Graduate Program in Sustainability Science Global Leadership Initiative

Graduate School of Frontier Sciences

The University of Tokyo

2017

Master's Thesis

Biomass Harvesting from Housing Dismantlement in Urban Fringe Area, Japan

Submitted August 1st, 2017

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ABSTRACT

Growing number of vacant houses is an emerging issue in Japan. According to the government statistics, the vacant house rate is about 13.5% nationwide in the year 2013. Vacant houses are not simply aesthetically unappealing to a community, it also poses health and safety threats, such as becoming hotbeds for mosquitos or collapsing during earthquake. From social sustainability point of view, vacant houses show a community is indifferent to their living environment, and thus potentially invites criminal activities; this is widely known as the broken window theory.

A driving force for the emergence of vacant houses is the new housing development projects that often motivate people moving into urban core area for a better quality of life. Particularly, the Japanese government is promoting the Compact City Policy as a recent urban planning strategy. Compact city, in general, emphasizes a relatively dense residential area in urban core with a mixed of other land-use, such as commercial and services industries. The compactness of human activities will result in a more environmentally friendly lifestyle, such as a more efficient transportation, energy recycling system, and others. Compact City Policy will benefit the urban core, but not necessary the urban fringe area. A prospective change is, vacant houses will emerge when the population migrants from urban fringe to urban core areas. Meanwhile, vacant houses are hard to repopulate as Japan is entering a depopulation society.

To solve the vacant house issue, vacant house dismantlement in urban fringe area for urban regeneration is the key. A fundamental problem is, the cost of house dismantlement in Japan is very costly, and thus demotivate house owners to demolish the old houses. This research is therefore aiming to propose an innovative policy suggestion to incentivize house owners in dismantling the vacant houses. The proposal is about designing a biomass harvesting system by reutilizing waste wood from housing

construction and dismantlement. Since most housing materials in Japan are wood based, the implementation of biomass energy system is most likely feasible. In addition, by supplying waste wood as feedstock to biomass energy system, fossil fuel can be substituted. Therefore, cost can be saved and compensate to house owner, to incentivize vacant house dismantlement. From environment perspective, using waste wood, a renewable energy source, can reduce greenhouse gases emission thus mitigating global warming.

To examine the proposed solution, the objective of this study is to estimate the biomass potential from an urban fringe area, Nanbu Community. The case study is located in the South Kashiwa.

Three main analysis is conducted in this study.

1. Study site selection: To identify a target area that potentially being affected by the compact city policy based on the government development plans; and to quantify the current available houses in the site for further analysis.
2. Housing analysis: To estimate the potential biomass generating from the waste wood of dismantled and newly-built houses in the study site. For simulating the prospective population changes, five housing development scenarios are designed and analyzed.
3. Energy analysis: To estimate the potential energy yielding from biomass energy system, in terms of electricity and heat generation; and to evaluate the potential cost recovery and CO2 reduction by substituting fossil fuel with biomass.

The development plans of Kashiwa City were reviewed to show the expansion pattern of a city, specifically in the population density distribution over times. Then, the current house density was analyzed and mapped using the ArcGIS, a geographic information software. Nanbu Community was eventually selected as the case study area, as this urban fringe area was expected to reduce population density from 59 people per hectare to 31-40 people per hectare based on the Urban Promotion Area policy, promoted by the Kashiwa City government.

Based on the current available houses in the study area, five scenarios were designed to estimate the house density, number of newly-built houses, and dismantled houses, from the year 2010 to 2040: (Scenario 1) restriction of building new houses, (Scenario 2) housing expansion following current trend, (Scenario 3a, 3b, 3c) policy to achieved 31, 36, and 40 people per hectare, respectively.

Waste woods from new housing construction and housing dismantlement were quantified to estimate the potential biomass available for heat energy generation. Scenarios with higher housing density will have a higher energy potential. This study estimated the revenue that created from selling waste wood as biomass feedstocks. Also, the CO_2 reduction potential for each scenario was estimated.

For policy recommendation, to incentivize house owners to dismantle vacant houses, this study estimate a revenue potentially created from harvesting the waste woods. Benefit of CO_2 reduction was also converted to a monetary value. The total revenue, combining waste wood revenue and CO_2 reduction benefits, was able to compensate around 6-8% of housing dismantlement fee depending on the scenarios. Therefore, a subsidy policy was possible to encourage old house dismantlement.

Vacant house can be converted into vacant lands for other purposes, if housing dismantlement is no longer a problem. In short, urban regeneration or redesign is possible, by utilizing the vacant lands appropriately, such as converting into parking lots or urban farmlands, would not just prevent the vacant house problems, but also improve the quality of life for the community.

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ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest gratitude to Professor Yokohari, for the devoted guidance and instruction throughout the research as supervisor, and for introducing me about the field of urban planning and sustainability perspective. Co-supervisor, Lecturer Terada, has patiently supported me walking through each step of my research. Mentor, Assistant Professor Tanaka, has also gave me encouragement and helped me with issues about public policy.

This research is also indebted to all kinds of support from all my colleagues, professors, faculty members and secretaries from GPSS. Every advices and comments that I received from GPSS seminar presentations, poster presentations or talks have been inspired and enlightened me. Same gratitude to the faculties and students of the Forestry and Landscape Planning seminar that I have been joining for two years. Specially thanks to my lab members for the suggestions of this research and also the huge support for daily life.

Further, I would like to thank all my friends for their warm support and positive attitude, especially those on 7th floor and my roommate, to company my two-year study process and go through all those ups and downs.

Finally, heartfelt thanks given to my family, who inspire and supported me much in carrying out my study process, especially during my thesis project. Thank you very much!

1. INTRODUCTION

1.1 Vacant house issue

Growing number of the vacant houses is an important issue in Japan. According to the government statistics, the vacant house number has been increasing since the year 1958, and the national vacant house rate has reached 13.5% in the year 2013 (Statistics Japan, 2013). Vacant houses can be found not only in rural areas but also in urban areas, e.g. the vacant house rate of Tokyo Metropolitan was as high as 11% in 2013 (Statistics Japan, 2013), while other cities such as Detroit and London were 5.3% and 1.7%, respectively (Bryant 2016; Wilson, Foster & Barton, 2016). In short, Japan has entered a period that has too many redundant, or vacant houses.

Newly built houses in recent decades accelerate the emergence of vacant houses. In Japan, the housing number per household (or family) is increasing, currently is about 1.16 houses per household (Statistics Japan, 2013). New housing development projects, leads by real estate companies, are often driven by economic incentives, and disregard the actual household demand. Commercial advertisements from real estate companies, often motivate families to abandon old houses and move into new houses.

Urban migration is another cause of increasing vacant house, particularly in urban fringe areas. During past rapid growth period, residential areas are predominantly expanded to the surrounding of cities because of a high housing demand. However, these houses in urban fringe areas are becoming vacant nowadays, as the younger generation prefer to live in a more convenient urban core area.

Ideally, vacant houses should be turning into vacant lots for urban regeneration, such as providing additional parking lots and converting into farmland to improve the quality of life. However, in reality, house owners have little incentive to dismantle the vacant houses. It is because of an expensive housing dismantlement fee and a tax pressure, which can be referred to the "Real-Estate Law" in Japan and the details will be discussed in the later chapter (Shinobe & Miyachi, 2012; Shimizu, 2014).

Why do governments must deal with vacant houses? First, vacant houses are aesthetically unappealing; they degrade the surrounding landscape and scenery (Figure 1-1) (MLIT, 2008). Second, without a regular housing maintenance, vacant houses have a high risk of collapsing, especially during an earthquake event; therefore, they are a safety threat to other residents. Third, vacant houses are hotbeds for mosquitoes, flies and other pests. Fourth, vacant houses are likely becoming a spot for crime. A famous metaphor for this is the "broken window theory" (Wilson & Kelling, 1982). It showed that vacant houses in a residential area positively correlated with the crime rate (Sampson, Raudenbusch & Earls, 1997). Therefore, an increase of vacant houses will make a community harder to live. A more worrying sign is that Japan is depopulating, vacant houses are expected to be double in the year of 2033 (NRI, 2016). Immediate actions, therefore, must be taken to tackle the issue.

Figure 1-1. Street view of vacant houses in Minami Sakasai 5th district (taken by the author in Nov. 2016).

1.2 Vacant house and compact city policy

The Japanese government has been promoting a compact city policy. The policy intends to concentrate residential area to the city center with a mixed of other land use. The main purpose is to create a high population density urban core with thriving industries. Service industries are expected to be maintained more easily, and thus realizing a more convenient living space that will simultaneously contribute to building a low carbon society (Tsuchiya, Hasegawa, Imai, 2014).

Current compact city policy is not comprehensive enough as it neglects the issues in the urban fringe area during the transition. If the compact city policy is smoothly promoted, the vacancy problem in the urban core area can be solved. But, more vacant houses are expected in the urban fringe area.

In general, the solutions for vacant houses are house dismantlement and house reuse. As the population density is expected to decrease in an urban fringe area (motivated by the compact city policy), most vacant houses are getting harder to be reused due to a lack of demand. Therefore, the only practical option to deal with the vacant houses is, ensuring a smooth house dismantlement process. Financial support from the government to house owner is desirable due to the high cost of house dismantlement. However, through the review of Compact City Policy, all principles and investment focused only on the development of urban core. Therefore, the research interest of this study is to discover the value that we can obtain from the housing dismantlement process in an urban fringe area to support the process.

1.3 Housing dismantlement and biomass utilization

The biomass energy sector has a potential to provide monetary support to housing dismantlement process in an urban fringe area, as most houses in Japan are made from wood, which can ultimately serve as a feedstock for woody biomass energy production. According to an extensive survey conducted by the government, more than 80% of Japanese citizens have a strong desire for wooden houses. Hence, although the portion of the wooden house has been reducing annually, still nearly 60% of national houses are made of wood. The available wood from these houses still equivalent to nearly 80% of domestic wood demand (MAFF, 2007). In addition, Japanese houses have certain shelf-life depending on the material, building period and etc., and need to be dismantled or reconstructed (Weng & Yashiro, 2003).

The waste wood from the house dismantlement presents multiple challenges as well as opportunities. On the one hand, nearly 90% of the illegal disposal waste are from construction waste, which deteriorate the environment (Hashimoto, Obara, Terashima, 2000). Hence, the slashed and waste wood generated from the housing dismantlement, are required to be treated, which is a mandate in construction recycling policies (Weng & Yashiro, 2003; Tsunetsugu, Karube, Tonosaki, 2003; Kobayashi, Mamiya & Inoue, 2004). On the other hand, waste wood could be regarded as a source for biomass utilization in various methods, material recycling like paper or fertilizer and energy recycling, which can contribute to mitigating global warming by replacing fossil fuel utilization (Miura & Yamada, 2005).

Actually, besides waste wood from house dismantlement, there are also waste wood from the house construction, which can be regarded as an additional source to increase the amount of waste wood for biomass utilization (Miura & Yamada, 2005). Hence, if the amount of waste wood from house dismantlement and construction can be accounted for, the monetary value generated from biomass energy can be estimated. Such extra value from waste can be used as financial support for the house dismantlement in urban fringe area. Also, woody biomass energy, a carbon neutral energy source, is regarded as an important renewable energy for global warming mitigation. Converting waste wood into energy is, therefore, beneficial to realize a low carbon society (Figure 1-2, which is a principal component in compact city policy.

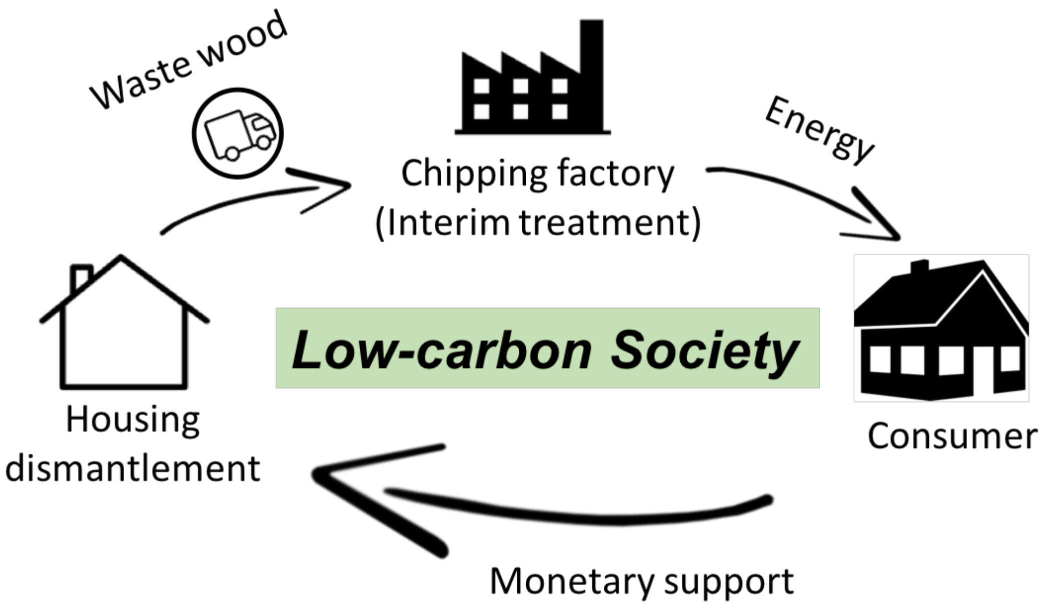

Figure 1-2. Conceptual diagram of achieving low-carbon society with recycling waste wood from house dismantlement as biomass energy.

