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BIM GATHERING

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coffey

Building Capabilities in Complex Environments

@BIMPossibleAndy

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Introduction and Abstract

- Recent growth in the use of BIM principles and Passive House design.
- *No method to transfer pertinant data from a BIM to the Passive House verification software, PHPP.*
- *This paper outlines a methodology to holistically merge the Passive House verification process with BIM processes and workflows during the design phase through the use of custom scripts created through graphical programming.*
- *This workflow results in time savings of **99.993%*** in the documented case study.

Previous Research

The Author has previously written on similar topics achieving time savings of **99.98%**. This process differed to those outlined in this paper for a number of reasons:

- Rather than utilising graphical programming, the author wrote add-ons in C# and VBA.
- Did not establish a “live-link” as outlined in this paper.
- Used a .txt file as an intermediary file to facilitate the data transfer.
- Process was cumbersome.

Passive House

"a building, for which thermal comfort can be achieved solely by post-heating or post-cooling of the fresh air mass which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air" (Feist, 2013).

PassivHaus Performance Requirements	
Annual Heating	*≤ 15 kWh/m²*
Annual Primary Energy	*≤ 120 kWh/m²*
Airtightness	*≤ 0.6 ACH @ 50 Pa*

Verification

A Passive House should remain at a constant 20°C. This constant temperature is usually achieved by virtue of highly efficient heating, ventilation, air conditioning (HVAC) Systems and heat exchangers paired with an "air tight" and "super insulated" envelope.

Verification and PHPP

- Passive House Planning Package
- Independent verification process carried out by accredited Passive House Certifiers
- Microsoft Excel based
- Comprises of 36 linked worksheets
- Dynamic energy simulation program
- Required to verify all Passive House buildings

"The PHPP takes guesswork out of the design process by accurately predicting a proposed design's energy performance", (Cotterell and Dadeby, 2013)

Climate: Washington DC*

Window Area Orientation	Global Radiation (Cardinal Points)	Shading	Dirt	Non-Perpendicular Incident Radiation	Glazing Fraction	SHGC	Reduction Factor for Solar Radiation	Window Area	Window U-Value	Window R-Value
maximum:	kBTU/ft²yr	0.75	0.95	0.85				ft²	BTU/hr.ft².F	hr.ft².F/BTU
North	44	0.70	0.95	0.85	0.493	0.53	0.28	28.19	0.18	5.68
East	121	0.20	0.95	0.85	0.599	0.53	0.10	69.23	0.17	5.79
South	231	0.43	0.95	0.85	0.636	0.62	0.22	183.00	0.18	5.70
West	123	0.19	0.95	0.85	0.611	0.53	0.09	70.65	0.16	6.20
Horizontal	193	0.69	0.95	0.85	0.659	0.44	0.37	5.96	0.31	3.23
Total or Average Value for All Windows.						0.58	0.18	357.04	0.17	5.73

