THE UNIVERSITY OF MELBOURNE

University of HUDDERSFIELD

ZEMCH

Dr Masa Noguchi

Associate Professor in Environmental Design
Faculty of Architecture, Building and Planning
Melbourne School of Design

Adjunct Professor
School of Architecture (V-SPARC)
Vellore Institute of Technology

Presentation Contents

ZEMCH

Mass Customisation

Environmental Experience Design (EXD)

Discussion for ZEMCH EXD R&D Opportunities


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

LinkedIn

ZEMCH NETWORK

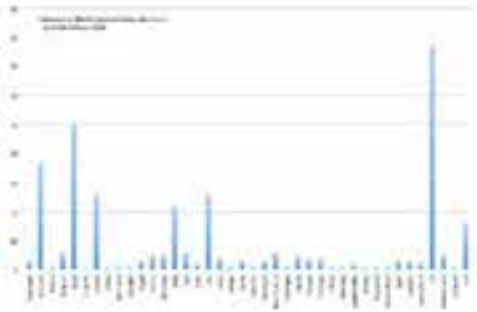
ZEMCH Network: Zero Energy Mass Custom Home R&D

927 members

Including Astrid Heimann MRICS and 865 other connections

866

Invite connections




EMCH 2013
RNATIONAL CONFERENCE
R 30TH - NOVEMBER 1ST, 2013, MIAMI, FL, USA
and
Technical
Seminars
2015 September
21-22-23-24-25
Bari - Lecce, Italy
ZEMCH 2016
INTERNATIONAL CONFERENCE
ZEMCH2014
ZEMCH 2018
International Conference
msd
ZEMCH NETWORK
ZEMCH LAB

Source details

Feedback > Compare sources >

ZEMCH International Conference

Scopus coverage years: 2019, 2021

Publisher: ZEMCH Network

E-ISSN: 2652-2926

Subject area: Engineering: Architecture | Engineering: Building and Construction | Engineering: Civil and Structural Engineering | Engineering: Safety, Risk, Reliability and Quality | Computer Science: Computer Science Applications | View all

Source type: Conference Proceeding

View all documents > | Set document alert | Save to source list | Source Homepage

CiteScore 2022
0.2

SNIP 2022
0.095

CiteScore | CiteScore rank & trend | Scopus content coverage

Export content for category

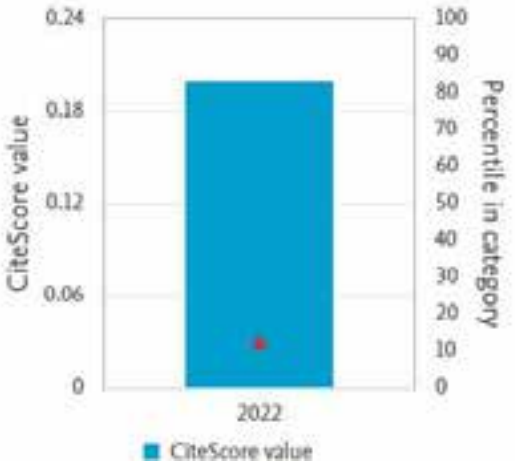
CiteScore rank 2022

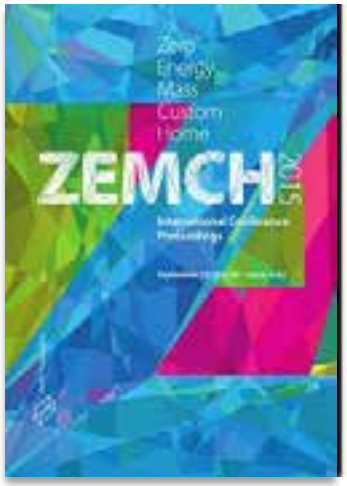
In category: Architecture

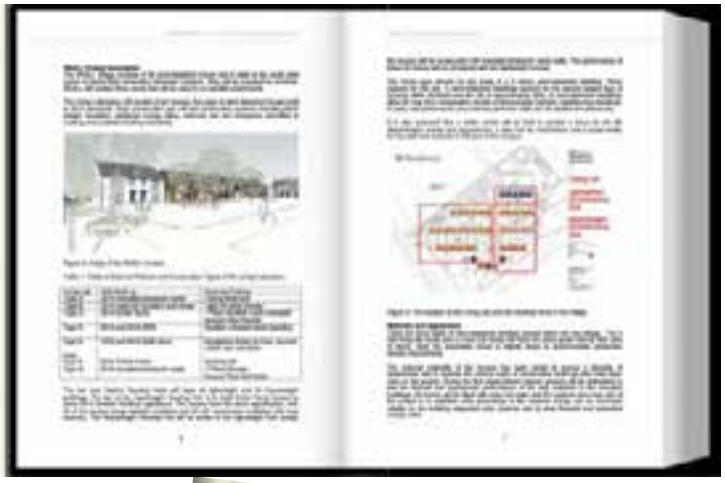
☆	#149 / 170	ZEMCH International Conference	0.2	12th percentile

Rank	Source title	CiteScore 2022	Percentile
#1	Design Studies	8.8	99th percentile
#2	Developments in the Built Environment	8.7	99th percentile
#3	Journal of Building Engineering	8.3	98th percentile
#4	International Journal of Construction Management	7.1	97th percentile