1.4 Research contribution and organization of thesis

The purpose of this research is to estimate the quantity of woody biomass that can be generated from house dismantlement and construction in an urban fringe area. The yield of biomass energy and its value are estimated to come up with a policy recommendation for compensating vacant house owners in house dismantlement, thus complementing the compact city policy.

Reviewing previous literature, biomass has been understood as an important renewable energy source, as well as a carbon free fuel from the viewpoint of carbon neutral (Minami & Saka, 2005). Because Japan is rich in forest resources, many researches have been discussed about the potential of unutilized forestry biomass (MAFF, 2015). However more recently, several studies have been paying attention to the potential of woody biomass amount from urban area, including potential biomass amount from urban greenery by seasonal changes (Division, 2015), biomass utilization from satoyama analyzing by management scenario (Terada., 2011). However, less studies are conducted to estimate the potential of biomass from housing dismantlement and considering the effect from different housing policies in different areas.

Previous studies that link biomass utilization with housing dismantlement are from waste wood recycling from industrial and technical viewpoints and the benefit of CO_2 reduction via energy generation (Murano, Fujita, , Hoshino, 2009). However, less study discusses about how the energy generated from the waste wood can contribute back to the housing dismantlement and local community.

The result of this research would contribute to elucidating the relationships between compact city policy, urban fringe housing policy, and biomass utilization, through evaluating the potential contribution from housing dismantlement and construction. Practical subsidy policy for house dismantlement can be drawn to give house owners incentive to treat vacant houses, and thus realizing a sustainable transition pathway towards a compact city.

This thesis is organized into seven chapter.

1. Chapter one introduction, includes the explanation of vacant house issues and the hidden issue of Compact City Policy, the brief idea of biomass utilization from housing dismantlement, as well as the research contribution and the organization of thesis;
2. Chapter two introduces the purpose and the summary of the methodology conducted in this study;
3. Chapter three is the result of the study site analysis, including the selection criteria of study site, the analysis of Kashiwa City and the current situation (landscape & housing) of the key study area, Nanbu Community;
4. Chapter four is the result of housing analysis. Starting with the introduction of future scenario designing for different density including new-house restriction scenario, current trend scenario and policy oriented scenario, and then based on the housing pattern to calculate the amount of available biomass;
5. Chapter five is the result of biomass analysis, first, calculating the energy (including heat and electricity) amount by each scenario and then calculating the CO_2 reduction from substituting the fossil fuel;

6. Chapter six is the discussion sector, after briefly summarize the results from four and five, recommended policies are proposed from the discussion, which divided into the contribution from biomass energy utilization and the value from low density in urban fringe area;
7. The last chapter is to draw the conclusion of the whole study and state the limitation and further study.

2. PURPOSE OF STUDY AND RESEARCH DESIGN

2.1 Purpose of study

The objective of this study is to estimate the biomass potential from an urban fringe area. To simulate the prospective population changes, five housing development scenarios are designed and analyzed. The originality of this research is to support the urban planning policy by assessing the biomass utilization potential.

This study includes three main analysis (Figure 2-1):

1) Study site selection: Identify an urban fringe area that would be impacted, based on historical and future development plan and housing density; and estimate the currently available houses.
2) Housing analysis: Estimate the biomass available from waste wood in five scenarios, which are based on different setting in population, newly built houses, and dismantled houses.
3) Energy analysis: Estimate energy yielding from dismantled and newly built houses. The value of biomass is further discussed in term of energy self-sufficiency and environmental benefit.

Finally, a recommendation for policymakers is expected. This is aimed to prevent an aesthetically unappealing landscape due to vacant houses, to increase the energy self-sufficiency, and to make the urban fringe area more sustainable under the population shrinkage context.

The current housing situation and future planning are the criteria for study site selection. The current housing situation includes two factors, the average age of houses and the housing density. Each house needs to be reconstructed after certain life span depending on the housing material. The average age of houses in the area, which can be referred from the historical development period, is a critical factor for house dismantlement. Also, the area with high housing density has high chances of vacant houses; but, at the same time, it holds a larger potential of generating waste woods from house dismantlement. Then, the selection of urban fringe area and notable transaction area in the future urban planning is determined through the interview with the local government.

With the assumption that different housing plans could lead to different future of the urban fringe area and generate a different quantity of biomass energy, the second section is to design future analytical scenarios. This is done based on housing density and various other indicators. The total dismantlement cost and the quantity of waste wood varies based on the density scenario.

Then, the final section is to analyze the potential value of biomass energy based on each scenario under the assumption of local heat utilization system. The value is analyzed from two aspects, the direct value from selling energy and the environmental value. The environment value includes the benefit from enhancing the local energy (heat) self-sufficiency as well as promoting a low-carbon society by using biomass energy as a substitution for the fossil fuels.

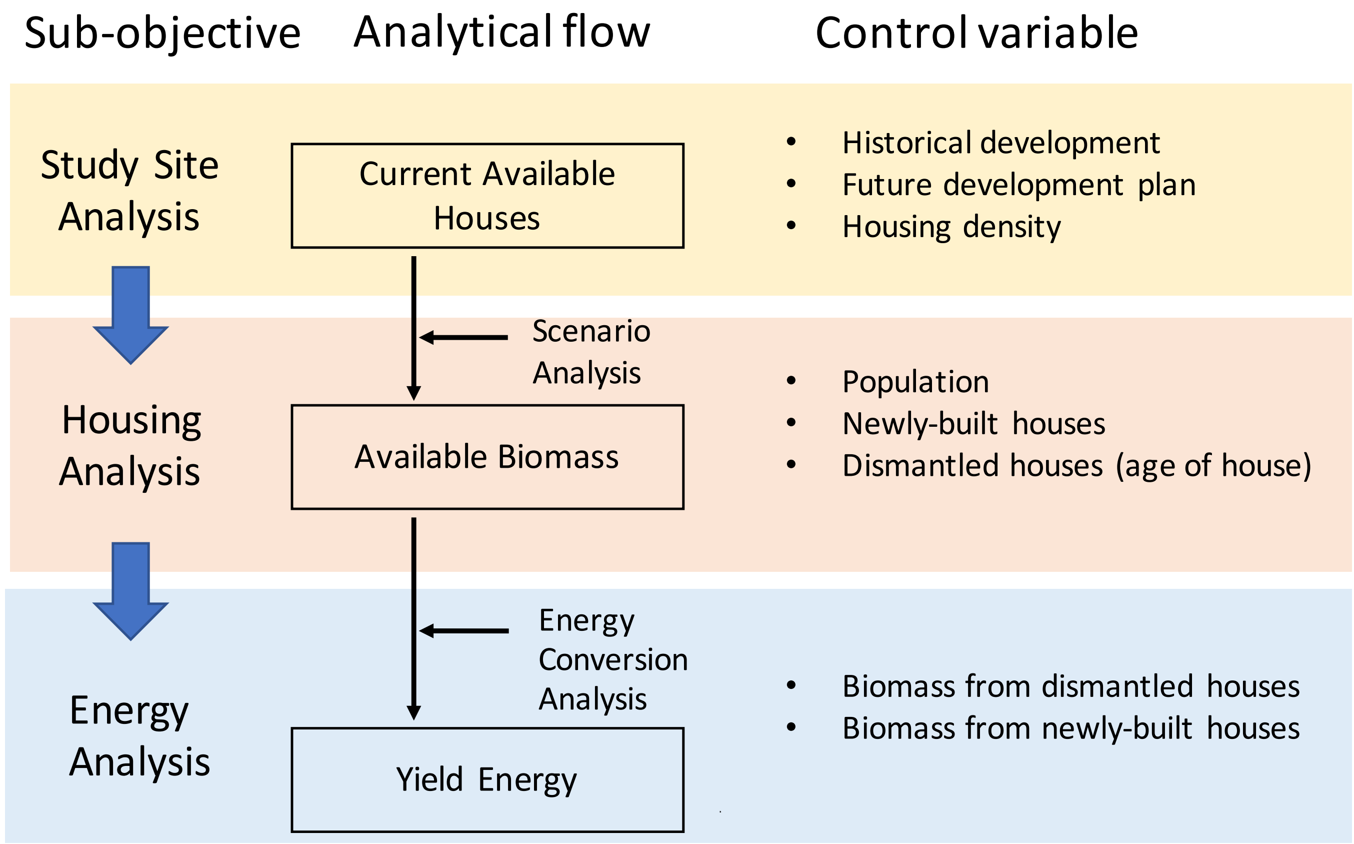

Figure 2-1. Analytical flow of this study.

2.2 Summary of methods

The main methodologies conducted in this research are summarized in Table 2-1 and is illustrated by following the order of three sections, study site, housing and biomass analysis. And, the detailed explanation is given in each chapter. According to the Kashiwa government Fifth Comprehensive Plan (Kashiwa City, 2016), Kashiwa has three unit of space division. Small zones, include 20 communities organized by residents and used for the urban master plan and welfare plan for the elderly; middle zones, consist 7 regions mainly used for daily life services; and big zones is defined to be the North, Center, South, and East Kashiwa.

In Chapter 3, the methodology consists of two scales of assessment for study site analysis. First, development period and the gap between current and future population density are used to be the indicator to identify the urban fringe area in Kashiwa City. The development period and the current population density is illustrated by the Densely Inhabited District (DID) map drew by the ArcGIS by using the population of 324 district units on city scale, and the future population density is roughly given based on the Center, South and North part according to the interview with the government officers. DID is defined as the district with population density over 4000 people/km^2 by Japanese Bureau (Statistics Japan, 2013). Then, the housing density map of Kashiwa City is also made by the ArcGIS using the building data from Kashiwa government to identify the high housing density area. Finally, via the historical data from Kashiwa City and the field observation, the housing situation of Nanbu Community, which is the urban fringe area defined by the first two steps, can be recognized and the analysis in the next two chapters is only based on community scale.

In Chapter 4, the thing to mention is that this estimation is to the year 2040, the same year that government sets the population target. The scenarios are divided into "new-house restriction", "current trend" and "policy oriented" to have various housing patterns and lead to different density (both housing and population density) in year 2040. The detailed information of scenario is provided in Chapter 4. The two control variables are the number of dismantled houses and newly-built houses. The newly-built house is depended on the scenario setting, but the dismantlement houses is referred to the interval remaining rate. The interval remaining rate is different depended on the housing period, material and location, so the calculation is referring to the historical housing data in Tokatsu area. Then, in order to give an example for showing the differences in land-use according to the density in year 2040, by the reference to the satellite image of a housing block in Minami Sakasai 4^{th} district, sketch maps of future can be made by illustrator. After completing the scenario design, the total biomass amount for each scenario is calculated based on the related indicators and formula regarding the number of both dismantled houses and newly-built houses.

The Chapter 5 for biomass analysis, first thing is to calculate the amount energy generation both electricity and heat from the results of available biomass quantity in each scenario from Chapter 4. Several indictors are required in calculation, e.g. energy content unit, energy conversion unit and etc. Then, focusing on the higher efficiency heat utilization, by assuming the heat is provided to individual houses, the CO_2 reduction from substituting fossil fuel can be estimated.

Finally, to examine the value of biomass heat utilization, the recovery rate of the house dismantlement fee is required to be calculated. The value of biomass energy includes the direct yield value of selling energy, and the other is the environment external cost of CO_2 reduction. On the other hand, the cost of housing dismantlement only refers to the number of dismantled house, and take no account of other transaction cost in the system.

Table 2-1. Summary of all methodologies applied in this study.

Section	Results	Methodology
Study Site Analysis	Urban fringe area identification	• Comparison of DID figures from 1973, 2000, 2010 made by ArcGIS • Interview to the Kashiwa city officers
	High housing density area identification	• Calculation on ArcGIS using Year 2011 housing data from Kashiwa City office
	Current area housing situation	• Review the development records and data • Field Observation
Housing Analysis	Future scenario	• Scenario analysis based on the housing density • Review of historical housing data from 2003, 2008, 2013 (Tokatsu area) and historical population data from 2004 to 2014
	Future spatial image	• Google satellite image & Illustrator software
	Available biomass amount	• Statistical analysis
Energy Analysis	Energy quantity	• Statistical analysis • Draw the material flow
	Recovery cost and CO_2 reduction	• Statistical analysis

3. THE STUDY SITE ANALYSIS

3.1 Selection of study site

The study site in this study is Kashiwa City, which located in the northwestern part of Chiba prefecture, in the outskirts of Tokyo Metropolitan region (Figure 3-1) (Kashiwa Education Committee, 2016). As mentioned in the Introduction (Chapter 1), the selection of case study site is based on two criteria, urban development plan that caused a scattered housing area, and vacant house issue, which would become deteriorate due to population shrinkage.