					Window Rough Openings		Installed		Glazing		Frame		SHGC	U-Value	
Description	Nr	Deviation from North	Angle of Inclination from the Horizontal	Orientation	Width	Height	in Area in the Areas worksheet	Nr.	Select glazing from the WinType worksheet	Nr.	Select window from the WinType worksheet	Nr.	Perpendicular Radiation	Glazing	Frames
		Degrees	Degrees		in	in	Select:		Select:		Select:		-	BTU/hr.ft².F	BTU/hr.ft².F
N LIB E	1	0	90	North	53.00	29.00	N WALL 2	5	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
N KIT B LEFT	2	0	90	North	29.00	29.00	N WALL 2	5	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
N KIT B CENTER	3	0	90	North	29.00	29.00	N WALL 2	5	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
N KIT B RIGHT	4	0	90	North	29.00	29.00	N WALL 2	5	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
E BED A	5	90	90	East	37.00	65.00	E WALL GABLE &	16	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
E BAT C	6	90	90	East	29.00	51.00	E WALL GABLE &	16	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
E LIB DR2	7	90	90	East	43.75	84.13	E WALL LIBRARY	18	INTUS SHGC 0.5:	2	INTUS DOOR FR.	2	0.53	0.09	0.26
E GAB A	8	90	90	East	37.00	65.00	E WALL GABLE &	16	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
S BAY D LEFT	9	180	90	South	41.00	65.00	S WALL BAY	12	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S BAY D RIGHT	10	180	90	South	41.00	65.00	S WALL BAY	12	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S BED D LEFT	11	180	90	South	41.00	65.00	S WALL M BED	13	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S BED D RIGHT	12	180	90	South	41.00	65.00	S WALL M BED	13	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S DOR D RIGHT	13	180	90	South	41.00	65.00	S WALL DORMER	14	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S DOR D CENTER	14	180	90	South	41.00	65.00	S WALL DORMER	14	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
S DOR D RIGHT	15	180	90	South	41.00	65.00	S WALL DORMER	14	INTUS SHGC 0.6:	1	INTUS WINDOW	1	0.62	0.11	0.17
W PAN C	16	270	90	West	29.00	51.00	W WALL ENTRY	6	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
W FOY C	17	270	90	West	29.00	51.00	W WALL ENTRY	6	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
W DIN A	18	270	90	West	37.00	65.00	W WALL GABLE	7	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
W LIV A	19	270	90	West	37.00	65.00	W WALL GABLE	7	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
W GAB A	20	270	90	West	37.00	65.00	W WALL GABLE	7	INTUS SHGC 0.5:	2	INTUS WINDOW	1	0.53	0.09	0.17
SKYLIGHT FAKRO	21	180	18	Horizontal	22.00	39.00	SOUTH MAIN RO	2	FAKRO SKYLIGHT	4	Clad Wood Caser	17	0.44	0.09	0.45
S FOY DR1	22	180	90	South	47.75	84.13	S WALL LIV RM	11	INTUS SHGC 0.6:	1	INTUS DOOR FR.	2	0.62	0.11	0.26
S LIV DR2	23	180	90	South	43.75	84.13	S WALL ENTRY	10	INTUS SHGC 0.6:	1	INTUS DOOR FR.	2	0.62	0.11	0.26

A portion of the PHPP "Windows" worksheet

A "Certified Passive House" plaque

Diagram outlining the information flow throughout the PHPP 6

Research

"Research is lacking regarding the use of BIM to support accreditation/certification to schemes such as Passive House" (Cemesova, 2012)

"in order for BIM to support Passive House certification, data transfer would have to be more direct between BIM tools and the PHPP analysis tool." (Cemesova, 2012)

The methodology outlined in this paper and presentation aim to create a direct link between the BIM and the PHPP.