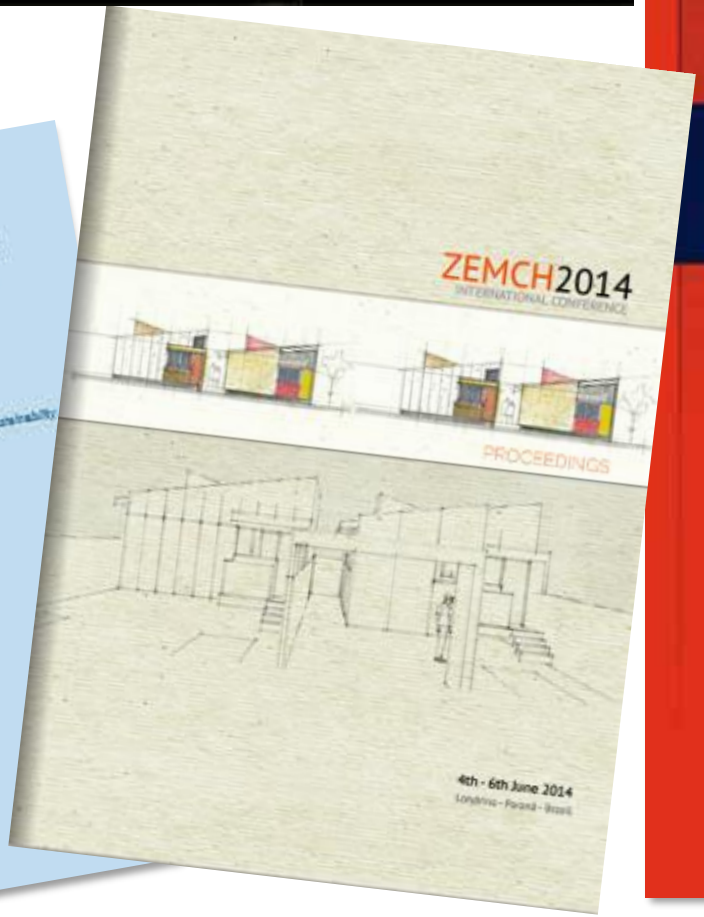
CiteScore trend

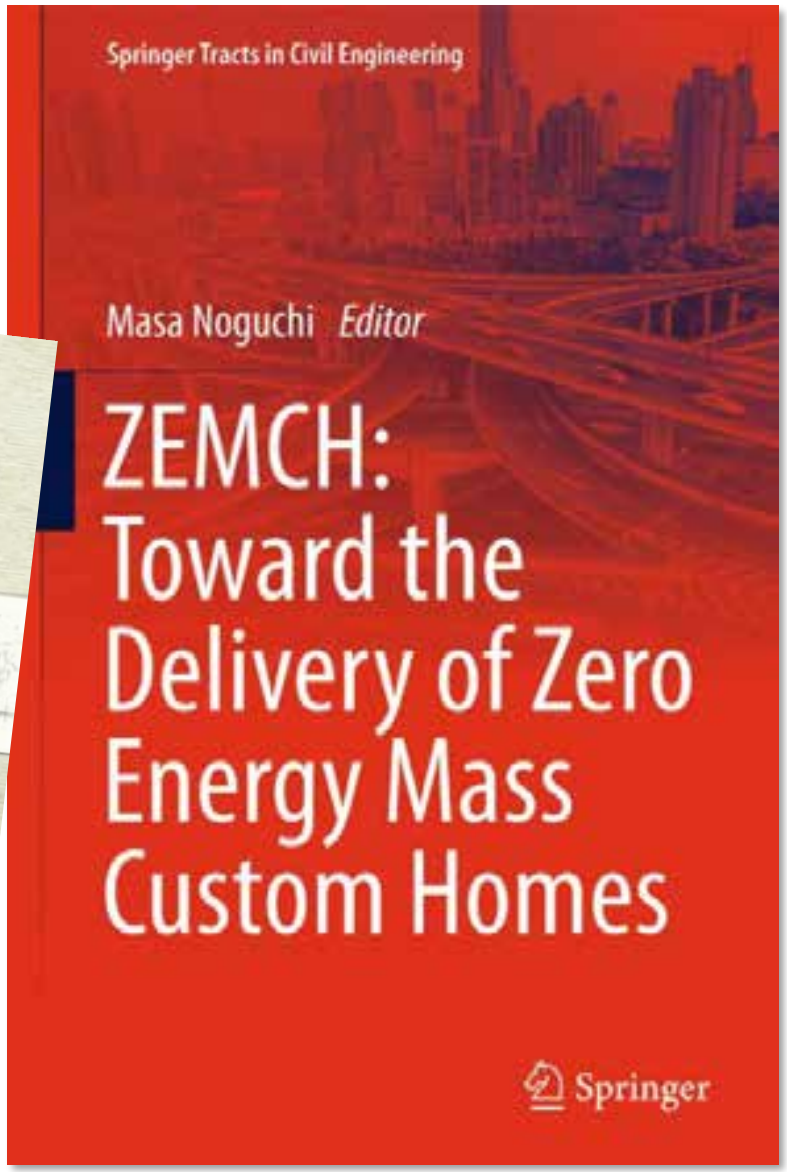



Zero
Energy
Mass
Custom
Home
ZEMCH
2015




ZEMCH Research Initiatives:
Mass Customisation and
Sustainability
Masa Noguchi
MDPI


ZEMCH2014
INTERNATIONAL CONFERENCE
PROCEEDINGS
4th - 6th June 2014


Springer Tracts in Civil Engineering
Masa Noguchi Editor
ZEMCH:
Toward the
Delivery of Zero
Energy Mass
Custom Homes
Springer


sustainability
an Open Access Journal by MDPI
IMPACT FACTOR 3.251
CITESCORE 3.9 SCOPUS
ZEMCH International Research Series
Guest Editors
Prof. Dr. Haşim Altan, Prof. Dr. Shaila Bantanur, Prof. Dr. Carlos Torres Formoso, Prof. Dr. Antonio Frattari, Dr. Arman Hashemi, Prof. Dr. Jun-Tae Kim, Dr. Masa Noguchi, Dr. John Odhiambo Onyango, Prof. Dr. [illegible] Prof. Dr. Sara Jane Wilkinson
Topical
Collection
Welcome to read


encyclopedia
Encyclopedia of ZEMCH Research and Development
Masa Noguchi, Antonio Frattari, Carlos Torres Formoso, Haşim Altan, John Odhiambo Onyango, Jun-Tae Kim, Rheira Anissa Tabet Aoul, Mehdi Amirkhani, Sara Jane Wilkinson, Shaila Bantanur (Eds.)
ZEMCH NETWORK
MDPI


ZEMCH WORKSHOP
Melbourne, 2018

ZEMCH 2019

International Design Workshop

November 19 (Tue) ~ 25 (Mon), 2019

Y-Valley(Yong-san), Seoul, South Korea
(http://y-valley.org/)

November 26 (Tue), 2019

The Korea Science and Technology Center, Seoul, South Korea
- International Convention Center
(http://icc.kofst.or.kr/)