First, same as most cities in Japan, the residential area has been distributed following the development of Kashiwa City because of the construction of public transportation. In the beginning, Kashiwa City renamed from Toukatsu city after the Kashiwa Station built in the year 1896. The population is just over 40 thousand people and almost accumulated in the center of Kashiwa Station. Contemporary, with the national highway 6 opened in the year 1957, the initial phase of housing complex was started. During the rapid growth period around the year 1970, with the establishment of national highway communicating Noda and Chiba, massive small-scale housing complexes have been constructed in South Kashiwa, where used to be an agriculture land. As a result of migration of young generation, Kashiwa city underwent a significant population increase. Kashiwa government enacted the second comprehensive plan of Kashiwa City in the year 1981, and another expressway opened to connect Kashiwa with Yata (Kashiwa government, 2009 ; Kashiwa Education

Committee, 2016 (a)). In the year 2005, the population of Kashiwa increased because of the merger with Shonan District. In the same year, the Tsukuba Express opened and Kashiwa City is now much more convenient to connect with Tokyo city core. Currently, the main target of urban infrastructure construction is in North Kashiwa and is expected to attract more citizens to move in. The expansion of residential area is represented by DID maps of the year 1973, 2000 and 2010 by calculating the population density referring to population data from the Japanese government in ArcGIS (Kashiwa City, 2016 (a))(Figure 3-2). Therefore, based on the development period, Kashiwa City can be divided into Center, South and North part (East Kashiwa is mainly for agriculture land), and the population is increasing to above 410 thousand people, located the middle place in the Chiba prefecture (Kashiwa City. 2016 (a)).

Although several new real estate projects are still under construction in the North Kashiwa, Kashiwa government has been paying attention to the vacant house issue. According to the statistic given by the government, the vacant house rate is recorded as 10.9% in the year 2013 (Kashiwa City. 2013). In addition, the population of Kashiwa City is expected to peak in the year 2025; and is expected to decrease to only three-fourths of current population number in the year 2100 (Table 3-2). Facing the challenges of a high risk of emerging vacant houses, Kashiwa government started to enforce the Special Vacant Housing Measure Act from the year 2015 (Kashiwa City. 2016 (b)) to supervise, exhort or command the owner on properly maintaining the vacant houses. In short, Kashiwa is chosen as a typical study area in this research, as it has a scattered residential area along with the vacant house issue.

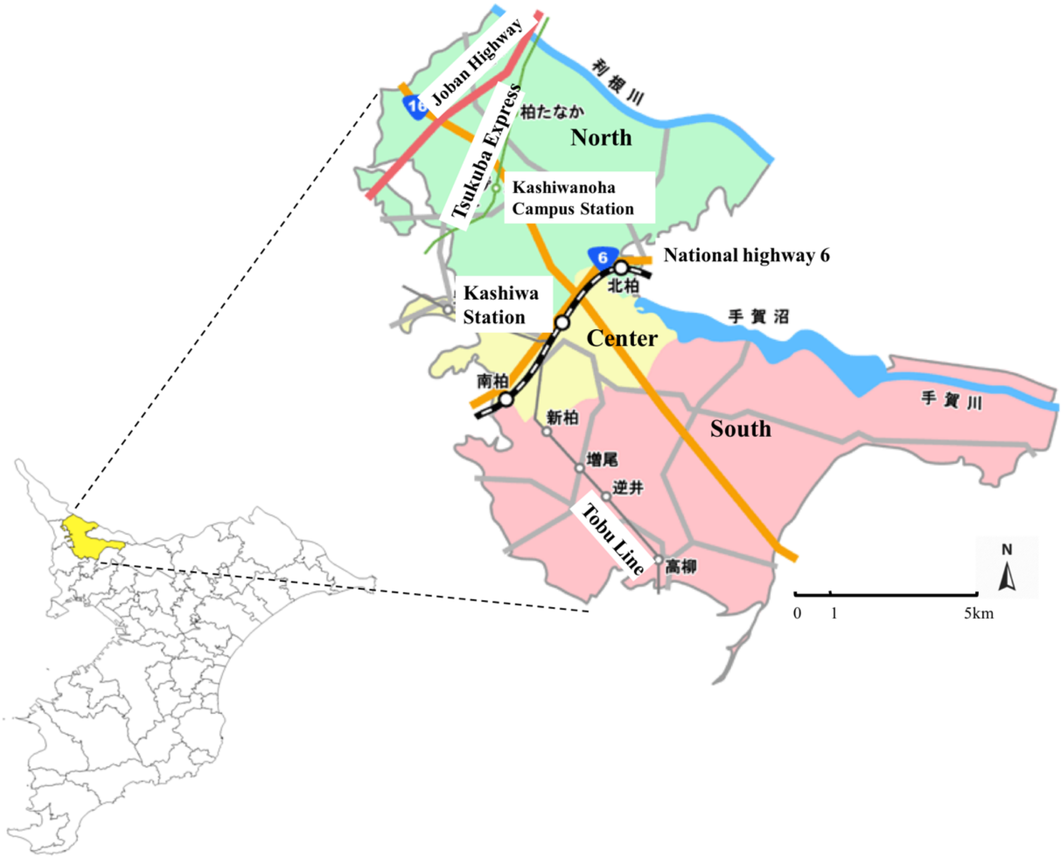

Figure 3-1. Location of study site, Kashiwa City.
(Kashiwa Education Committee, 2016)

Table 3-1. Historic development events of Kashiwa City.
(Kashiwa government, 2009; Kashiwa Education Committee, 2016)

Year	Events
1896	Establishment of Kashiwa Station
1954	Renamed "Kashiwa City"
1957	The national highway 6 opened The construction of initial housing complexes
1970	Setting the Urban Planning Area The national highway 16 "Noda-Chiba" opened
1973	The expansion of Kashiwa business district
1981	The expressway "Kashiwa-Yata" opened
2005	The Tsukuba Express line opened

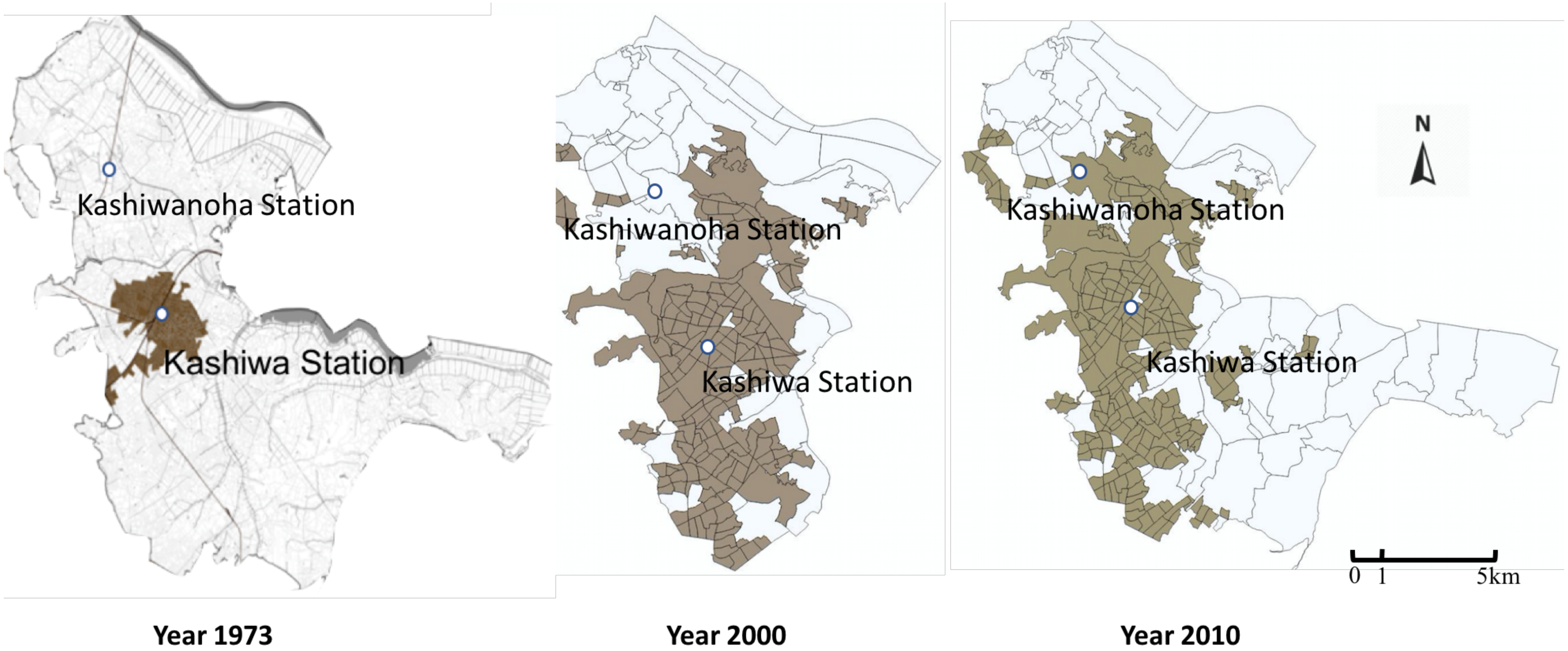

Figure 3-2. Densely inhabited district (DID) expansion in Kashiwa City.

(Kashiwa City, 2016 (a))

Table 3-2. Basic population information of Kashiwa City.
(Kashiwa City, 2016 (a))

Year	Population	Number of households	People per household	Population density (per km^2)
1955	45020	22412	5.24	610.85
1960	63745	31780	4.66	864.93
1965	109237	55227	3.94	1496.19
1970	150635	76562	3.75	2063.49
1975	203065	103565	3.53	2781.71
1980	239198	121509	3.27	3276.68
1985	273128	138150	3.24	3741.48
1990	305058	154372	3.04	4182.89
1995	317750	159841	2.86	4358.11
2000	327851	164209	2.70	4496.65
2005	380963	190138	2.64	3315.60
2010	404012	201045	2.49	3516.21
2015	413954	205971	2.40	3607.80

3.2 Study site analysis

It is important to note that the housing situation and future development plan in each region of Kashiwa are different because of the development background. Then, the next step is to identify the urban fringe area in Kashiwa City, where the housing dismantlement is necessary to avoid the vacant house issue during the transition to low population density.

The analysis of current house density is performed using the ArcGIS by reviewing the housing data from Kashiwa government in the year 2013 (Kashiwa City, 2013). The housing density was calculated by summing up the total housing number in each district and divided by the district area (Equation 1). From the calculation, the average housing density of Kashiwa City is 26.48 houses per hectare and Minami Saikai 5th District, which located in South Kashiwa, has the highest housing density, 59 houses per hectare. The housing density distribution mapped by ArcGIS is shown in Figure 3-3. Comparing with Center or North Kashiwa, almost all of the districts located in South Kashiwa were developed around the year 1970. They have high housing density that went above the average of Kashiwa.

$$\text{Housing density (houses/ha)} = \text{Total housing number (houses)} / \text{Area (ha)}$$

(Equation 1)

On the other hand, considering the population distribution and aging society, Kashiwa government has been forming a new Restructuring Plan to improve the quality of life. Based on the conducted interview and information provided by the government officers, Kashiwa City intends to shrink the Urban Promotion Area (UPA). In this plan, a targeted population density in the year 2040 in the UPA is proposed. This is planned based on the characteristics of the area, the convenience of transportation and other factors. Then, compared with the current population density, the prospective population trend can be grouped into three patterns, increasing, decreasing and maintaining the current trend. (Figure 3-4) Therefore, to avoid the vacant house in a decreasing population density context, the housing density is anticipated to decrease by accomplishing the housing dismantlement.

By means of comparing the high housing density area in Figure and the expected population density shrinking area in figure, the two events coincided in Nanbu Community. Therefore, even though there is no clear division of urban fringe area by Kashiwa government, Nanbu Community is identified as an urban fringe area. It is selected to be the key study area because having a low population density future, and a relatively large number of houses that are necessary to be dismantled, as the gap of housing density between current and future target is wide.