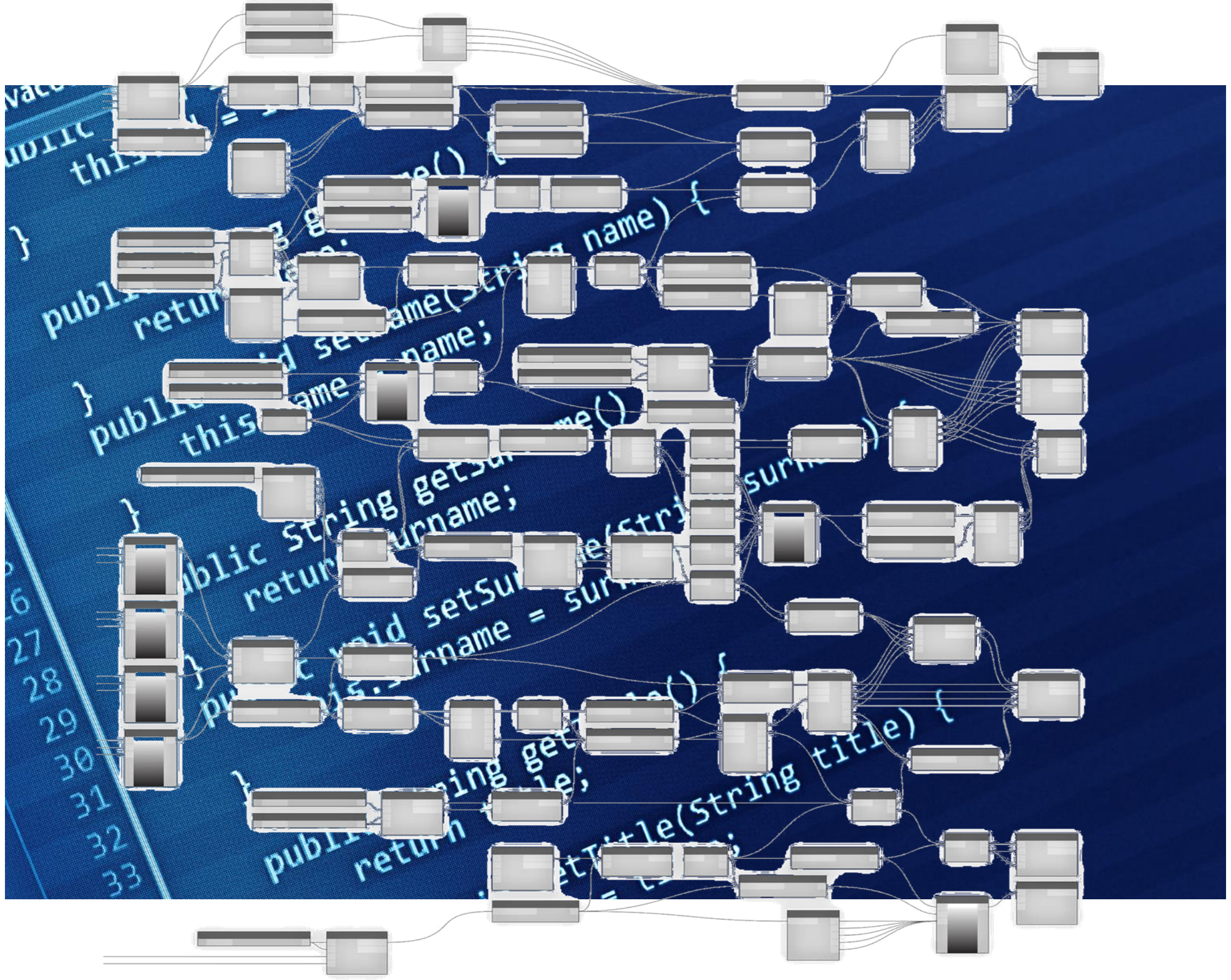
Research Findings

Several parallels can be drawn between BIM and the Passive House Design process:

1. *Design and process are central; neither are a box-ticking compliance exercise.*
2. *Information matters most. Colourful, graphical images alone are of no benefit to the process.*
3. *Rigorous model analysis and testing are crucial; the design is built virtually to get it right, then built only once on site.*

Graphical Programming

- Replaces textual coding with graphical components such as input fields, buttons, sliders, etc.
- The user can miniplate program elements graphically, rather than textually.
- Allows users with limited programming capability to create complex scripts.
- Notable examples include Scratch, Grasshopper for Rhino and Bubble.



