Using Building Information Models (BIM) in social housing sustainability development
Goal and structure of the report

### Goals for ARA’s own use

ARA is presently taking into use new tools and guidelines to process applications for funding, including what support will be available for constructors.

A case study exercise was carried out as part of this study with Settlementti-Asunnot. The case study and related guidance was only issued in Finnish.

### International cooperation

ARA is a member of European Federation for Living, an association bringing together various housing related actors from different countries in Europe.

ARA has various cooperative projects with EFL and its members, to which ARA contributes back with this study which was authored in English.

### Study aims to showcase how and why to integrate BIM and sustainability in the social housing design / funding process.

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SUSTAINABILITY IN SOCIAL HOUSING</td>
<td>Discusses the imperative of sustainability in social housing as key enabler of governmental goals</td>
</tr>
<tr>
<td>2. TYPICAL RESIDENTIAL DESIGN PROCESS</td>
<td>Highlights the importance of the early design, making apparent the need to focus on this phase</td>
</tr>
<tr>
<td>3. BIM IN HOUSING DESIGN &amp; DEVELOPMENT</td>
<td>Explores the current status of use of BIM in residential development projects</td>
</tr>
<tr>
<td>4. POSSIBLE REQUIREMENTS AND INCENTIVES</td>
<td>Looks at possible mandatory requirements and voluntary incentives that might be put in place</td>
</tr>
<tr>
<td>5. COST IMPLICATIONS OF REQUIREMENTS</td>
<td>Studies the potential cost impact of putting requirements or incentives in place</td>
</tr>
<tr>
<td>6. SUMMARY AND RECOMMENDATIONS</td>
<td>Synthesizes results and gives recommendations</td>
</tr>
</tbody>
</table>
About ARA

ARA is a Finnish government agency charged with promoting sustainable, high quality and affordable housing as well as developing the housing market according to the government priorities. ARA guarantees loans and provides grants for qualified housing projects.

The study is funded from ARA’s development funds. For more information about ARA visit www.ara.fi.

About Bionova

Bionova Ltd is a Finnish construction sustainability specialist. Bionova provides professional services on developing sustainability programs and regulations to governments and businesses.

Bionova is developing and selling construction sector life-cycle assessment and costing software One Click LCA, which was used for results in report.

For more information about Bionova please visit www.bionova.fi or www.oneclicklca.com.
1. SUSTAINABILITY IN SOCIAL HOUSING
Background: government goals

Finnish government has goals for developing the housing and construction sector, including:
- Availability of affordable housing
- Digitalising the construction industry with BIM
- Reducing carbon emissions from construction

These goals do have synergies and it’s possible to develop a combined approach to address them.

BIM as the technical enabler

Building Information Models are the technical enabler for meeting both lower cost construction as well as lower carbon construction.

The models contain information supporting the effective design and construction, and can be used to ensure sustainability of the project using a methodology called Carbon Footprinting.

Background: accelerating key policy goals

1) AFFORDABLE HOUSING
2) DIGITALISATION WITH BIM
3) LOW CO2 CONSTRUCTION

OPPORTUNITY TO ADDRESS SEVERAL GOALS AT ONCE
Climate change affects most the less well off

Our climate is already changing

Number of studies show already that climate impacts are already incurring, in spite of mitigation.

Some of the impacts may be reduced with decisive mitigation efforts, but the overall trajectory is that climatic conditions will become more turbulent.

This hits less well off the most

Generally, any natural disaster impacts will affect more people and families with less financial resources, whose livelihood has less buffers for unexpected events and fewer opportunities to fall back on alternative solutions while conditions are remedied.

A number of affected people will live in social housing, and emissions of this particular building stock also contribute towards global warming.

Source: European standardisation in support of an climate-resilient infrastructure, 2015
Life-cycle performance saves costs & carbon

Life-cycle cost as a metric

Life-cycle costs consider all the costs, including investment, operating costs, repairs, renovations as well as the end of life costs of a building.

Optimizing life-cycle cost means inhabitants can enjoy affordable housing on the long term, as no corners are cut in project that would expose the inhabitants to higher future operating costs.

Otherwise, quick savings today may hit back even up to tenfold in form higher operating costs.

