 07). *How Fast Does a Supercharger Charge a Tesla?* Retrieved from Medium.com: <https://medium.com/@DonB/how-fast-does-a-supercharger-charge-a-tesla-589c7e0530d8>
- Danilovic Mike, W. M. (n.d.). *Platform thinking in the automotive industry – managing the*. Retrieved from Product Innovation and Technology Management : <https://www.pomsmeetings.org/confpapers/007/007-0355.pdf>).
- Electric Vehicle Outlook* . (2017). Retrieved from IEA.ORG: <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf>
- EY. (2017). *UK Construction Margin Pressure*. Retrieved from EY.COM: [http://www.ey.com/Publication/vwLUAssets/UK_Construction_Industry_-_Margin_matters/\\$FILE/ATTJK7IP.pdf](http://www.ey.com/Publication/vwLUAssets/UK_Construction_Industry_-_Margin_matters/$FILE/ATTJK7IP.pdf)
- Felxoconcepts. (2015, 12 01). *What the Automakers Have Taught Us About Manufacturing Efficiency* . Retrieved from Felxoconcepts: What the Automakers Have Taught Us About Manufacturing Efficiency
- Gann, D. M. (1996). *Construction as a manufacturing process? Similarities and differences*. Retrieved from Researchgate: https://www.researchgate.net/profile/David_Gann/publication/24077213_Construction_as_a_manufacturing_process_Similarities_and_differences_between_industrialized_housing_and_car_production_in_Japan/links/53e7c7a20cf2fb748722ebf0/Construction-as-a-manufactu
- Gann, D. M. (1996). *Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan. Construction Management and Economics*, 437-450.
- Hardcastle., N. (2005). *Henry Ford and mass production*. Retrieved from Grammer School: [ttp://www.dhahranbritish.com/history/A9_HenryFord.htm](http://www.dhahranbritish.com/history/A9_HenryFord.htm)

-
- Institute, M. B. (2018). *Why Modular*. Retrieved from Modular Building Institute :
http://www.modular.org/HtmlPage.aspx?name=why_modular
- Jansson, G. (n.d.). *Platforms in Industrialised House-Building*. Retrieved from
<https://www.diva-portal.org/smash/get/diva2:991788/FULLTEXT01.pdf>
- Kallstrom, H. (2015). *Intense competition leads to low profit margins for automakers*. Retrieved from www.marketrealist.com:
<https://marketrealist.com/2015/02/intense-competition-leads-low-profit-margins-automakers>
- Kristin Ystmark Bjerkan, T. E. (2016). Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway. *Transport Research Part DD* , 169-180. Retrieved from https://ac.els-cdn.com/S1361920915002126/1-s2.0-S1361920915002126-main.pdf?_tid=44e306be-a4bc-4248-8411-42cb41ab5ba1&acdnat=1526291668_a1f6c5150424d9696df79c0f13994538
- Lo, A. (2018, 01 117). *Jeddah Tower: What does the world's next tallest skyscraper look like now?* Retrieved from CNN:
<https://edition.cnn.com/style/article/jeddah-tower-saudi-arabia-new/index.html>
- Mahmoud-Jouini, S. B., & Lenfle, S. (2010). Platform re-use lessons from the automotive industry. *International Journal of Operations & Production Management*, 98-124.
- McKinsey. (2017). *Reinventing-construction-A-route-to-higher-productivity-*. Retrieved from McKinsey:
<https://www.mckinsey.com/~media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20through%20a%20productivity%20revolution/MGI-Reinventing-construction-A-route-to-higher-productivity-Full-report.ashx>
- Modular House prices*. (n.d.). Retrieved from Green Home Gnome:
<https://www.greenhomegnome.com/modular-home-prices/>
- Potemans, A. (2017). Modular Building in a circular economy. *Modular Building in a circular economy*.

-
- REDS10. (n.d.). *THE MYTHS OF MODULAR BUILDING – FACT OR FICTION?* Retrieved from REDS10: <http://www.reds10.com/the-myths-of-modular-building-fact-or-fiction-needs-pictures/>
- Siddique, Z. a. (2001, 10 01). Identifying common platform architecture for a set of similar products. *World Congress on Mass Customization and Personalization*. Hong Kong.
- Tesla. (2018). *Tesla super charger*. Retrieved from Tesla: https://www.tesla.com/en_IE/supercharger
- Whyte, F. A. (2014). Uptake of Off-site Construction: Benefit and Future. *World Academy of Science, Engineering and Technology*.
- B, D. (2017, 10 07). *How Fast Does a Supercharger Charge a Tesla?* Retrieved from Medium.com: <https://medium.com/@DonB/how-fast-does-a-supercharger-charge-a-tesla-589c7e0530d8>
- Danilovic Mike, W. M. (n.d.). *Platform thinking in the automotive industry – managing the*. Retrieved from Product Innovation and Technology Management : <https://www.pomsmeetings.org/confpapers/007/007-0355.pdf>.
- Electric Vechicle Outlook* . (2017). Retrieved from IEA.ORG: <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf>
- EY. (2017). *UK Construction Margin Pressure*. Retrieved from EY.COM: [http://www.ey.com/Publication/vwLUAssets/UK_Construction_Industry_-_Margin_matters/\\$FILE/ATTJK7IP.pdf](http://www.ey.com/Publication/vwLUAssets/UK_Construction_Industry_-_Margin_matters/$FILE/ATTJK7IP.pdf)
- Felxoconcepts. (2015, 12 01). *What the Automakers Have Taught Us About Manufacturing Efficiency* . Retrieved from Felxoconcepts: What the Automakers Have Taught Us About Manufacturing Efficiency
- Gann, D. M. (1996). *Construction as a manufacturing process? Similarities and differences*. Retrieved from Researchgate: https://www.researchgate.net/profile/David_Gann/publication/24077213_Construction_as_a_manufacturing_process_Similarities_and_differences_between