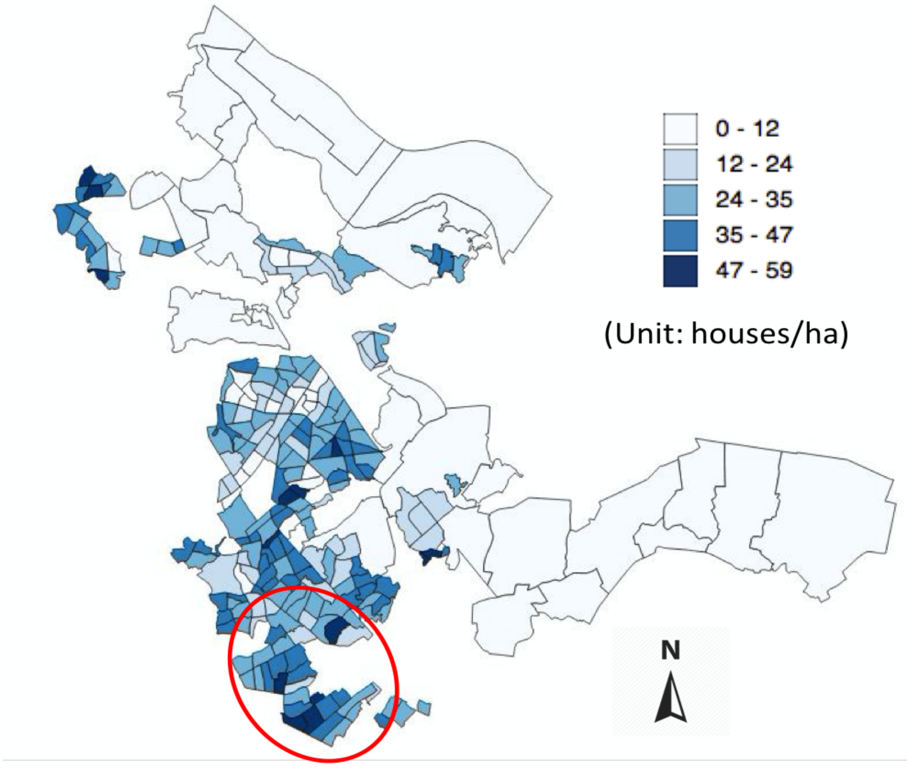

Figure 3-3. Mapping of housing density in Kashiwa City (houses/ha).
(Kashiwa City, 2013. Mapped by ArcGIS)

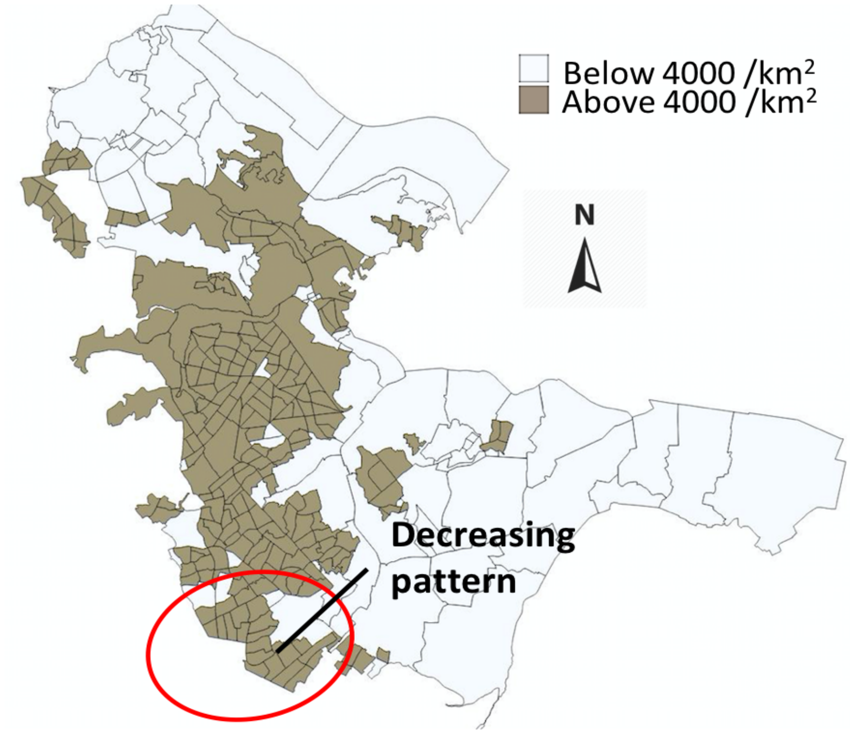

Figure 3-4. Location of population decreasing pattern area in Kashiwa City.
(Kashiwa City, 2016 (a) & Interview)

<u>3.3 Area analysis of current Nanbu Community</u>

In Nanbu Community, the average population density of each district is 59 people per hectare and the future population target is set as 31 to 40 people per hectare according to Kashiwa government. The housing complexes are mainly located in the western part of Nanbu Community while the eastern part is mainly nature landscape with agriculture land and forest (around 20 community). The landscape characteristics of Nanbu Community are shown in Figure 3-5 taken in November 2016. The ongoing reconstruction of old houses and vacant houses with extravagant vegetation (because of no regular maintenance), can be observed. Also, a housing block example in Minami

Sakasai 4th district is illustrated (Figure 3-6). The high housing density shrinks the space between houses that eventually block out sunlight, and several roads are too narrow to pass through with two vehicles at a same time, and the green spaces are limited.

The housing construction in Nanbu Community is mostly started from the year 1970, and the total number of houses in the year 2010 is 7568, which is about 19 houses per hectare. The highest housing density district, Minami Sakasai 5th district, is also located in this community (Kashiwa City, 2013). From Figure 3-7 of house stock in the year 2010, the number of houses built during 1970 to 1990 is accounted for more than 50%; in another word, most houses in Nanbu community is more than 30 years old, reaching the age limit. Also, almost all houses in this community are detached houses, and the wooden house rate of the detachments house is as high as 92.6%. Considering the target of decreasing density, a lot of this houses must be dismantled, which in turn will yield high biomass potential. Therefore, by having this available biomass, the next chapter will estimate the possible change of house stock in Nanbu Community and calculate the quantity of biomass that can be harvested from the transition process.

Figure 3-5. Street view of houses in Minami Sakasai 4th district.
(taken by the author in Nov. 2016)

Figure 3-6. Aerial image and sketch map of a housing block in Minami Sakasai 4th District.

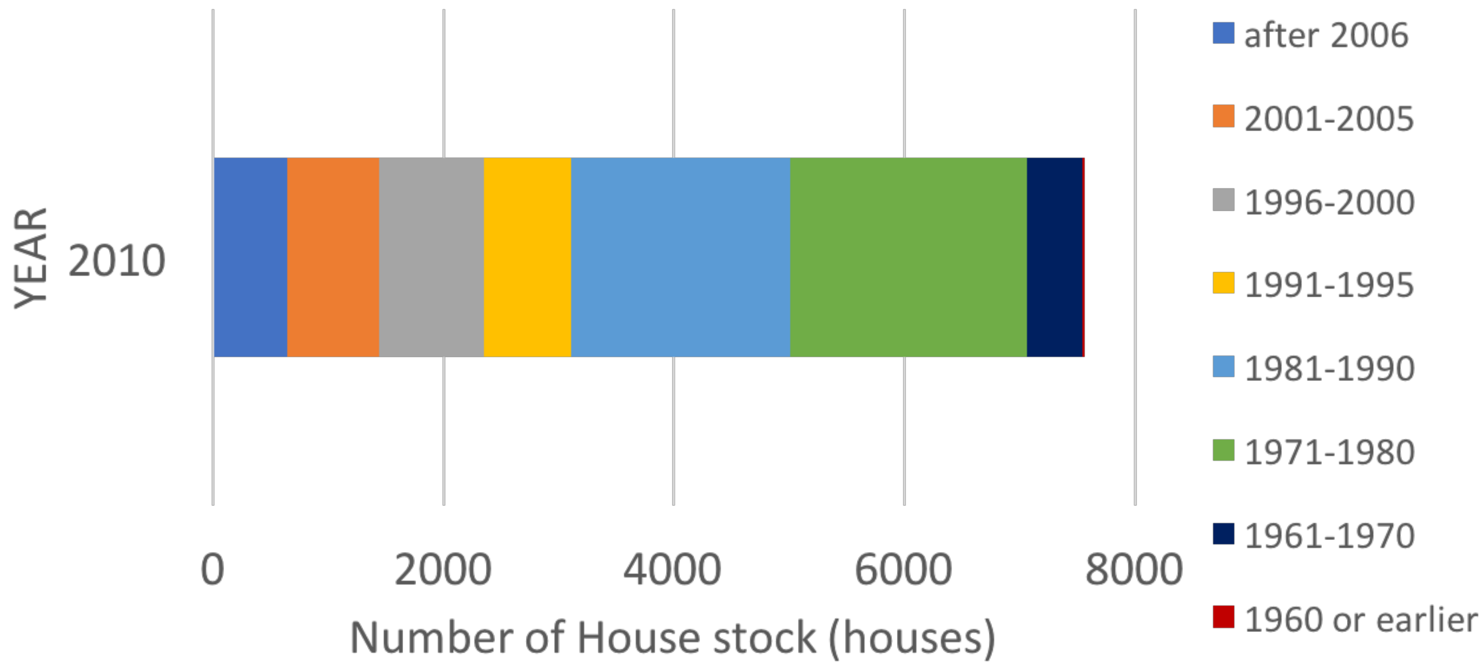

Figure 3-7. Number of house stock in Nanbu Community, in the year 2010.

(Kashiwa City, 2013)

4. HOUSING ANAYLSIS

4.1 Design of future housing scenarios

A scenario analysis is conducted to estimate the prospective house stock. Two control variables in the setting are the annual number of dismantled houses and newly-built houses. The timescale of the estimation is set as 30 years from 2010 to 2040, which is the same year with the target population density. Three main scenarios were designed: restricting a development of new houses (Scenario 1), housing expansion following the current trend (Scenario 2), and housing expansion following the policy, or targeted population density (Scenario 3). The policy oriented scenario (Scenario 3) is further divided into three sub-scenarios: minimum, maximum, and average population density, in corresponding to the population target range of 31~40 people/ha, set by the government. The result of available houses in each scenario is shown in Figure 4-1.

One premise need to be mentioned in advance. As introduced in the previous chapter, reviewing the present research, even if no action is taken to accelerate the housing dismantlement, after some time, Japanese houses, especially wooden houses need to be dismantled or reconstructed. Instead of forcing the residents to move out, all of the scenarios are following a same dismantlement speed, which is defined as interval remaining rate, a percent number of dividing the number of houses by the remaining number of houses one year after. The calculation method is explained using scenario1 in below.

Scenario1: New-house Restriction Scenario

The assumption of this scenario is that government will restrict newly-built houses in Nanbu Community during next thirty years. And then, because of no newly-built houses, the only control variable is the number of dismantled houses, which is highly related to the remaining rate. The remaining rate can be estimated using Equation 2, which is affected by housing material, housing ages and the location. Because nearly all houses in Nanbu community are wooden houses, the key influences are housing ages and the location. Therefore, the historical house stock data of the Nanbu Community is required to calculate the interval remaining rate. However, the number of house stock of Kashiwa is recorded at city scale, and only data for the year 2003, 2008 and 2013 is available. To improve the reliability of estimation, the interval remaining rate used in this study is the average rate from the cities in Tokatsu area, including Kashiwa City, Nagareyama City, Matsudo City, Noda City, Abiko City and Kamagata City. A limitation of this interval remaining rate (shown in Table 4-1) is that the division of housing age is overlapped due to the range of housing age layer after 1980 is recorded each ten year instead of five year.

$$R(t+5|t) = \frac{H_{(t+5,y+5)}}{H_{(t,y)}} \quad \textbf{(Equation 2)}$$

t: age of houses

y: year

R(t+5 | t): interval remaining rate of age t (%)

$H_{(t,y)}$: number of houses aged t in year y (Houses)

(Toshihiro & Takao, 2002; Toshihiro & Shori, 2005)

Table 4-1. Interval remaining rate in Tokatsu Area by housing ages.
(Statistics Japan, 2013)

Age	**≤2**	**3-7**	**8-12**	**13-22**	**23-32**	**33-42**	**18-27**	**28-37**	**38-47**	**≥48**
%	100	91.00	88.66	89.71	94.74	78.88	88.23	90.94	83.26	71.67

The house stock in year 2015 is estimated based on the average interval remaining rate of Tokatsu area, and the house stock of Nanbu Community in year 2010, following the Equation 2. And so, for the rest of the estimation until the year 2040. Therefore, by restricting new houses, the housing density will decrease from 19 houses/ha to 7 houses/ha. Then, by assuming no vacant houses in 2040, the population is derived from the number of house stock referring to Table 4-2, which shrinks from 59 people/ha to 20 people/ha. Referring to the spatial image given in Chapter 4, the future situation of Nanbu Community with the population density (20 people/ha) is illustrated in Figure 4-2.