Registration

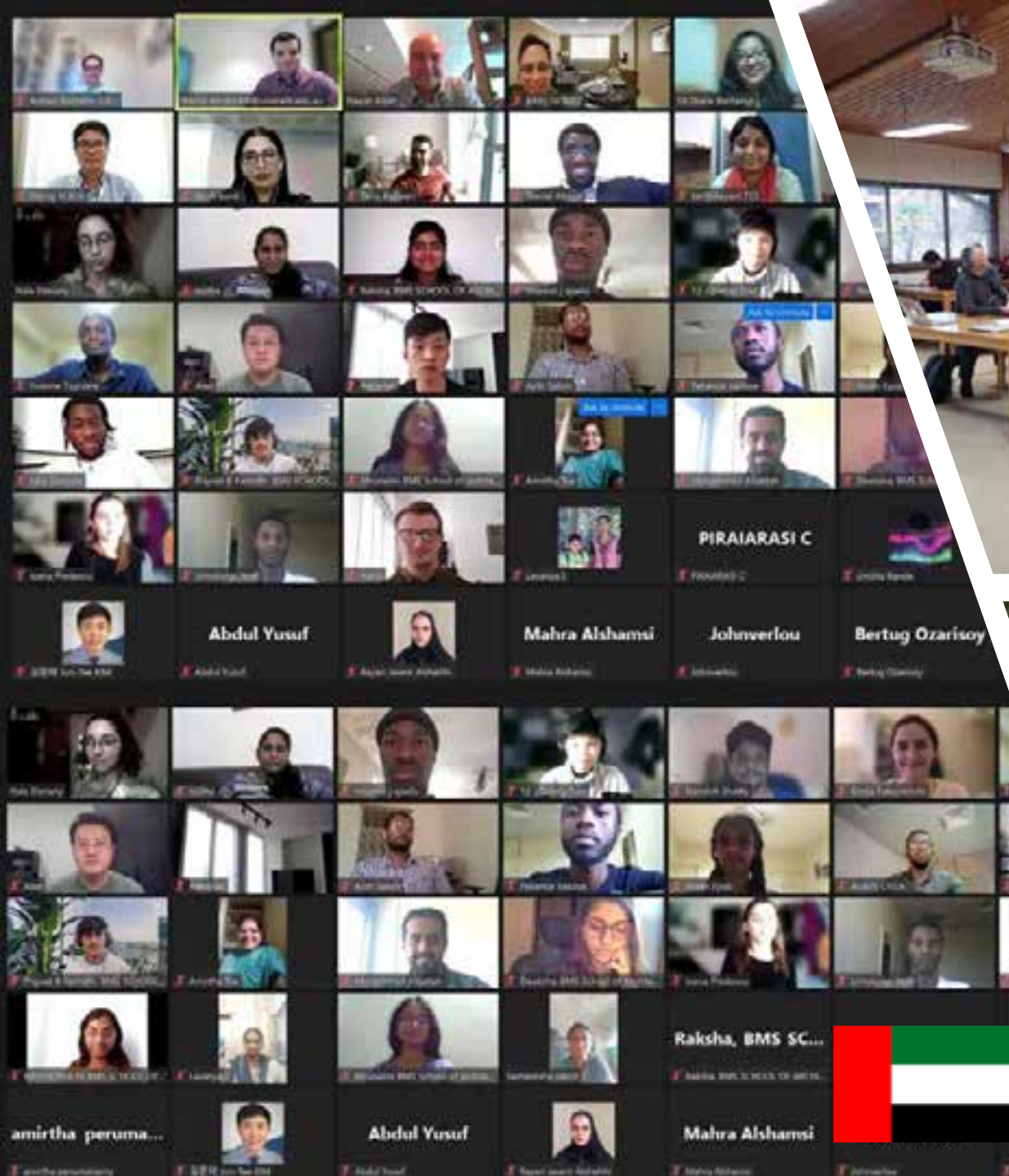
September 06, 2019: Last date of registration
September 13, 2019: Confirmation by email

http://www.zemch2019seoul.org
https://www.facebook.com/groups/640769903065926/
Contact: archiram04@gmail.com


ae Kim
ttee Chair


ZEMCH


ZEMCH
2019

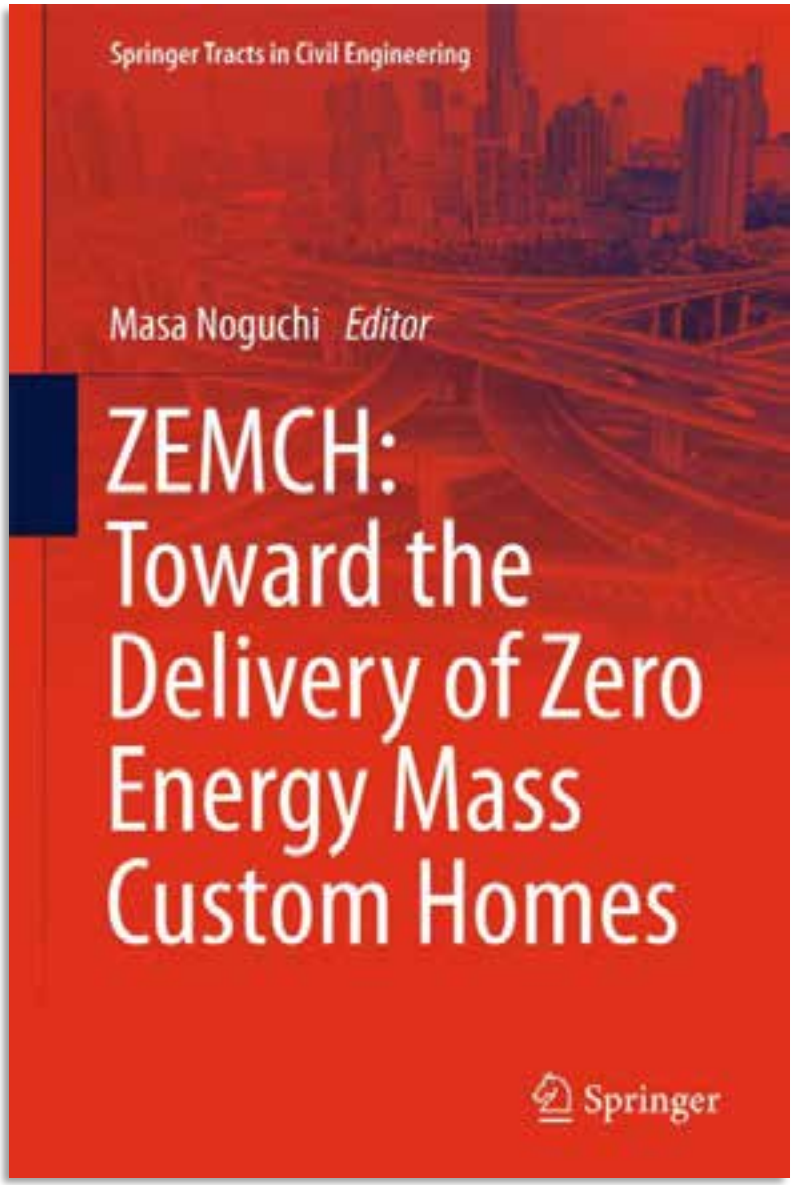

PIRAIARASI C
Abdul Yusuf
Mahra Alshamsi
Johnverlou
Bertug Ozarisoy
Raksha, BMS SC...
amirtha peruma...
Abdul Yusuf
Mahra Alshamsi


ZEMCH
2022
ZEMCH22
RMSSA

Thiagarajar College of Engineering

65 YEARS 1957-2022

where quality and ethics matter




GROUP-1

M.Arch in Digital Technology in Buildings

ABOUT THE PROGRAM

Given the technological change in the realm of design, the moment has come to pursue evolutionary ideas, creative design approaches and improved co-ordination techniques.
To meet sustainable standards, this two year masters programme offers Industry collaborated exploratory and experimental avenues for architects into the perfect intersection of architecture, digital technologies and construction.