-
- n_industrialized_housing_and_car_production_in_Japan/links/53e7c7a20cf2fb748722ebf0/Construction-as-a-manufactu
- Gann, D. M. (1996). Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan. *Construction Management and Economics*, 437-450.
- Hardcastle., N. (2005). *Henry Ford and mass production*. Retrieved from Grammer School: http://www.dhahranbritish.com/history/A9_HenryFord.htm
- Institute, M. B. (2018). *Why Modular*. Retrieved from Modular Building Institute : http://www.modular.org/HtmlPage.aspx?name=why_modular
- Jansson, G. (n.d.). *Platforms in Industrialised House-Building*. Retrieved from <https://www.diva-portal.org/smash/get/diva2:991788/FULLTEXT01.pdf>
- Kallstrom, H. (2015). *Intense competition leads to low profit margins for automakers*. Retrieved from www.marketrealist.com: <https://marketrealist.com/2015/02/intense-competition-leads-low-profit-margins-automakers>
- Kristin Ystmark Bjerkan, T. E. (2016). Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway. *Transport Research Part DD* , 169-180. Retrieved from https://ac.els-cdn.com/S1361920915002126/1-s2.0-S1361920915002126-main.pdf?_tid=44e306be-a4bc-4248-8411-42cb41ab5ba1&acdnat=1526291668_a1f6c5150424d9696df79c0f13994538
- Lo, A. (2018, 01 117). *Jeddah Tower: What does the world's next tallest skyscraper look like now?* Retrieved from CNN: <https://edition.cnn.com/style/article/jeddah-tower-saudi-arabia-new/index.html>
- Mahmoud-Jouini, S. B., & Lenfle, S. (2010). Platform re-use lessons from the automotive industry. *International Journal of Operations & Production Management*, 98-124.
- McKinsey. (2017). *Reinventing-construction-A-route-to-higher-productivity-*. Retrieved from McKinsey: [https://www.mckinsey.com/~media/McKinsey/Industries/Capital%20Project s%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20t](https://www.mckinsey.com/~media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20t)

hrough%20a%20productivity%20revolution/MGI-Reinventing-construction-A-route-to-higher-productivity-Full-report.ashx

Modular House prices. (n.d.). Retrieved from Green Home Gnome:

<https://www.greenhomegnome.com/modular-home-prices/>

Potemans, A. (2017). Modular Building in a circular economy. *Modular Building in a circular economy*.

REDS10. (n.d.). *THE MYTHS OF MODULAR BUILDING – FACT OR FICTION?* Retrieved from REDS10: <http://www.reds10.com/the-myths-of-modular-building-fact-or-fiction-needs-pictures/>

Siddique, Z. a. (2001, 10 01). Identifying common platform architecture for a set of similar products. *World Congress on Mass Customization and Personalization*. Hong Kong.

Tesla. (2018). *Tesla super charger*. Retrieved from Tesla:

https://www.tesla.com/en_IE/supercharger

Whyte, F. A. (2014). Uptake of Off-site Construction: Benefit and Future. *World Academy of Science, Engineering and Technology*.

(2018-05-03). Henry Ford and mass production. Retrieved from:

http://www.dhahranbritish.com//history/A9_HenryFord.htm

(2018-05-05). Assembly line. Retrieved from:

<https://www.britannica.com/technology/assembly-line>

(2018-05-05). Supply Chain Management in Automotive Industry. Retrieved from:

<http://www.advantech.com/logistics/case%20studies/39fd76a1-9fc7-4c5f-82d7-ac017d1a1a61/>

(2018-05-14). What Makes Modular Homes Different? Retrieved from:
<https://www.thebalance.com/what-makes-modular-homes-different-1797805>

(2018-05-15). What Are Modular Homes vs Manufactured? Retrieved from:
<https://www.thebalance.com/what-are-modular-homes-1797807>

(2018-05-20). How much will it cost to transport and crane my modular home?
Retrieved from: <http://www.modehomes.com.au/how-much-will-it-cost-to-transport-and-crane-my-modular-home/>

(2018-05-31). Automotive Industry Analysis 2018- Cost & Trends. Retrieved from:
<https://www.franchisehelp.com/industry-reports/automotive-industry-analysis-2018-cost-trends/>

(2018-05-31). 5 Market Conditions to Impact the Housing Industry. Retrieved from:
<http://themreport.com/daily-dose/12-19-2017/5-market-conditions-impact-housing-industry>