Dynamo

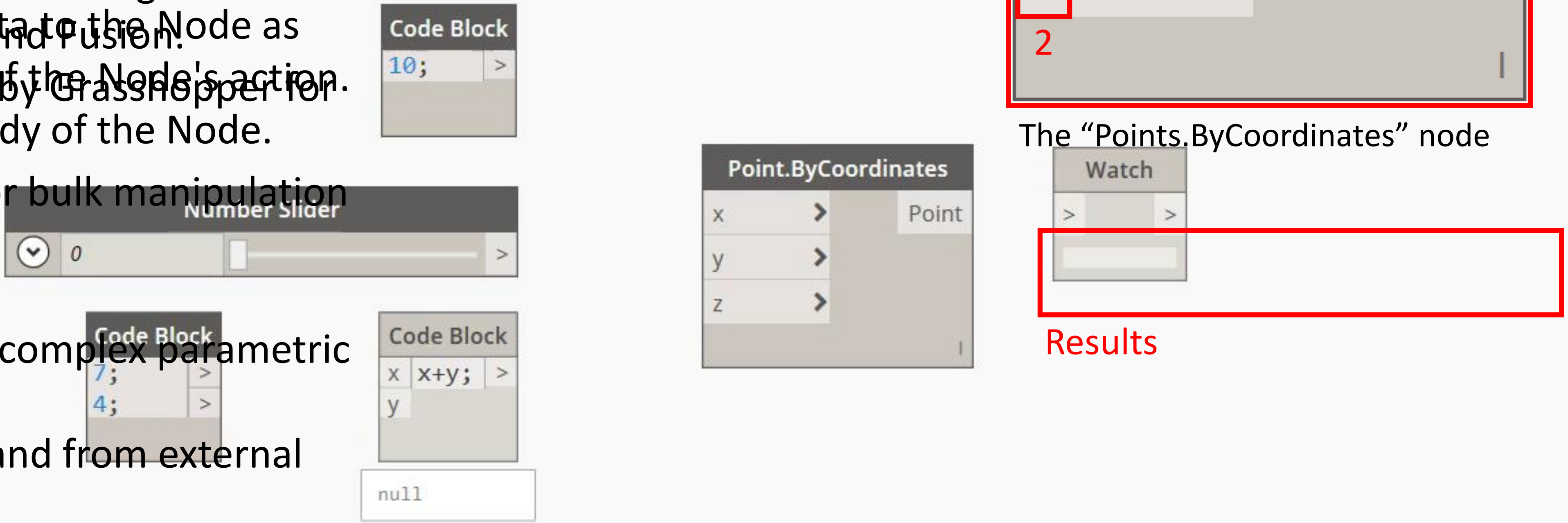
There are three parts to a Dynamo node:

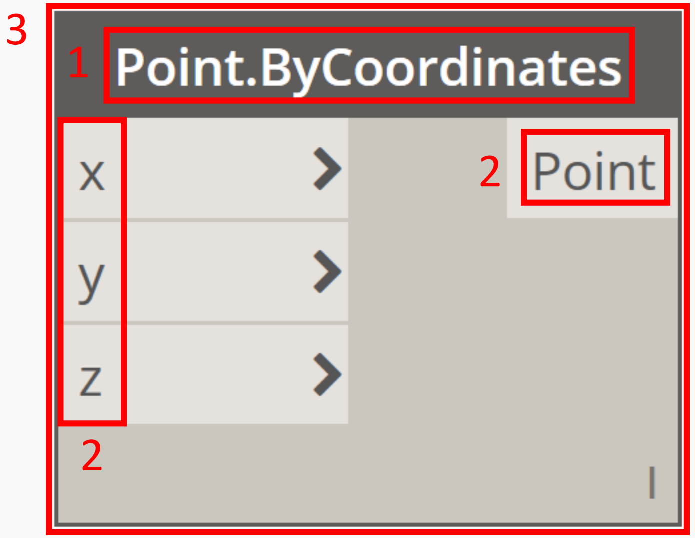
1. Name – The Name of the Node with a Category.Name naming convention.
2. Ports – The receptors for Wires that supply the input data to the Node as well as the results of the Node's action.
3. Main – The main body of the Node.

- A free, open-source graphical programming tool.
- Allows access to the API of several pieces of software including Autodesk Revit, Navisworks and Fusion.
- Heavily influenced by Grasshopper for Rhino.
- Extremely useful for bulk manipulation

Dynamo can:

- Create and modify complex parametric geometry.
- Read and write to and from external databases.





The "Points.ByCoordinates" node

Methodology

A certified Passive House was identified and chosen as a case study.

- The dwelling:
  - Was designed in 2011.
  - Is a 178m^2 three-bed, traditional style Irish home.
  - Cost €190,393.00 to build.
  - Estimated heating costs of €190 per annum.
  - Designed by Passive House Plans.