Eligibility

- No Entrance Exam
- Pass with 60% marks in Bachelor of Architecture from a CoA Recognised University/Institute

PROGRAM HIGHLIGHTS

- BIM integrated Curriculum
- Form finding techniques for sustainable geometries
- Informed decisions on energy usage in buildings
- Apt for Research oriented curricular opportunities
- ulti-Dimensional career scope in Construction, gn Research and Academics
- v - Institute partnership for joint sessions
- Collaboration with Reputed International

Stay Tuned for other Updates and Application Information

Contact

E-mail
vsparclife@gmail.com
Phone No.
+91 9443805240

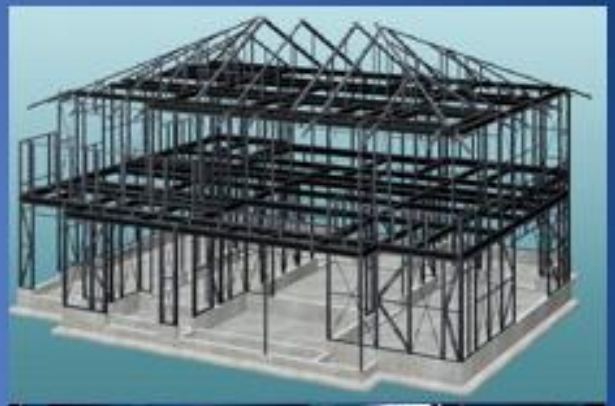
ZEMCH NETWORK

ZEMCH Mission to Japan
Technical Study Visits
2006 – 2023


FACTORY
PRIDE
H-1

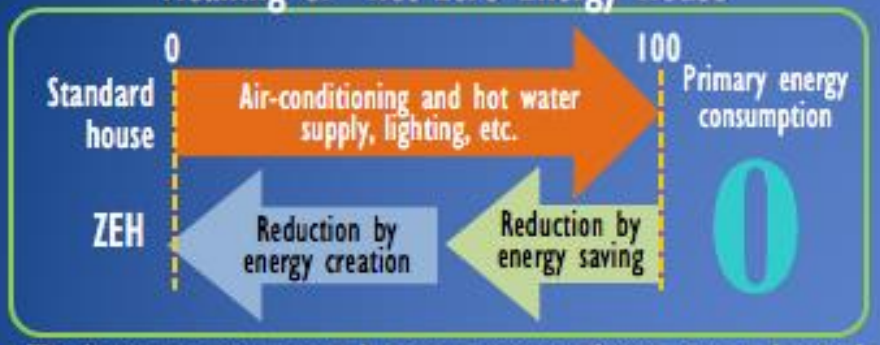
INDUSTRIALIZED
ZERO ENERGY MASS CUSTOM HOMES

- Sekisui House builds industrialized custom home.
- About 60,000 parts in a house.
- Provide a stable performance and quality in all of the houses.
- Producing a large number of parts in the factory.
- 95% automated production lines in some factories.
- 100% recycling of waste at all our factories.



NET ZERO ENERGY HOUSES

Meaning of Net Zero Energy House



The Japanese government has set a target of zero energy house in the half of the new house in 2020.

24,465 houses

Total number of ZEH constructed
(No.1 in the world)

71 %

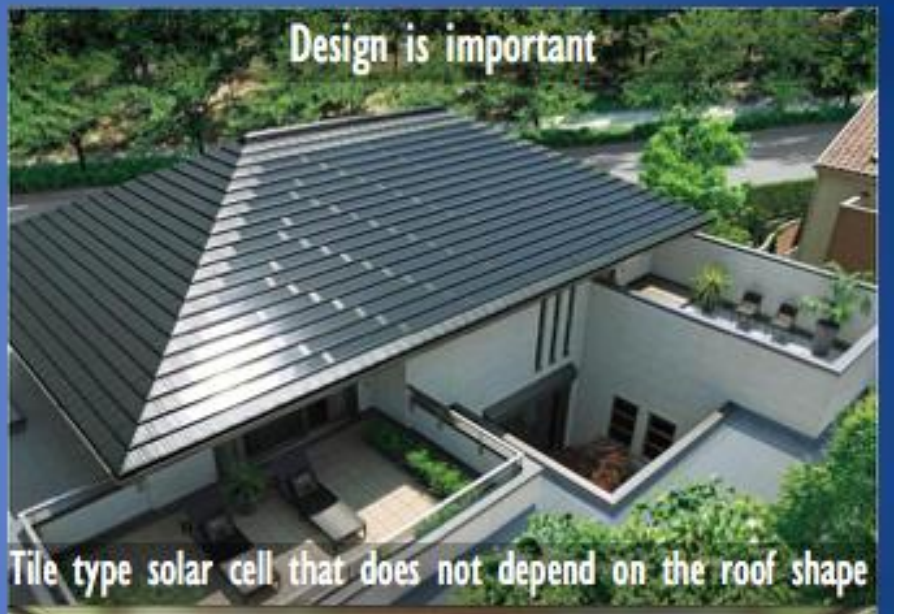
Rate of ZEH in newly built detached housing
(No.1 in Japan)

42,337 houses

Total number of houses equipped with fuel cells

Compared to houses built in 1990, our detached houses newly built in 2015 emitted