Life-cycle carbon as a metric

Life-cycle carbon footprint of a building looks as the greenhouse gas emissions arising from materials manufacturing, transport, installation as well as repair, maintenance and operating energy and water uses, and end of life processing of building.

Life-cycle carbon emissions is a very reliable indicator, as it’s allowing to identify trade-offs which optimize the whole life performance, not just a sub-part of the life-cycle.
Real projects show improvement is feasible

Carbon reduction is feasible

A 2014 study on five social housing projects showed that social housing projects can reduce carbon emissions significantly without overall adverse effect on life-cycle cost.

Projects were able to reduce life-cycle carbon emissions by 25-50% compared to regulatory level; the project included one control building.

Life-cycle cost can be reduced

While two of the considered improved projects were able to achieve also lower life-cycle costs, two projects likewise ended up to higher costs. There is more uncertainty in this area.

The projects were located in different cities and sample size is small, so further and larger scale validation for the results will still be required.

Source: Ympäristö- ja elinkeirimittareiden hyödyntäminen ARA-kohteissa, 2014
Historically cost-driven

Social housing funding has historically been focused on affordability as well as ensuring supply of housing to groups with specific housing needs. This has led to focus on accessibility as well.

Social housing energy performance level in Finland has improved mostly with regulatory actions, though some pilot projects have been funded for building near zero energy buildings as well. These practises have not been generalized.

Starting life-cycle thinking

The strategy of Finnish social housing funding organisation ARA for period 2016-2020 puts sustainability on par with affordability as a goal.

Outside of specific development projects, there are no financial incentives to drive sustainability in project development, nor actual KPIs to measure whether projects are in fact sustainable or not.
2. TYPICAL RESIDENTIAL DESIGN PROCESS
Influence is cheap early on

Following Norman Foster’s principle of early phase influence, the exactly same applies to the life-cycle performance of a construction project.

At later stages improvements are all additional investments and not results of the design process.

Requirements influence early

The first set of design constraints and targets tabled are always the requirements.

This in short means, that to be most effective, sustainability goals also need to form mandatory requirements, which preferably also must be documented and delivered upon early on, to ensure no documentation is created after the fact.
Early design lack of focus …

Early design focus is on capital cost and functional planning. While these are crucial areas, they are not complemented by life-cycle cost design or any substantial energy or environmental design in normal residential projects.

… leads to lost opportunity

Good life-cycle performance is inherent property of a project, and can’t be baked in at a later stage in a cost-effective manner.

All available “discrete options” typically carry higher capital or operational cost than such as are achieved with focus on design.

Source: Tiekartta rakennuksen elinkaaren hiljalanjäljen huomiomiseksi rakentamisen ohjauksessa, 2017
**Design investments are low**

Typical projects are designed with the budget allowing a project to apply for funding. This phase is typically performed at a great haste.

However, this stage of the design is the one where targets for performance must be set.

The funding scrutiny periods expected from ARA by the constructors are very short as well.

**Targets needed in early phase**

Constructors need to provide the design teams performance targets at the earliest possible stage.

The current incentive structures do not drive this to happen; and even if social housing investors are long-term owners, not all set such targets; owing to lack of time, competence or resources.

Structural incentives would help ensure constructors invest in such capabilities in design.

---

**Design process for ARA-funded projects**

**EARLY PHASE DESIGN DOES NOT RECEIVE ENOUGH FOCUS & FUNDS TODAY**

**Performance targets need to be set here**
3. BIM IN HOUSING DESIGN & DEVELOPMENT
Some projects are modeled

Most social housing organisations have some projects which are modelled in 3D; most often also documenting some information in the model – thus becoming Building Information Models (BIM).

Specific BIM requirements are not common so far in social housing design assignments.

Models are developed both by architects and structural engineers, but not always coordinated by the client and information content may vary.

BIM requires an all-in approach

BIM is not improving performance as long as it’s done “additionally”. To make BIM the source of accurate design data, it must be used by all parties on the project, and not have some parties use other tools as the “actual tools” for their design.

Otherwise, dual processes will eat out any efficiency gains available with BIM use.