Methodology

The building was modelled in the BIM authoring software, Autodesk Revit with the intention of analysing

> *"the combination of Passive House verification paired with BIM and graphical programming while exploring new areas and issues where little guidance is available",* McNamara (2017).

Research Aims

This study aims to meet a number of practical, research based objectives:

1. Create a standard Revit to PHPP template file for further research and development.
2. Develop a "Live-link" between the BIM and the PHPP with minimal interaction or manual input.
3. Reduce the amount of time required to populate the relevant data in the PHPP. The original designer spent **21 hours** measuring elements in AutoCAD and inputting the information into the PHPP.

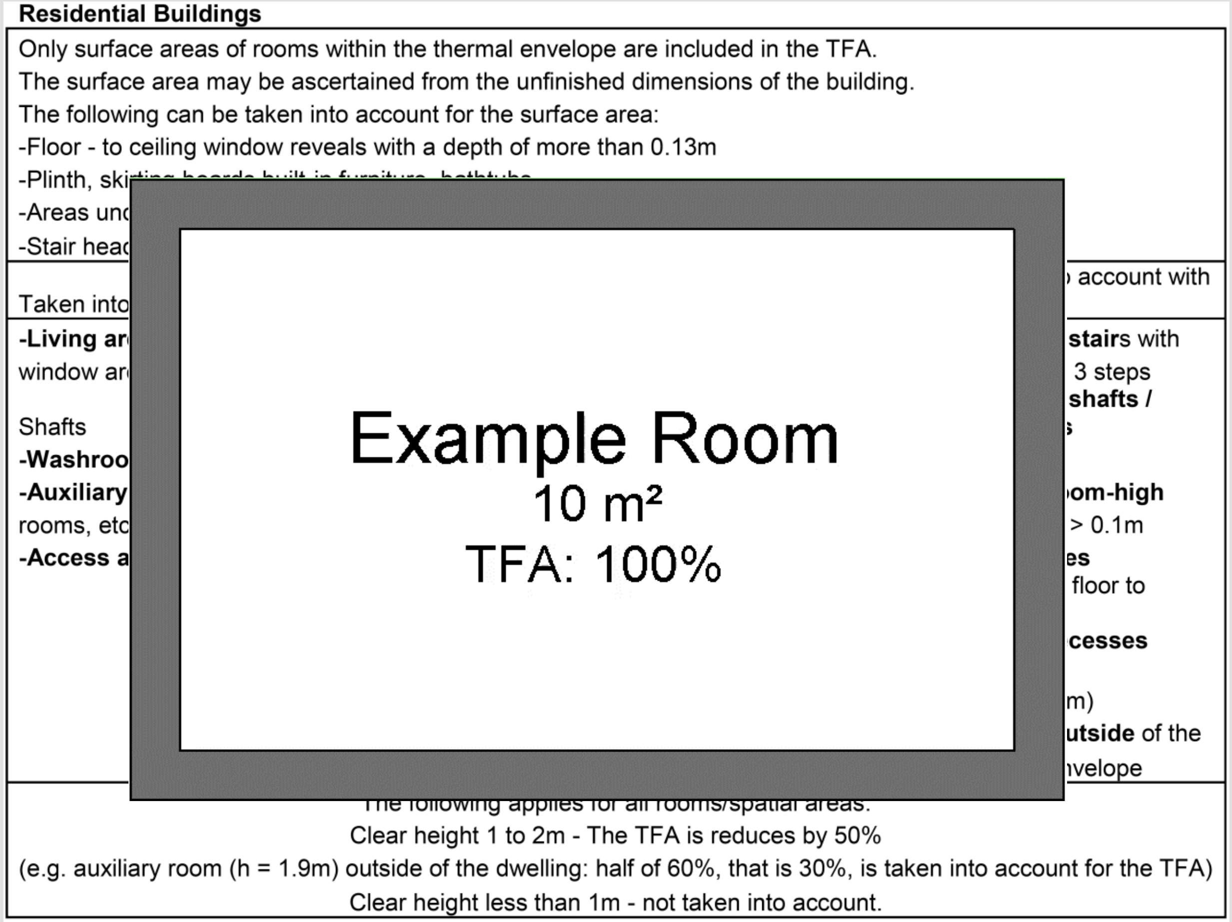
Methodology Stages

Stage 1:
Develop a number of Revit parameters to facilitate the information requirements of the PHPP.