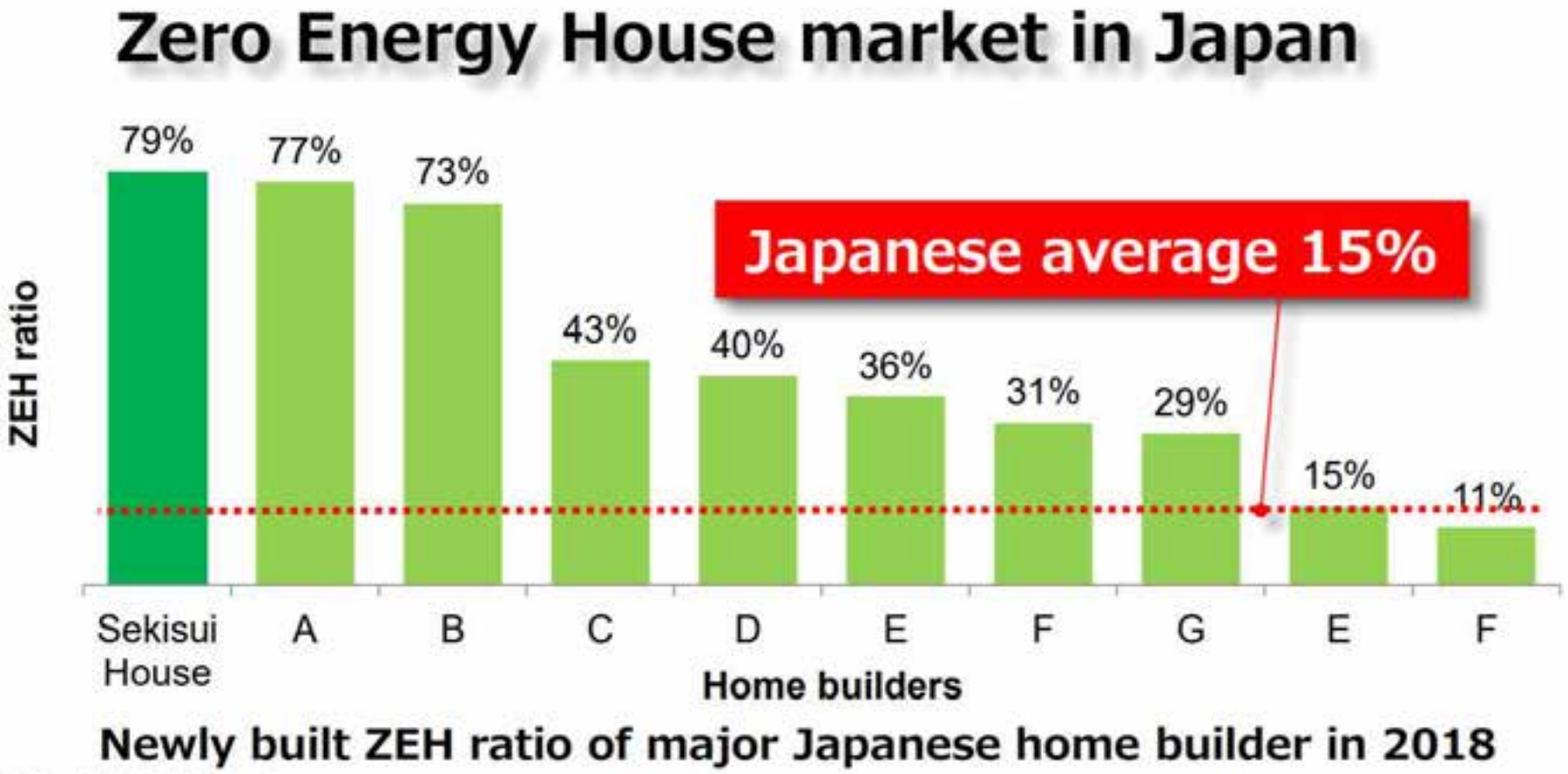
75.5 % less CO_2



Tile type solar cell that does not depend on the roof shape

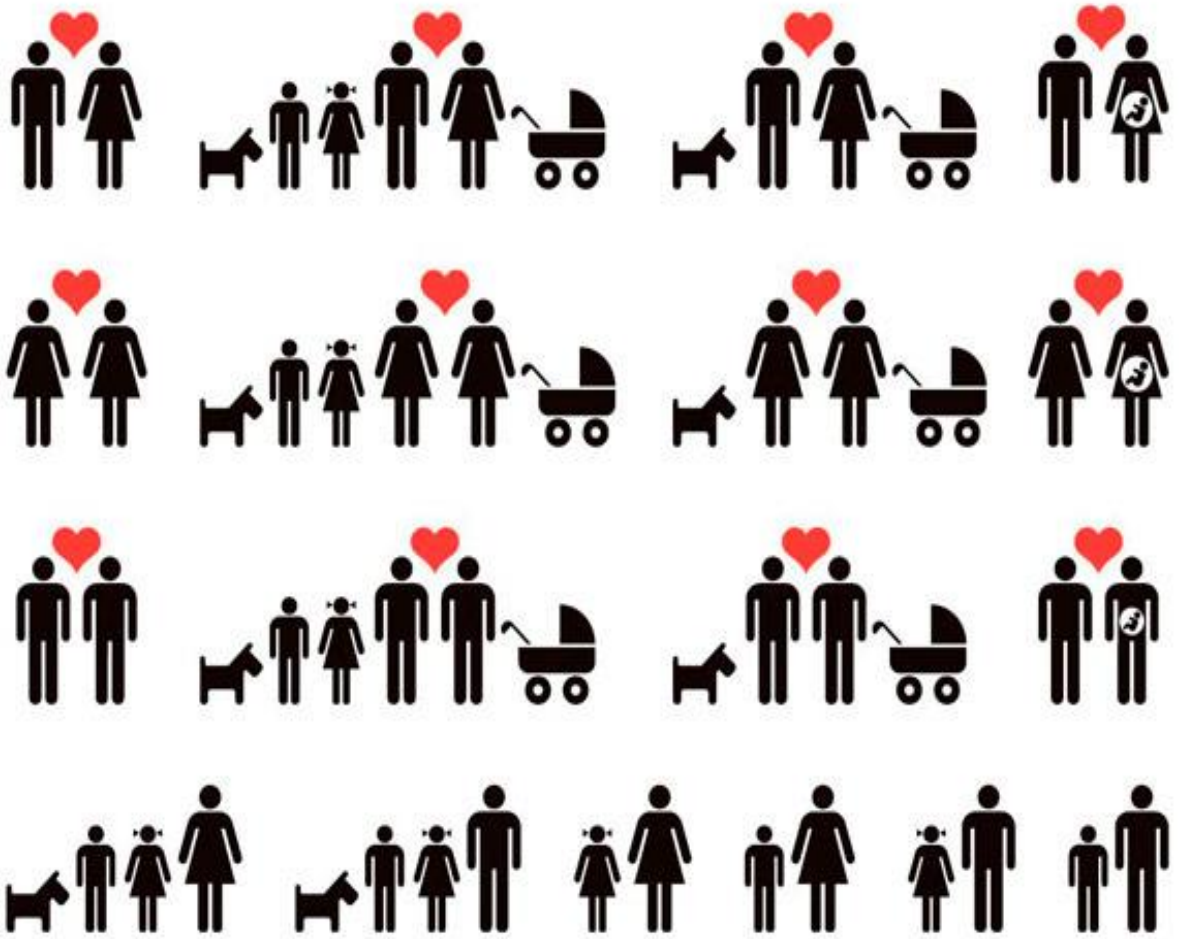
The window is also big, bright and comfortable house