Table 4-2. Conversion coefficient between the house, household and population.
(Kashiwa City, 2013)

YEAR	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Houses / Household	7568 / 9300 = 0.814						
People / Household	2.49	2.38	2.37	2.35	2.34	2.33	2.32

Scenario2: Current Trend Scenario

The house stock in this scenario is assumed to follow the current trend with no policy intervention. The control variables in this scenario are dismantled houses and newly-built houses. The estimation of newly-built houses from the construction marketing point of view is difficult, because it is necessary to input the influence indicator from both housing and economic aspects (Tadaide, 2017). Instead of doing so, this research proceeded from the most critical factor, the population trend, to estimate the demand of house stock in the future. Then, reviewing the historical data of population from 2004 to 2015 in Nanbu Community (Kashiwa City, 2016 (a)), the population in next 30 years can be estimated using Cohort method by separating the age group into over 5 years old and 0 to 4 years old and multiply by the death rate (Equation 3, 4 & 5). A limitation of this estimation is that the number of migrant is not taken into the consideration. The result of the population estimation, along with the household and house stock is shown in Table 4-3.

$$P_{(t+5,y+5\ )} = P_{(t,y)} \frac{P_{(t+5,y)}}{P_{(t,y-5)}}$$ **(Equation 3)**

$$P_{(\ 0-4,y+5)} = P_{(25-34,y+5)} \frac{P_{(0-4,y)}}{F(25-34,y)}$$ **(Equation 4)**

$$P_{(\ total)} = (P_{(t+5,y+5\ )} + P_{(\ 0-4,y+5)}) \times d$$ **(Equation 5)**

t: age of people

y: year

$P_{(t,\ y)}$: population aged t in year y

$F_{(25\text{-}34,\ y)}$: number of female aged 25 to 34 in year y

d: death rate is 0.008 (Kashiwa City, 2016 (a))

(IPSS, 2011)

Table 4-3. Population, household & house stock trend of current trend scenario. (Kashiwa City, 2013 &2016 (a))

YEAR	2010	2015	2020	2025	2030	2035	2040
Population	23,177	23,703	23,592	23,213	22,518	21,527	20,383
Household	9,300	9,978	9,970	9,861	9,618	9,236	8,767
House stock	7,568	8,120	8,113	8,025	7,827	7,516	7,135

Then, by having the total house stock, the number of newly-built houses can be estimated following Equation 6. The calculation method for the number of dismantled houses is same as the New-house Restriction Scenario (Scenario1). As newly-built houses increase the future house stock, the number of dismantled houses is then larger than Scenario 1. Therefore, following the current trend, the result of house stock trend and the spatial image in year 2040 is shown in Figure 4-2. The housing density is only changing from 19 houses/ha to 18 houses/ha, along with the population density changing from 59 people/ha to 52 people/ha.

$$N(y+5) = H(y+5) - \sum_{t=1}^{n} (H_{(t,\ y)} \times R_{(t+5|t)}) \qquad \textbf{(Equation 6)}$$

y: year

t: age of houses

n: the max age

$H_{(y+5)}$: number of estimated total house stock in year y+5

$\sum_{t=1}^{n} H_{(t,y)}$: number of total house stock in year y

$N_{(y+5)}$: number of newly-built houses in year y+5

Scenario3: Policy Oriented Scenario

After having the population density of both Scenario 1 (20 people/ha) and Scenario2 (52 people/ha), for Scenario 3, based on the Kashiwa government target, it is estimated that the newly-built should achieve a target population density of 31~40 people/ha. Therefore, the newly-built houses amount is determined by adjusting the ratio of dismantled houses with newly-built houses. After repetitive calculation, the population density could achieve the policy target, when having the newly-built houses ratio equals to 0.5 to 0.7 of the total dismantled houses. The Policy Oriented Scenario is divided into three sub-scenarios: 0.5 of dismantled houses (Scenario 3a), 0.6 of dismantled houses (Scenario 3b), 0.7 of dismantled houses (Scenario 3c).

Therefore, by having the total dismantled houses referring to the house stock in year 2010 and the interval remaining rate, newly-built houses can be estimated, as well as the house stock for the years after (Figure 4-1). Following this Policy Oriented Scenario, by realize the target population density, the housing density is reduced to 11~14 houses/ha and the spatial illustration is shown by Figure 4-2.

Briefly summarize five future scenarios from scenario description, determine indicators and the housing density in year 2040 in Table 4-4. The change of house stock in Nanbu community and the sketch map of how the future will be by estimating the same spot in three scenarios are shown in Figure 4-2.

Table 4-4. Description of the five future housing scenarios.

Scenarios	**Description**	**Indicator**	**Housing density** (per hectare)
Scenario 1	Restricting newly-built houses	Average interval remaining rate of Tokatsu area	7
Scenario 2	Following the current trend	Population trend	18
Scenario 3a	Following the policy oriented	0.5 of dismantled houses	11
Scenario 3b		0.6 of dismantled houses	13
Scenario 3c		0.7 of dismantled houses	14

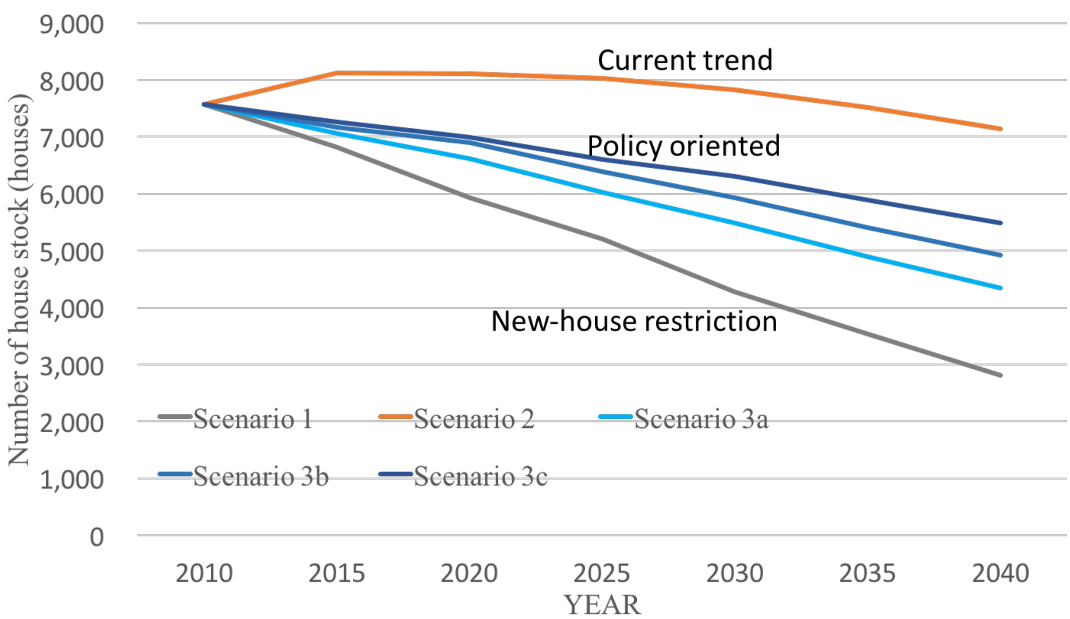

Figure 4-1. Prospective house stock changes in the five scenarios in Nanbu Community.

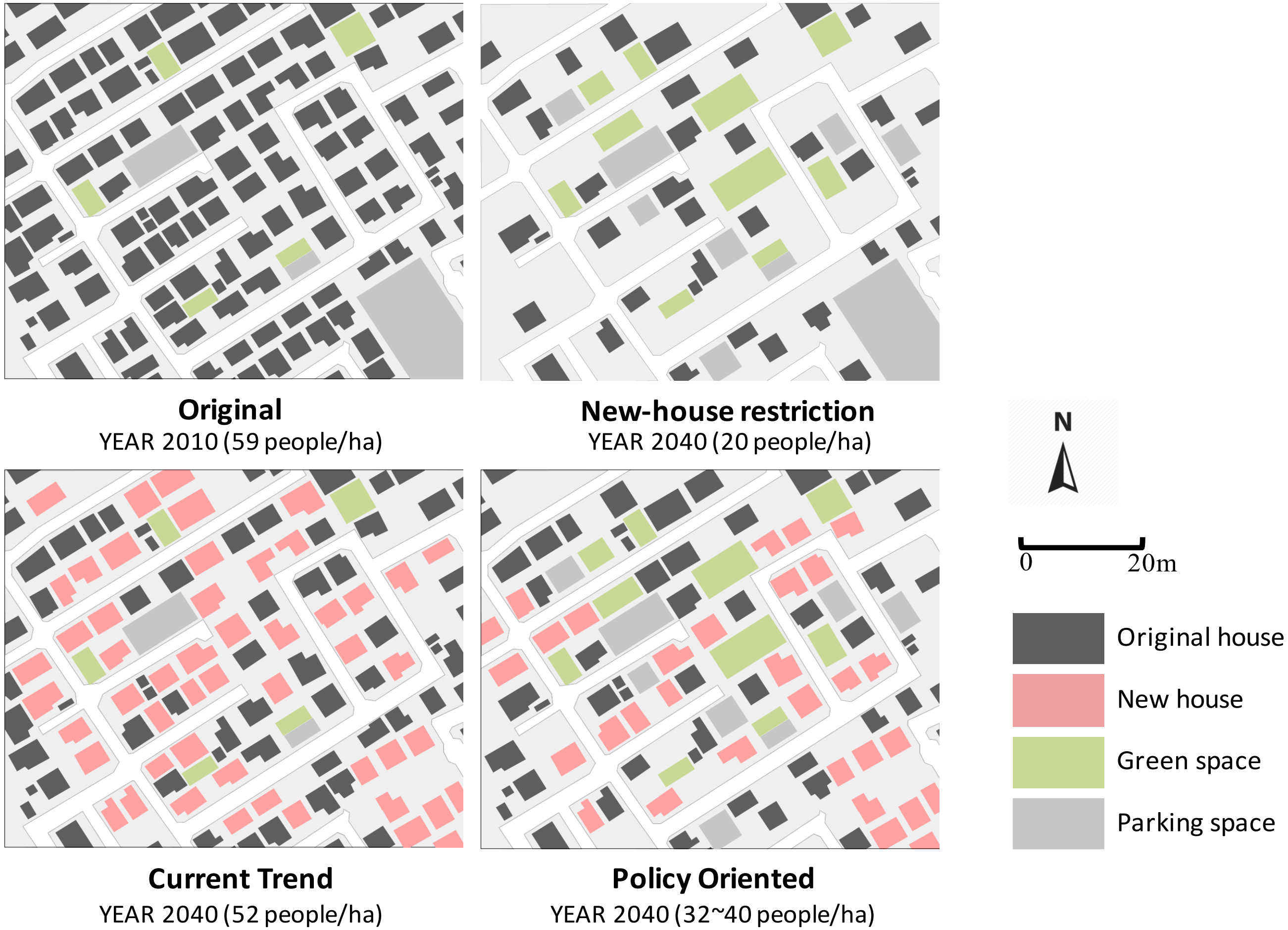

Figure 4-2. Sketch maps of a housing block in Nanbu Community in the year 2010, and 2040 in each scenario.

4.2 Estimation of available biomass

The available biomass amount is the total waste wood that can be recycled from the construction site for biomass utilization and the calculation method is shown in Equation 7. First, according to the previous research, the waste wood generated from dismantled houses and newly-built is different. The indicators include the waste wood generation unit of the dismantled house ($w_{(dismantled)}$), the average housing area of Nanbu Community (S) and the waste wood generation unit for each newly-built house ($w_{(newly-built)}$). Then, the number of both dismantled houses and newly-built houses in each scenario is summarized in Table 4-5 and the recycling rate of the waste wood is referred to the data of Chiba prefecture recorded by MLIT.

$$B_{(y)} = S \cdot w_{(dismantled)} \cdot D_{(y)} \cdot R_{(dismantled)} + w_{(newly-\mathrm{built})} \cdot N_{(y)} \cdot R_{(newly-built)}$$

(Equation 7)

y: year

$B_{(y)}$: available amount of woody biomass (t)

S: average housing area in Nanbu Community (m^2), 63.89 m^2

$w_{(dismantled)}$: 84.83 kg/m^2,

$w_{(newly-built)}$: 821 kg/house

$D_{(y)}$: number of dismantled houses during year y

$N_{(y)}$: number of newly-built houses during year y

$R_{(dismantled)}$: recycling rate of dismantled houses, 89.80%

$R_{(dismantled)}$: recycling rate of newly-built houses, 97.4%

(MLIT, 2005; The Committee for the Promotion of Recylcing of Construction By-product, 2008)

The result of the total waste wood is shown in Figure 4-3. The waste wood amount is positively related with the house stock in the former year and the higher density scenario has more available biomass amount. Therefore, there are at least 708 tons/year biomass potential in the urban fringe area from house dismantlement, and the newly-built house can add on more value by increasing the house stock. On the other hand, during the population shrinkage, the newly-built houses could be regarded as the pressure for housing dismantlement in the future.

Table 4-5. Number of dismantled & newly-built houses in each scenario.