Use of BIM is not yet systematized

EXAMPLE OF A SOCIAL HOUSING BUILDING INFORMATION MODEL
Contractors use modeling most

Contractors get process benefits from clearly modeled BIM as it helps them to source right products and install them in the right way at the right time. This has also led to contractors using BIM more than most. In the US, 74% of contractors use BIM, with 60% of them using BIM for establishing energy performance.

Engineering firms: size matters

Some smaller architectural or engineering offices do not find economic benefits in moving to 3D modeling tools, especially in absence of specific requirements from client.

There are of course numerous exceptions, so this can not be considered a rule.

Any size company will ensure they are in possession of tools required by the work for their clients.

Structural models

Many high-rise residential projects are getting structural engineering modelled to ensure efficient engineering design and compliancy.

In general, structural models are very good for establishing the life-cycle performance of structure.

Structural engineering tools also help avoid unnecessary use of materials, when construction strength and safety can be achieved with less use of materials, or possibly replacing parts with lower specification concrete, for example.

Architectural models

Architectural models are often visually clear and provide a good tool for functional design. However, they may contain definitions which have been only included for visual purposes, such as “Shadow”, or “White” or other parameters.

At other times, they perform well for life-cycle performance analyses.
BIM requirements in Europe

No housing-specific rules

No requirements could be identified that apply at a national level to social housing anywhere in Europe. It is possible that some could not be identified due to language barriers.

However, in the UK government has a requirement for Level 2 BIM for all projects with central government funding. Central government funds several affordable housing programmes.

Local requirements may exist

This does not preclude local requirements for countries and regions funding social housing at a city or province level.

NOT A SINGLE SOCIAL HOUSING SPECIFIC BIM REQUIREMENT WAS IDENTIFIED

UNITED KINGDOM
Level 2 BIM for all projects with central government funding. This does not include all social housing projects.
4. POSSIBLE REQUIREMENTS AND INCENTIVES
Austria: Klima:Aktiv

Social housing projects can earn additional funding by complying with Klima:Aktiv at high level.

The scheme promotes good planning, energy saving, renewable energy and favours use of sustainable materials using LCA methodology.

National level funds are managed by Klima+Energiefonds, while provinces manage their own subsidies. The total amount of subsidies have varied over time, but have been substantial.

France: Energie-Carbone

French government has allocated an initial 20 M€ to promote the social housing associations to develop 6000 apartments in new low carbon projects complying with the Energie-Carbone government label through an open tender.

The label will become part of regulation; it remains to be seen if a long term structural incentive will be available for social housing.

Sustainability incentives in Europe

STRUCTURAL SUSTAINABILITY INCENTIVE FOR SOCIAL HOUSING IS NOT THE NORM

FINLAND
Pilot projects subsidized only; no structural incentive

AUSTRIA
Bonus incentive for projects earning points in Klima:Aktiv

FRANCE
Call for funding for projects achieving Energie-Carbone label
1. **Explain optimisation**
   Constructor would need to explain their strategy of life-cycle optimisation of the project.
   
   Low effort; but also low on impact.

2. **Show LCC and LCA results**
   Constructor would have to show the targeted life-cycle cost and carbon performance; and demonstrate both when project is commissioned.
   
   Effort is moderate, but has no hard targets.

3. **Require achieving target**
   Constructor would need to demonstrate their performance for LCC & LCA so that it meets threshold values. This can have exception when it can be shown to not be cost-optimal in a case.
   
   This requires more effort; brings best results.
1. Setting project targets
Constructor would need to set and deliver a performance target that’s better than minimum.
Low effort; but also limited impact.

2. Achieving threshold target
Constructor would have to show the targeted life-cycle cost and carbon performance and meet prescribed level of performance.
Moderate effort and outcome.

3. Variable bonus on results
Constructor would need to demonstrate with calculations their target performance for LCC & LCA and this would unlock financial gains.
This requires more effort; brings best results.

Possible voluntary incentives for projects

REQUIREMENTS IN ORDER OF EFFORT AND IMPACT

1. Incentive based on achieving better than regulatory requirements
2. Incentives based on achieving bonus threshold performance
3. Incentives based on achieved life-cycle performance
5. COST IMPLICATIONS OF REQUIREMENTS
Investment costs are limited to design costs

Example of cost implications

Professional life-cycle design, including sustainable materials design in a typical Finnish residential housing project of 3000 m² could represent approximately 30 hours of work – variations being significant based on actual requirements.