SEKISUI HOUSE



Sustainable Open Innovation Initiative provides the ZEH delivery details

https://sii.or.jp/zeh/builder/search




housing
large
probably
paying
inclusionary
means
economic
just
end
think
now
addressing
low
demand
transit
seems
much
taxes
money
etc
current
someone
poverty
list
linkage
economy
lower
another
program
without
number
rate
land
assistance
people
use
way
workforce
may
building
like
increase
affordable
community
helping
benefit
waiting
start
political
eliminating
built
applications
lot
quality
fee
income
living
company
deduction
jobs
fees
go
ask
required
pay
prices
enough
years
public
needs
developers
live
family
mortgage
going
single
time
near
build
home
interest
cost
kids
used
government
really
policies
supply
et
full
subsidizing
need
make
offset
break
shortage
good
families
tax
address
business
also
meaning
get
year
instead
solve
wages
programs
savings
costs
better
units
poor
high
profit
example
provide
employers
buy
qualcomm
last
want
question
industry
affordability
amount
parking
little
keeping
creating
well
benefits
soitec
likely
development
funding
long
new
one
help
region
less
many
work
problem
something
rather
making
sdhc

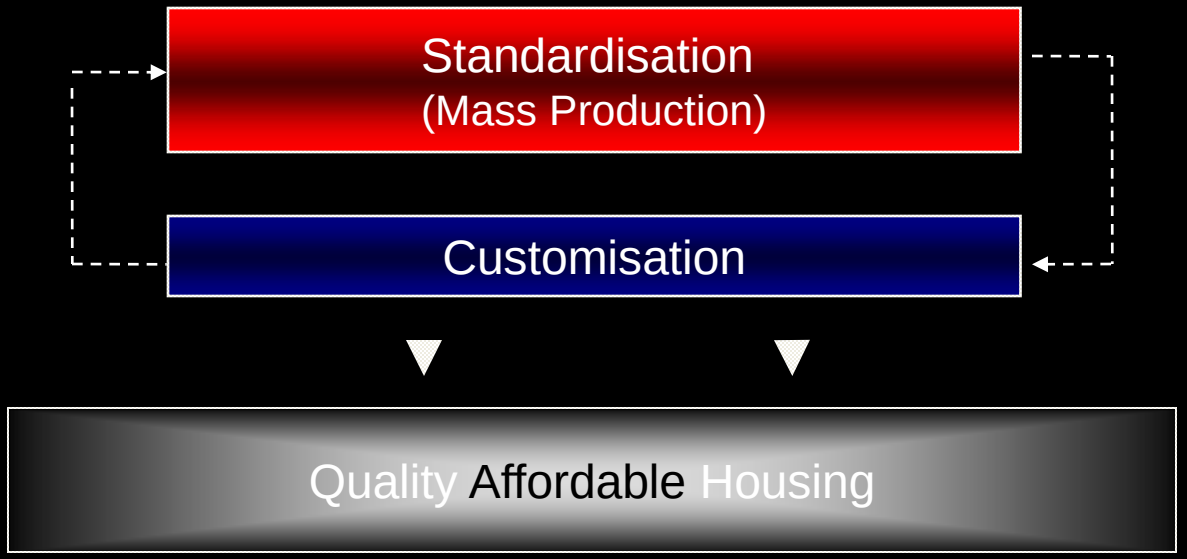
Homebuilder types & general design approaches

- Production Builder : Speculative (or production) design
- Semi-custom Builder : Semi-custom design
- Custom Builder : Custom design

	STANDARDISATION LEVEL	CUSTOMISATION LEVEL
Ready-built home	High	Low
Semi-custom home	Medium	Medium
Custom home	Low	High

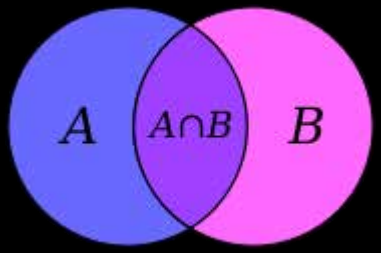
(Source: Smith 1998; Noguchi 2003)

Production GAP



Mass Customisation

In the broad sense:



Standardised Components

Customised Products

"Mass Production of Individually Customised Goods and Services"

(Source: Pine II 1993 & Georg Cantor)

ELSEVIER

Habitat International

Volume 29, Issue 2, June 2005, Pages 325-336

A 'mass custom design' approach to upgrading conventional housing development in Mexico

Masa Noguchi[a,*], Carlos R. Hernández-Velasco[b]

[a] *McGill University, 6890 rue Lacroix #3, Montreal, Quebec, Canada H4E 2V3*
[b] *University of Glasgow, UK*

Received 22 May 2003; received in revised form 16 June 2003; accepted 18 November 2003

Abstract

In order to maintain the *economies of large-volume work* that help reduce construction costs, homebuilders in Mexico tend to *mass produce* low-cost housing using conventional methods and targeting low- and middle-income earners before having buyers for the units. Even though these homes respect a *minimum* of housing quality as defined by *housing institutions* such as governmental bodies providing financial assistance via loans provision, homebuyers appear dissatisfied with these *ready-built shelters* that barely meet their housing requirements.

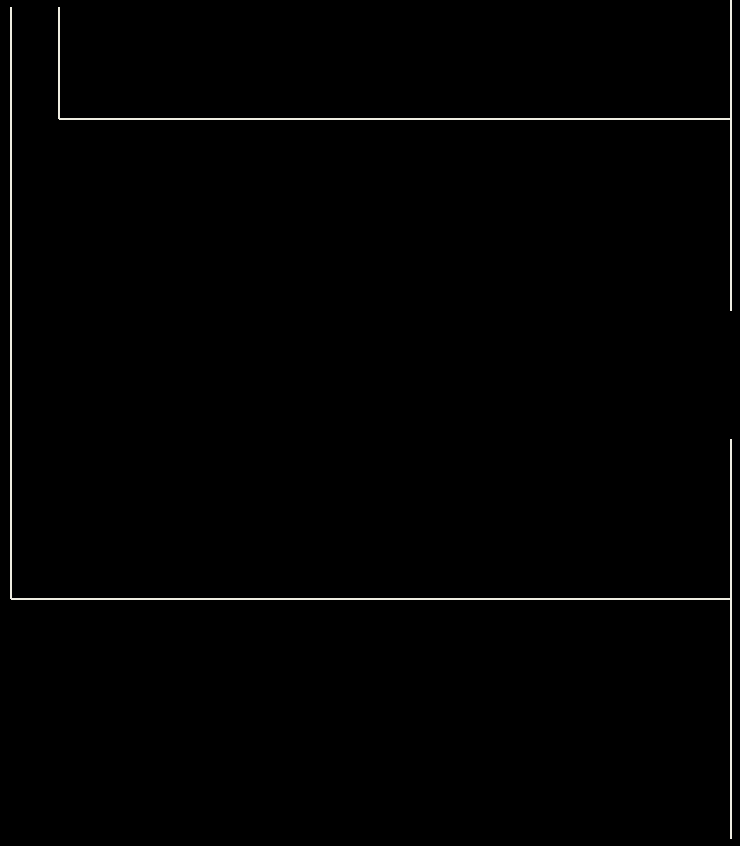
In order to identify today's market demand for new homes in Mexico, the authors surveyed some typical low-cost housing developments located in Aguascalientes—a middle-sized city located in the central part of the country. The authors visited construction sites and conducted personal interviews with selected homeowners. Based on their observation of such housing developments, the authors found that many homebuyers 'extensively' modify their new home immediately after occupancy. This need to personalise their new house may be explained in part by the lack of *customisability* in housing design at the purchase stage.