(Nanbu Community) (Unit: houses)

(Kashiwa City, 2013; Toshihiro & Takao, 2002; Toshihiro & Shori, 2005)

YEAR	2011-15		2016-20		2021-25		2026-30		2031-35		2036-40	
Category of Housing	Dismantled	Newly-built	Dismantled	Newly-built house	Dismantled house	Newly-built house	Dismantled house	Newly-built house	Dismantled house	Newly-built house	Dismantled house	Newly-built house
Scenario 1	750	0	886	0	732	0	927	0	735	0	727	0
Scenario 2	750	1302	886	879	849	761	1141	943	1002	692	1074	693
Scenario 3a	750	246	886	444	754	152	992	454	815	223	842	290
Scenario 3b	750	347	886	616	763	259	1018	557	851	335	885	392
Scenario 3c	750	448	886	612	772	388	1028	727	455	678	921	516

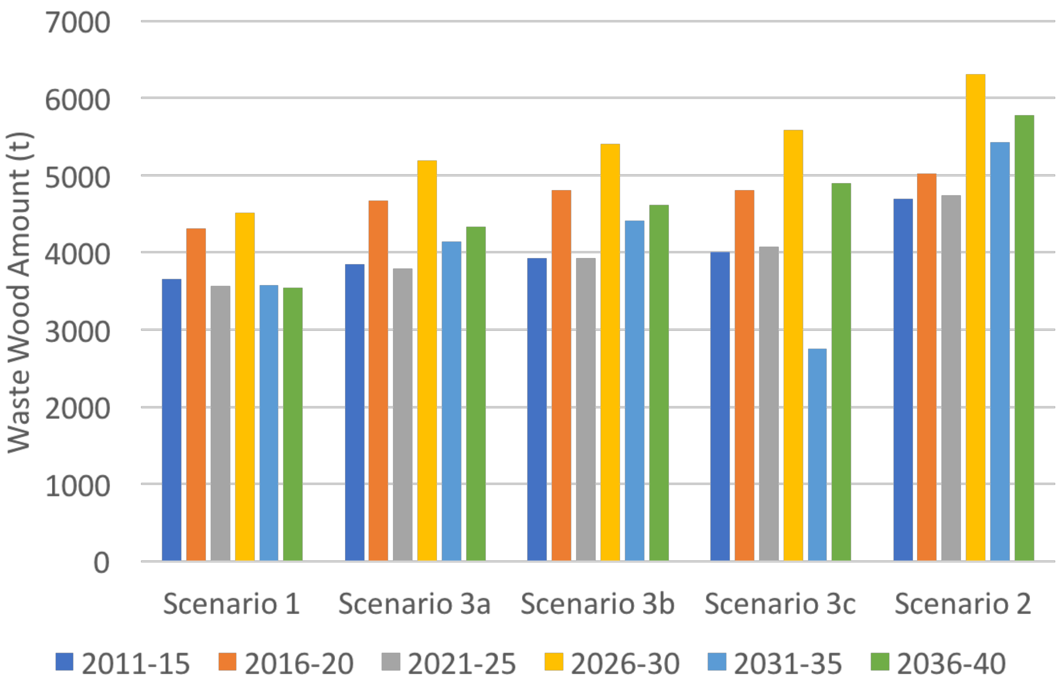

Figure 4-3. Available biomass amount in each scenario (Nanbu Community). (Unit: houses)

5. BIOMASS ANALYSIS

5.1 Estimation of biomass energy

The available biomass amount from each scenario can be calculated according to the method in Chapter 4. As mentioned in the literature review, the biomass utilization method is broadly divided into material and energy recycling (みずほ, 2005). Because one of the purpose of Compact City Policy is to create a low carbon society, as biomass energy is regarded as one of the renewable energy, this study will focus on the energy recycling to discuss the electricity and heat generation amount following the analytical flow of heat (Figure 5-1). The final energy content (e) could be different based on the quality of waste wood, especially the moisture content (U_w), ash content, and the boiler efficiency of the chipping factory (National Chip Union). By assuming, 25% moisture content in waste wood, 70% boiler efficiency, and 2% ash emission rate, the final energy amount (e) can be calculated using Equation 8, 9, 10. The result is 8.37 MJ/kg waste wood. For electricity utilization, the industry waste is recycled at the municipality level, the waste wood generated in Kashiwa City is recycled in the biomass power plant in Ibaraki Prefecture, following the material flow (Figure 5-2). The electricity conversion rate in this study is assumed to be 22.47%, same as the power plant. The result of both energy generation in the form of electricity and heat is shown in Figures 5-3 and 5-4. As the electricity conversion rate is lower, it is more efficient to convert biomass into heat than electricity. Therefore, the following biomass analysis is based on heat utilization system. Cost of transportation of waste wood is excluded in the analysis.

$$Q_{LW} = -0.2326U_W + 17.7$$ **(Equation 8)**

$$e = 0.685 \cdot Q_{LW}$$ **(Equation 9)**

$$E = e \cdot \mathrm{B} \cdot EF$$ **(Equation 10)**

Q_{LW}: Lower heating value (MJ)

U_W: Moisture content (%)

E: amount of energy (MJ)

e: energy contain, 8.37 MJ/kg

B: Amount of available biomass amount (kg)

EF: electricity conversion rate, 22.47%

(1kWh = 3.6 MJ)

(National Chip Union)

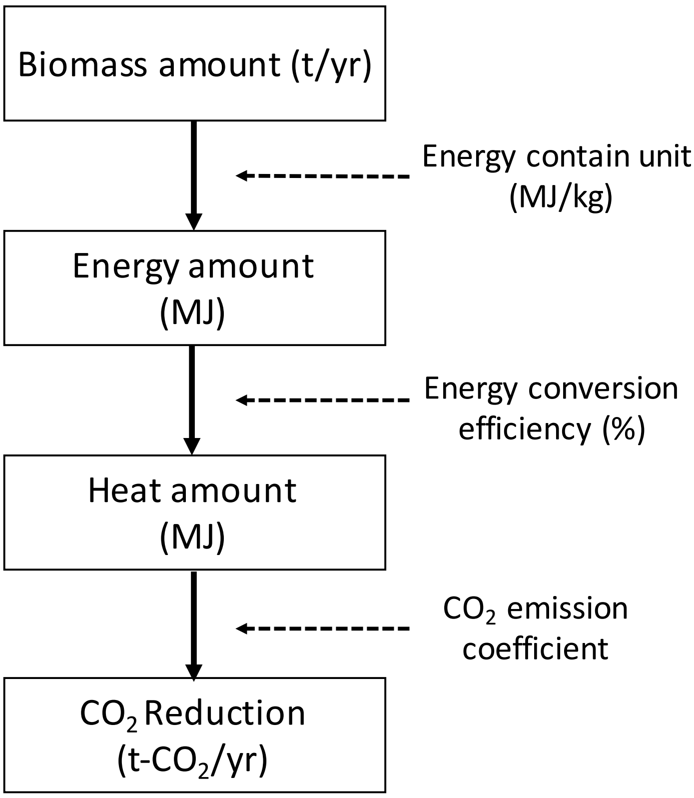

Figure 5-1. Analytical flow of biomass energy generation.

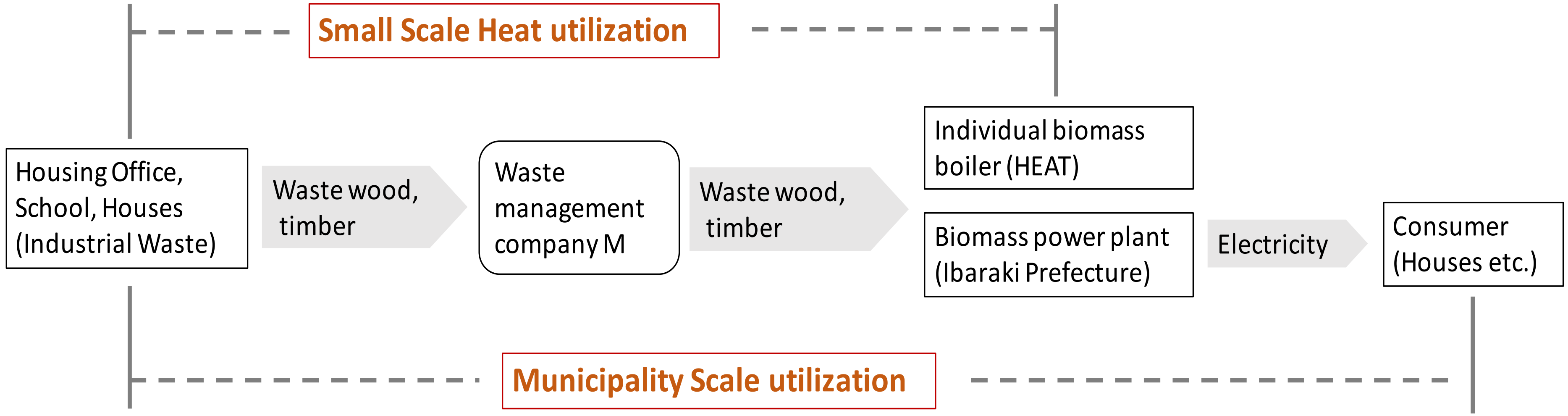

Figure 5-2. Material flow of the processed waste wood for energy generation (heat & electricity).

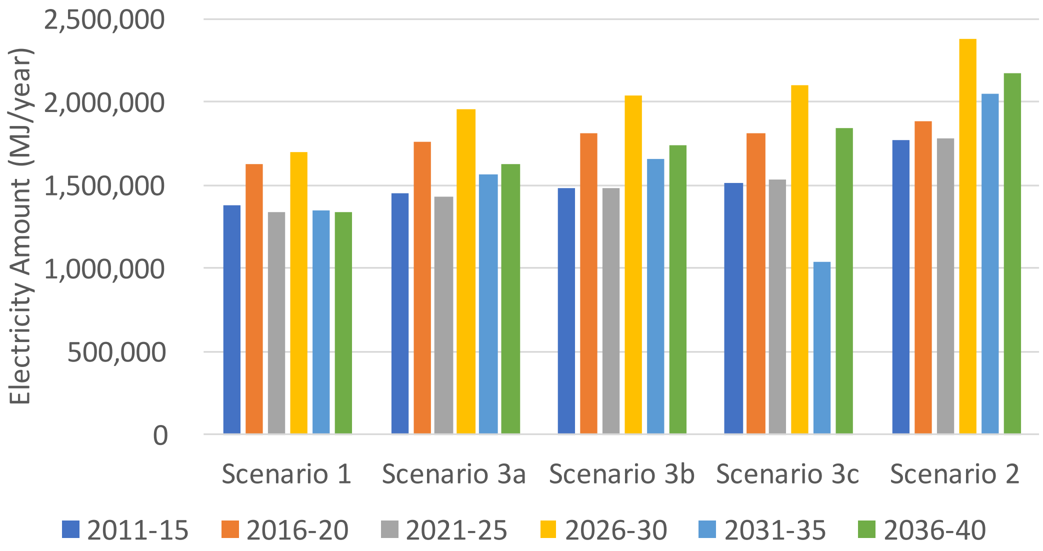

Figure 5-3. Electricity generation amount from available biomass.

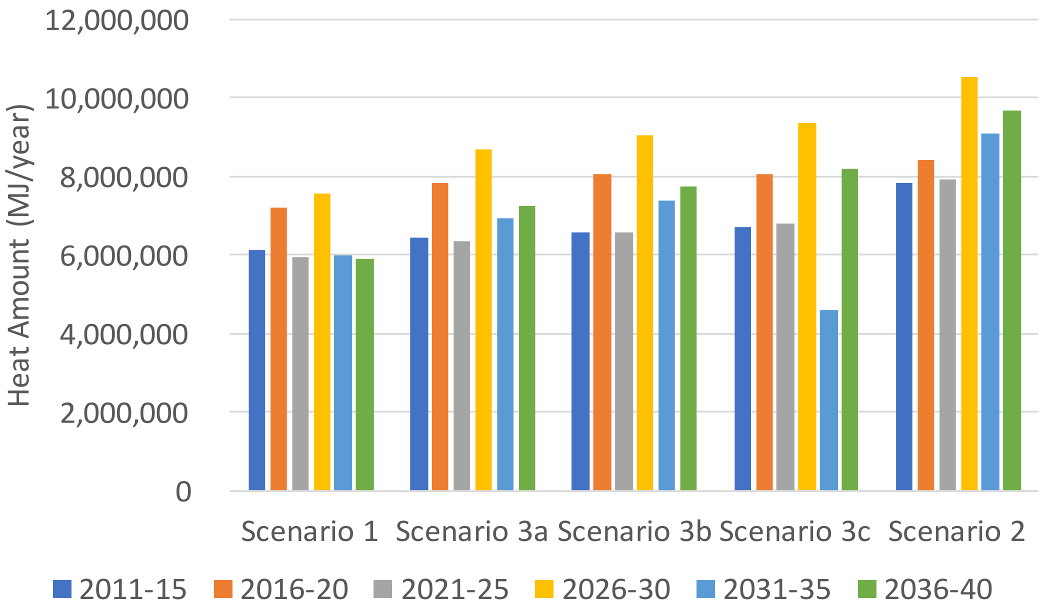

Figure 5-4. Heat generation amount from available biomass.