Stage 2:
Transfer pertinent information from Revit to the appropriate places in the PHPP using the graphical programming tool, Dynamo.

Case Study – Treated Floor Area

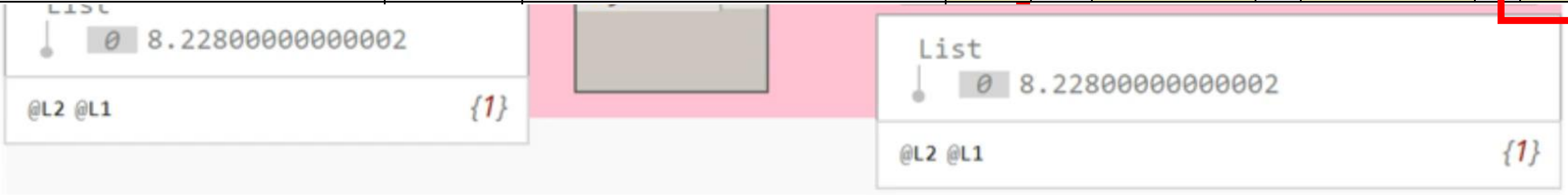
- PHPP uses treated floor area (TFA), rather than the standard room area.
- TFA is a measurement of utilisation of a room’s area.
- Each room area is weighted as a percentage (0%, 60% or 100%) depending on the use of the room.
- The TFA of each room can be modified from the room tag.



Case Study – Treated Floor Area – Data Flow

Multiply the room area by the TFA percentage and remove any null values

Area input											
Area Nr.	Building element description	Group Nr.	Assigned to group	Quan-tity	x (	a [m]	x	b [m]	+	User-Deter-mined [m²]
	Treated Floor Area	1	Treated Floor Area	1	x (		x		+	8.22



This process is repeated numerous times for various parameter values including:

Windows

- Quantity
- Description
- Deviation from north
- Angle of inclination from the horizontal
- Orientation
- Width
- Installed Surface Number
- Installed Glazing Number
- Installed Frame Number

- Installation Details
  - 1/0 Right
  - 1/0 Bottom
  - 1/0 Top
  - 1/0 Left
  - Ψ installation left
  - Ψ installation right
  - Ψ installation bottom
  - Ψ installation top
- hHori
- dHori
- oReveal
- dReveal
- oOver
- dOver
- rOther

- **Volumes**
- **Wall Areas**
- **Wall U-Values**
- **Door Sizes**
- **Frame U-Values**
- **Glazing G-Values**
- **Glazing U_g-Values**
- **Summer shading reduction factors**
- **Temporary sun protection reduction factor**

Results

- All scripts were run simultaneously and the overall time taken was recorded.
- This was repeated three times on a high-end workstation.

Time taken to transfer data from the BIM to the PHPP	
Experiment 1	*9 seconds*
Experiment 2	*9 seconds*
Experiment 3	*10 seconds*

Results	
Average time taken	***9 seconds***
Time taken using traditional methods	***21 hours***
Time saving	***99.993%***

Conclusion

- Alleviates the manual input of the majority of building data.
- Each of the research objectives have been achieved.
  1. Create a standard Revit to PHPP template.
  2. Develop a "Live-link" between the BIM and the PHPP with minimal interaction or manual input.
  3. Reduce the amount of time required to populate the relevant data in the PHPP.

Limitations

- The paper does not investigate the need for additional training / hardware.
- Building scope
- Requires a "culture change".

Future Research

- This paper has produced promising results that, with future research could become an integral part of the Passive House design process.

Thank You

Coffey Group

Galway-Mayo Institute of Technology

Cathal Spellman – Passive House Plans

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Thank you

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