For a total of 1500 hours of architectural planning this would be an 2% increase. Considering this would have some implications for other design fields too, a project level cost increase could be in the range of 0.1 – 0.2 % increase in capital cost.

If started in the early phase, significant additional capital outlay can often be avoided by seeking most effective means to achieve the targeted values.

To ensure the costs remain manageable and controlled, the requirements need to be specific, focus on the early phase, and most importantly, help improve the actual resulting projects.

LIFE-CYCLE PERFORMANCE DESIGN AND DOCUMENTATION EFFORT COULD INCREASE ARCHITECTURAL DESIGN WORKLOAD BY APPROXIMATELY 2 %
**Targets unlock opportunities**

Optimizing life cycle cost and carbon is easiest if it is taken into account in each of the design steps as part of the natural design process. This is because each of the design process stages has different kind of decisions that impact the final result. Setting the target early enables doing this through the process.

This also ensures the carbon or life-cycle cost optimisation opportunities are leveraged in the order of the highest impact and lowest cost.

Enclosed visualisation shows an approximation of the order in which such optimisation take place.

**“Add-ons” are more costly**

If project is essentially designed and will need a change to improve life-cycle performance, such changes will typically incur much higher change costs and adaptation to fit the overall project than solutions which are designed in.

This reinforces the need of early phase focus.
Initial gains are substantial

If done early enough, the project targets can be achieved in design at moderate cost impact.

In present day (2017) context typical ARA-funded project will go for performance meeting C-class energy performance levels, unless municipal requirements impose better performance. See illustration; most of the projects are in the C class.

At this stage, there are very cost effective incremental improvement opportunities. As shown in illustration, in the C class projects the additional investments required for improvement are very moderate; which also means they have very positive impact on the life-cycle cost and payback.

The cost curve only steepens substantially when getting close to, or into the B energy class.

Source: Tiekartta rakennuksen elinkaaren hiilijalanjäljen huomioimiseksi rakentamisen ohjauksessa, 2017
6. SUMMARY AND RECOMMENDATIONS
Summary of the study findings

Sustainability incentives today

France and Austria presently apply incentive program for social housing projects that achieve sustainability targets. In Austria, such programs have been in place for a longer period of time.

In France, the main programmes have started in the year 2017 and there’s no established experience from these outcomes. Nevertheless, these are becoming regulations in 2019-2020.

BIM requirements today

The only country where a BIM requirement was identified is the UK. The requirement there is applying to central government funded projects in general, and is not specific to social housing.

It’s possible local requirements are in place but were not identified e.g. due to language barriers.

LIFE-CYCLE DESIGN CAN SAVE COSTS AND CARBON. THIS NEEDS FOCUS IN THE EARLY STAGE DESIGN. THIS NEEDS INCENTIVES OR REQUIREMENTS FOR PROJECTS.

Climate change affects most the less well-off, and life-cycle costs are a tool to ensure their housing remains affordable.

Influencing the life-cycle cost requires consideration very early on in the process. This is best done via targets or requirements.

BIM is adopted by some projects, but not on whole-sale basis. This limits the potential efficiency gains from BIM at this stage.

Sustainability incentives for projects are in place in France and Austria. Other types of incentives and requirements are possible.

Sustainability could increase architectural design workload by ca. 2 %. Targets can drive forward very cost-efficient improvements.
**Start with reporting figures**

As the Finnish government prepares for national carbon regulations for construction, it’s natural to start requiring carbon targets and reporting. This can apply initially for projects seeking grants. This also prepares market for future regulations.

**Move to target performance**

In a second step, this can be complemented with life-cycle cost optimisation targets. This will require education activities before being applied.

Target performance level can be set for building types, but can be capped at cost optimal level. This ensures no unreasonable investments are made.

**Support with cash incentives**

Once the market has developed the necessary skills, incentives can be rolled out. This will require reliable verification methodology to ensure results are fairly earned by all applicants.

---

**Recommendation: setting performance targets**

1. **REQUIRE REPORTING**
   - Develops the skill base

2. **SET TARGETS**
   - Drives performance

3. **SUPPORT WITH INCENTIVES**
   - Supports launch and projects