5.2. Estimation of CO_2 reduction

Biomass energy is a carbon neutral energy. The waste wood from housing can be treated as a substitution to fossil fuel for heat generation. CO_2 can therefore be reduced by avoiding the use of fossil fuel, creating an environmental benefit. Since heat is finally utilized by individual houses in the heat utilization system, the calculation of carbon dioxide reduction is based on the number of household. First, by having total heat consumption by each household in Kando area (Q), the amount of heat generation (E) can be converted into the household number. Then, referring to the CO_2 emission from heat utilization by each household (k), the total amount of reduction (c) can be calculated by Equation 10. The result is shown in Figure 5-5.

$$C_{substitution} = k_{heat} \cdot \frac{E}{Q} \qquad \textbf{(Equation 10)}$$

$C_{substitution}$: the CO_2 reduction by using biomass to substitute for fossil fuel (t- CO_2)
k: annual CO_2 emission from heat utilization by each household (0.781t-CO_2/household)
E: total amount of heat (MJ)
Q: the average heat utilization amount, 9791 MJ/household/year
(Agency for Natural Resources and Energy)

From two results of the energy generation and the CO_2 reduction amount, the findings are:

1. The housing dismantlement and construction in urban fringe area has the value of generate biomass energy, electricity from 1038 GJ/year to 2373 GJ/year or heat from 4616 GJ/year to 10554 GJ/year. And, heat generation has more efficiency than the electricity.

2. There will be value of CO_2 reduction, if waste wood can be well-used for energy generation. For example, through heat generation, the reduction amount of CO_2 ranges from 368 t-CO_2/year to 842 t-CO_2/year.

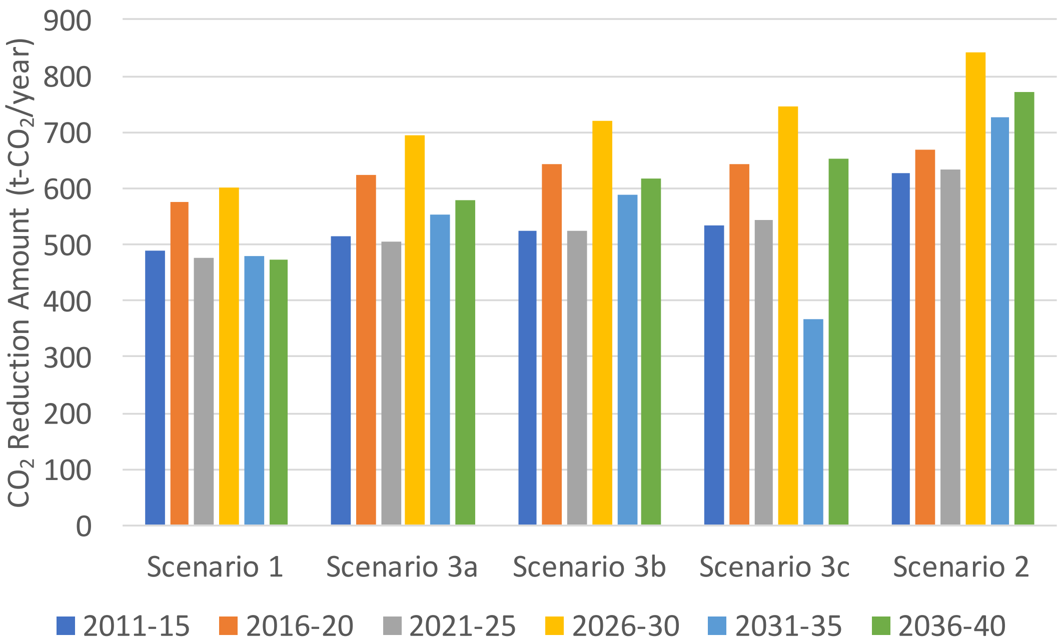

Figure 5-5. CO_2 reduction from substituting fossil fuel for heating.

6. DISCUSSION

To examine the value of biomass from housing dismantlement in urban fringe area, this study selected the Nanbu Community in Kashiwa City to be the case study area. Briefly summarize the findings of Chapter 4 and 5:

1) According to the future scenario, different patterns of housing dismantlement and construction in urban fringe area could lead to differential density of housings and variance land use in the future;

2) Waste wood can be harvested from both housing dismantlement and construction in urban fringe area, and the higher density scenario has higher potential of harvesting waste wood because of the number of newly-built houses;

3) Utilization waste wood for biomass energy can contribute to reduce the CO_2 emission from replacing fossil fuel.

Therefore, this chapter furtherer discusses about how can the value biomass energy contribute back to the housing dismantlement and how can this wood biomass utilization link with the Compact City Policy.

6.1 Contribution from biomass energy utilization

The value from biomass includes direct yield of selling energy and environment benefit of CO_2 reduction. To harvest the waste wood, the total cost of housing dismantlement (M) by each scenario can be calculated by Equation 11 (Figure 6-1). This study only considered the cost for dismantling houses, without the cost of transportation or the energy generation. Taking the heat utilization as an example, the direct yield is selling heat energy (Equation 12). With the data of total heat amount each five years (V_{heat}) and the unit selling price (v_{heat}) with the range from 0.6 yen/MJ to 1.4 yen/MJ, the total value from selling heat in each scenario can be calculated (Figure 6-2). The other value is environment benefit of CO_2 reduction by substituting the fossil fuel heating. In order to promote CO_2 reduction, Japanese government starts the Japan-verified emission reduction system (J-VER) to convert CO_2 into monetary value (Figure 6-3). The trading process of this system is shown in the figure below. There are several standard to value the CO_2 from 234yen/t-CO_2 to 10881 yen/t-CO_2, and this study adopted the data (v_{CO2}: 2500 yen/t-CO_2) provided by Japan Ministry of the Environment. Then, referred to the amount CO_2 reduction by using biomass from housing, the result of CO_2 reduction value is shown in Figure 6-4 (Equation 13).

To answer the question that how much value can biomass support for housing dismantlement, dismantling houses by comparing the total value and cost in each scenario, almost same proportion, nearly 7% of the housing dismantlement fee can be covered by the value from biomass energy generation (Figure 6-5). Therefore, to give the policy recommendation for accelerating the housing dismantlement for achieving the low density and avoiding vacant house issue in the meantime, government, or the beneficiary from biomass energy generation, could give a monetary support to cover 7% of the total housing dismantlement fee.

$$M = S \cdot m \cdot D \qquad \textbf{(Equation 11)}$$

M: the total cost of housing dismantlement (yen)

S: the average housing area in Nanbu Community, 63.89 m^2/ houses m: Unit cost of housing dismantlement (9.98 thousand yen/m^2)

D: the total number of dismantled houses based on the scenario

(Crassone. 2013;)

$$V_{heat} = E_{heat} \cdot v_{heat}$$ **(Equation 12)**

V_{heat} : the total value from selling heat

E_{heat}: the amount of heat

v_{heat}: the unit selling price of heat, 1 yen/MJ taking the average price

$$V_{substitution} = C_{substitution} \cdot v_{CO2}$$ **(Equation 13)**

$V_{substitution}$: the total offset value from CO_2 reduction

v_{CO2}: CO_2 offset value unit, 2500 yen/t-CO_2

(Ministry of the Environment)

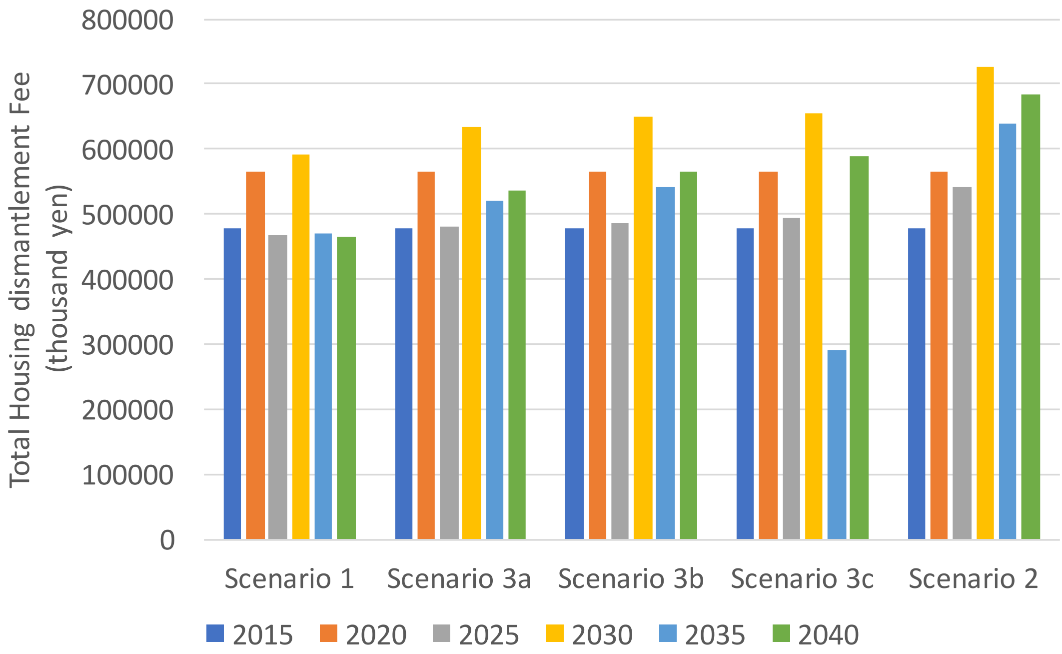

Figure 6-1. Total housing dismantlement fee in each scenario (thousand yen).

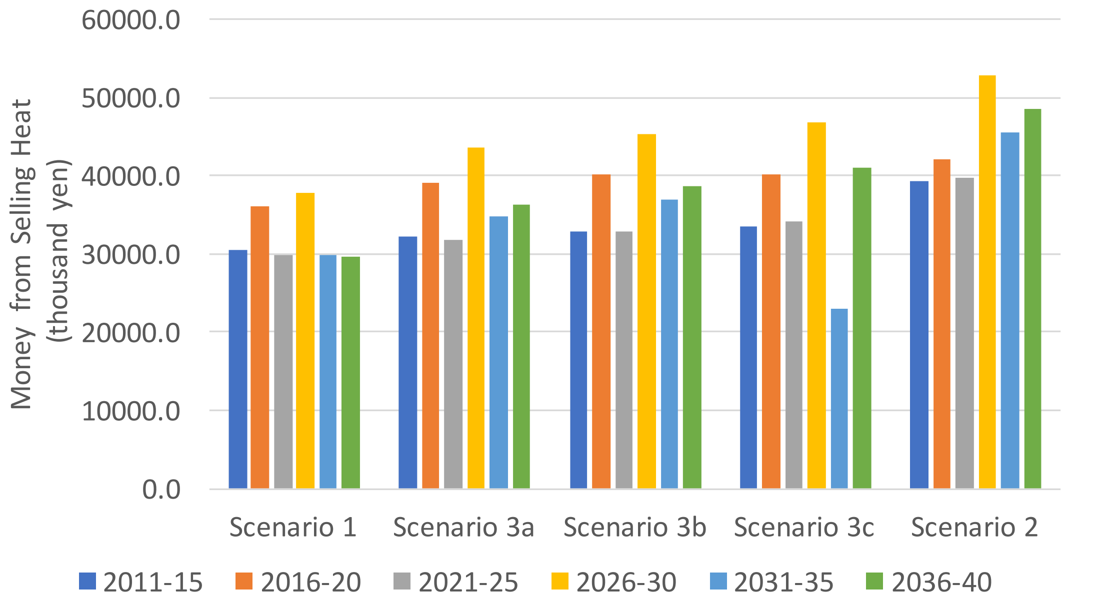

Figure 6-2. Monetary value from selling heat (thousand yen).

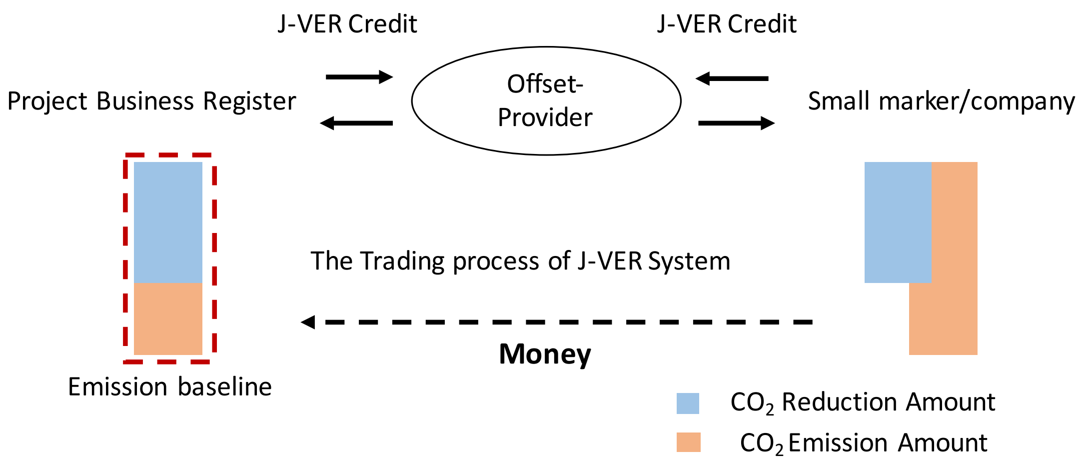

Figure 6-3. Conceptual map of Japan-verified emission reduction system (J-VER).

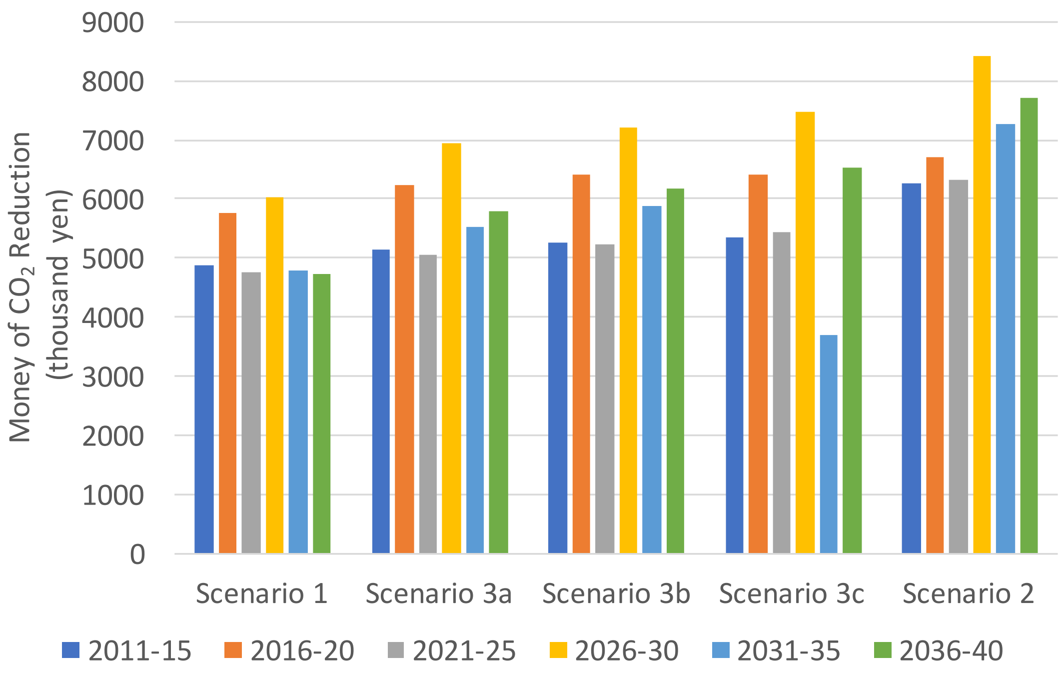

Figure 6-4. Monetary value of CO_2 reduction in each scenario (thousand yen).

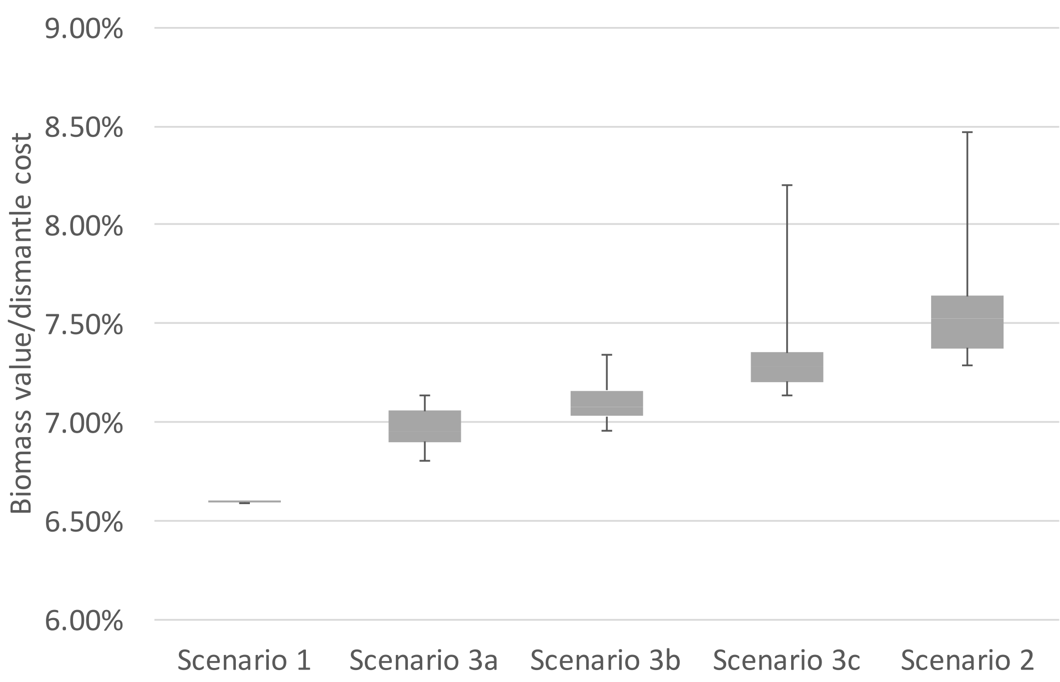

Figure 6-5. Ratio of total biomass value over dismantlement cost in each scenario.

6.2 Value from low density housing in urban fringe area

The purpose of both promoting biomass utilization from housing dismantlement and Compact City policy is to realize the low density urban fringe area. As mentioned above, to tackle the population shrinkage, Compact City Policy focuses on the investment on high-density urban core area to attract residents to move in. However, comparing with the high efficiency, convenient living environment in urban core with high density, the low-density area also has several benefits. Together with the CO_2 reduction from biomass energy utilization, the low-density is also beneficial to the CO_2 emission reduction from decreasing household numbers. Because of the energy consumption for heat and electricity consumption, totally 3.825 t- CO_2/year on average is exhausted by each household. Figure 6-6 shows the total CO_2 emission decreasing from 2010 to 2040 and five-year decreasing from 2035 to 2040 along with the trend of household decreasing in each scenario.

$$C_{emission\ reduction} = k \cdot \mathrm{HH} \quad \textbf{(Equation 14)}$$

$C_{emission}$: the CO_2 reduction by reducing the household (t- CO_2)
k: the total CO_2 emission from energy utilization by each household (3.825 t-CO_2/household)
HH: the number of household

The other one is according to the sketch map of future based on scenario, low density provides more possibility for land regeneration. Vacant lots have been observed to be valuable spatial resources to improve quality of life for local residents. Vacant houses are commonly change into gardening, parking, and building housing for parents and children, but also common spaces for children to play ((Harada et al., 2006; Terada et al., 2012). In addition, dismantling the houses could provide more space for more sunlight and air to penetrate adjacent housing (Asami, 2014).

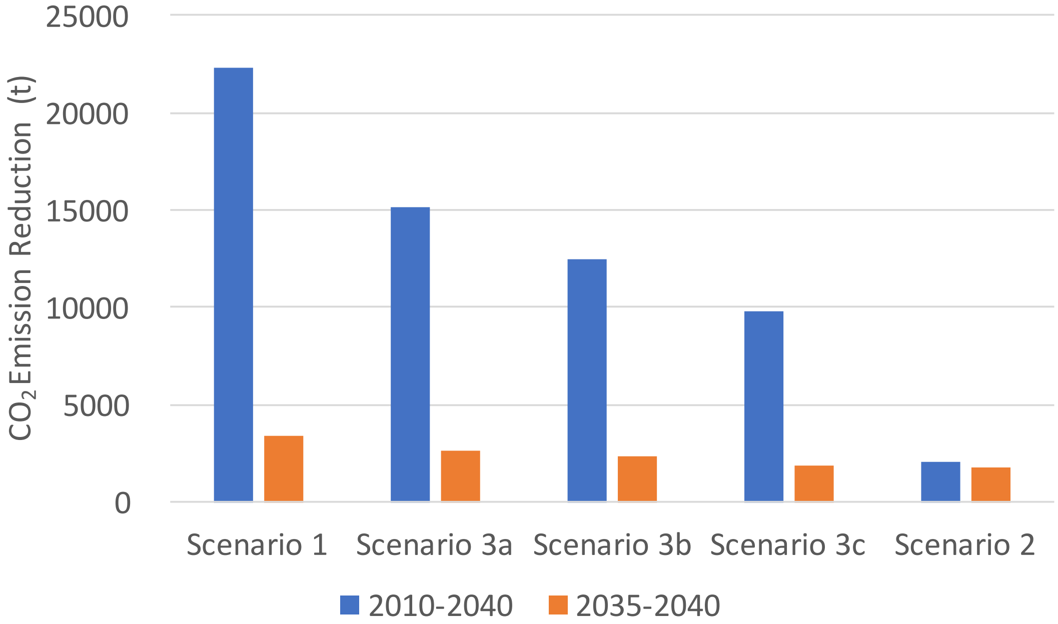

Figure 6-6. CO_2 emission reduction from year 2010 to 2040 and from year 2035 to 2040 as decreasing household in each scenario (t-CO_2).

7. CONCLUSION

The number of vacant house is 8.2 million, more than a twofold increase over the past 25 years, and will increase to 20 million by 2033. In addition, no maintenance often makes them eyesores of dismantling the surrounding area and pose danger to the nearby residents. These phenomena alarm the government to take actions to deal with the vacant house issue. Government proposed the Compact City Policy to shrink the urban area via investing the urban core area to attract a population. However, this policy has a hidden problem that more vacant houses could emerge in urban fringe area and mainly of them has no plan to live in because of the graying of the local population. Housing dismantlement is necessary to conduct in urban fringe area for achieving the low density together with avoiding the vacant house issue. But, the high cost from housing dismantlement is the fundamental problem. Fortunately, because wooden house rate is more than 60% (MLIT, 2016), waste wood from housing dismantlement can be regarded as woody biomass resources for generating energy. Therefore, this study aims to estimate the values of biomass energy to promote local residents' enthusiasm of housing dismantlement in urban fringe area.

The findings from five future scenario and recommendations for Kashiwa City are summarized by Table 7-1, and the sketch map of future scenario shown in Figure 4-2.

- Future scenarios are built to understand the process of housing dismantlement and construction for reaching differential density, which will create the local appearance significantly different in the future.
- Waste wood can be generated from both housing dismantlement and construction

in urban fringe area, and higher density with more newly-built houses has more available biomass. And the same, higher density can generate more biomass energy and contribute to reducing more CO_2 emission from substituting fossil fuel.

- Converting the CO_2 reduction amount into monetary value, plus with the direct yield of selling energy are defined as the total value of biomass energy in this study. By the result of comparing with the total housing dismantlement cost, the recommended policy is that via utilizing the waste wood for energy generation, Kashiwa government could provide nearly 7% of housing dismantlement fee for residents.
- Instead of emerging vacant houses, housing dismantlement is the process of changing houses into vacant lots. As the common use of vacant lots includes parks, community gardens and etc., it provides more opportunity to makes low density area more attractive. Therefore, the recommended policy is that except the investment in urban core, Compact City Policy could also promote the investment on vacant lots in urban fringe area for a better living condition.

This research examined the biomass amount from different scenarios to understand the value of housing dismantlement and linkage with Compact City Policy. And the study area, Nanbu Community in Kashiwa City, is a typical area representing urban fringe areas that have been developed in rapid growth period and now facing population shrinkage. However, for better running this biomass utilization system, the opinion of residents from willingness of housing dismantlement and preference of vacant lots land-use should be considered in further research.

Table 7-1. Summary of the findings in this thesis.

Findings					
	Scenario 1	**Scenario 2**	**Scenario 3a**	**Scenario 3b**	**Scenario 3c**
Description	Restricting newly-built houses	Following current trend	Following policy oriented		
Housing density in 2040 (per hectare)	7	18	11	13	14
Heat on average (MJ/year)	6461	8920	7247	7557	7288
CO_2 Reduction ($t\text{-}CO_2$/year)	515.34	711.52	578.11	602.81	581.35
CO_2 Emission reduction in 40 years ($t\text{-}CO_2$)	22363.21	2037.20	15178.44	12443.46	9793.40
Discussion					
Value from biomass energy could cover nearly 7% of the total housing dismantlement fee.			Vacant lots provide more opportunity for improving the quality of living condition.		
Policy Recommendation					
Provide subsidy to promote local residents' enthusiasm of housing dismantlement			Attract more investment on vacant lots development		

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