This study therefore sought to introduce a 'mass custom design' approach that may bridge the production gap between the need for the mass production of housing that helps lower selling prices and the need for the design customisation required by today's consumer. This paper also examines the potential effects of this new design approach on the delivery of conventional, low-cost housing in Mexico.

Keywords: Low-cost housing; Mass customisation; Mass custom design; Mass custom home; Mexico

Mass Custom Design System Model

MC = *f* (PS)



Service sub-system

S = *f* (l, t, p)

l: Location

t: Tool

P: Personal

Product sub-system

P = *f* (v, e, i, o)

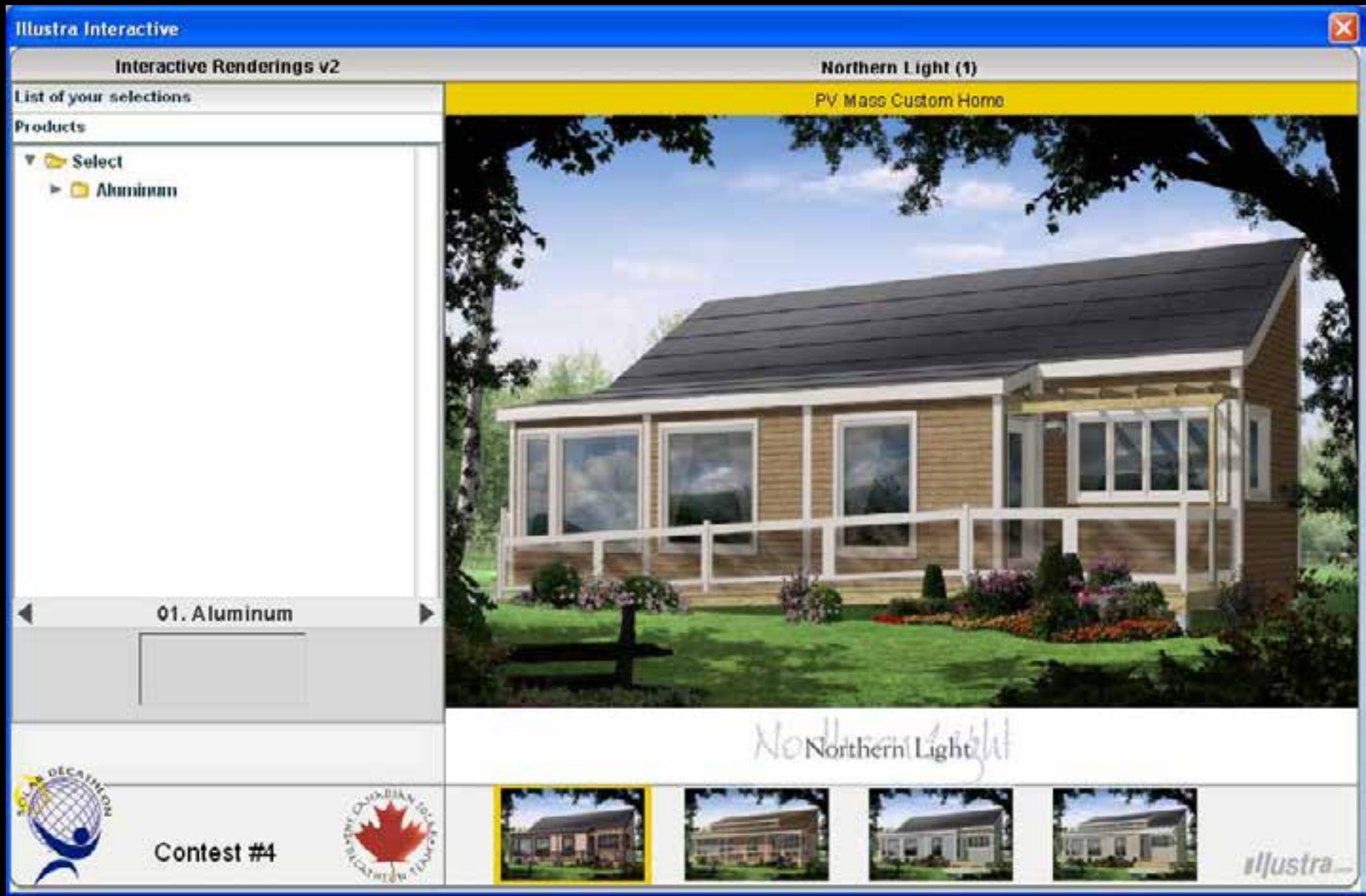
v: Volume component

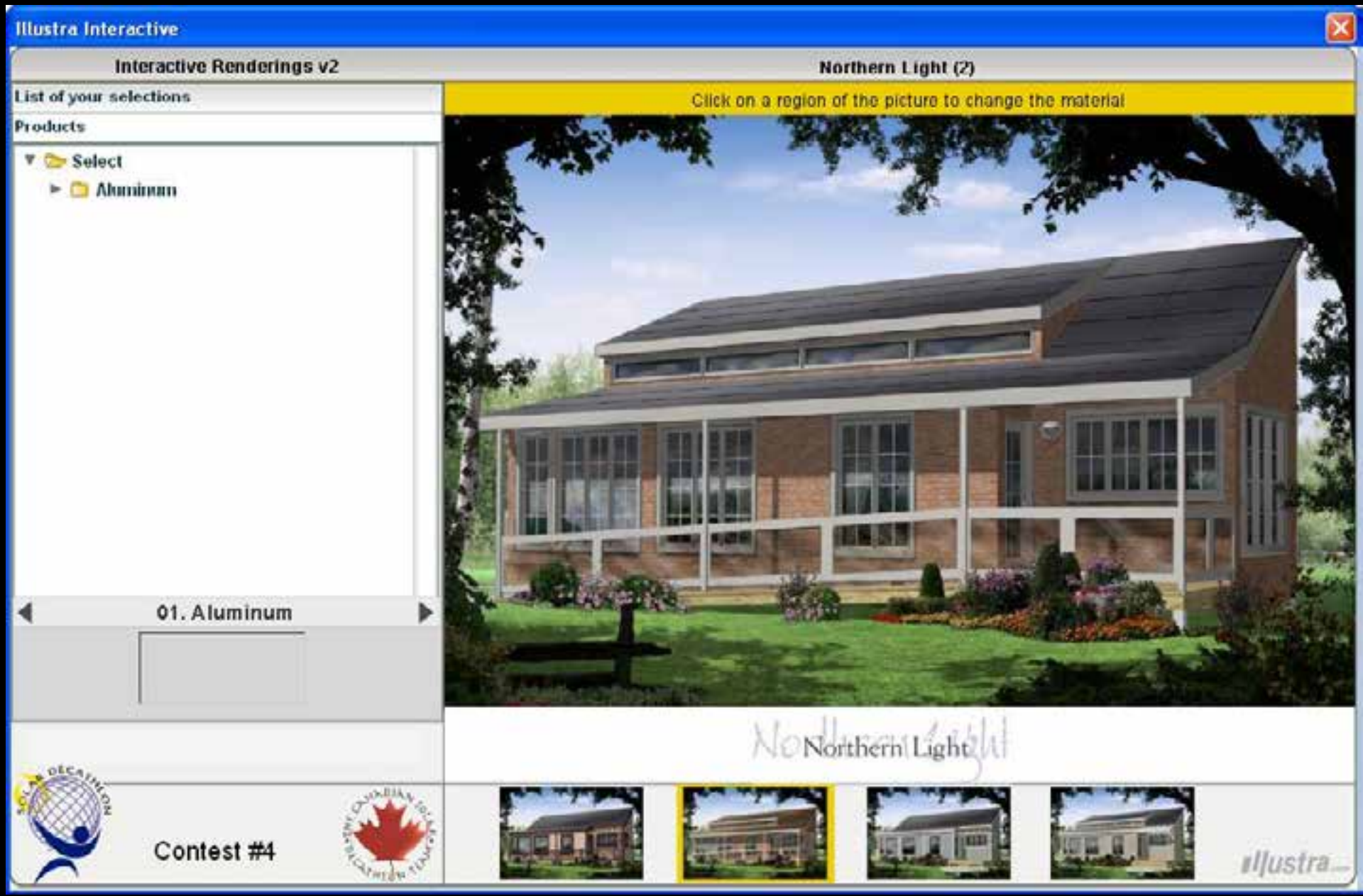
e: Exterior component

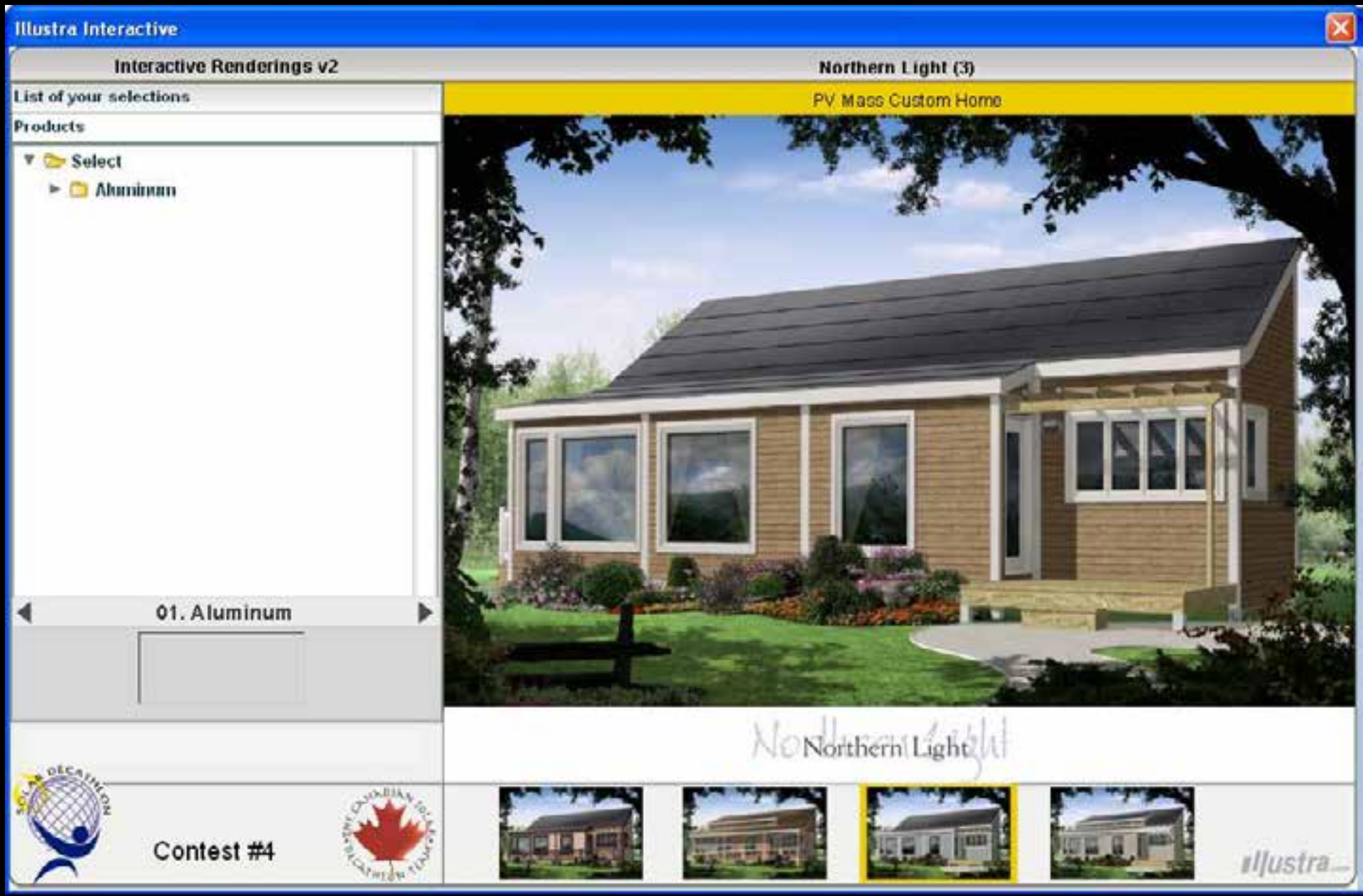
i: Interior component

o: Optional equipment

Low energy mass custom home

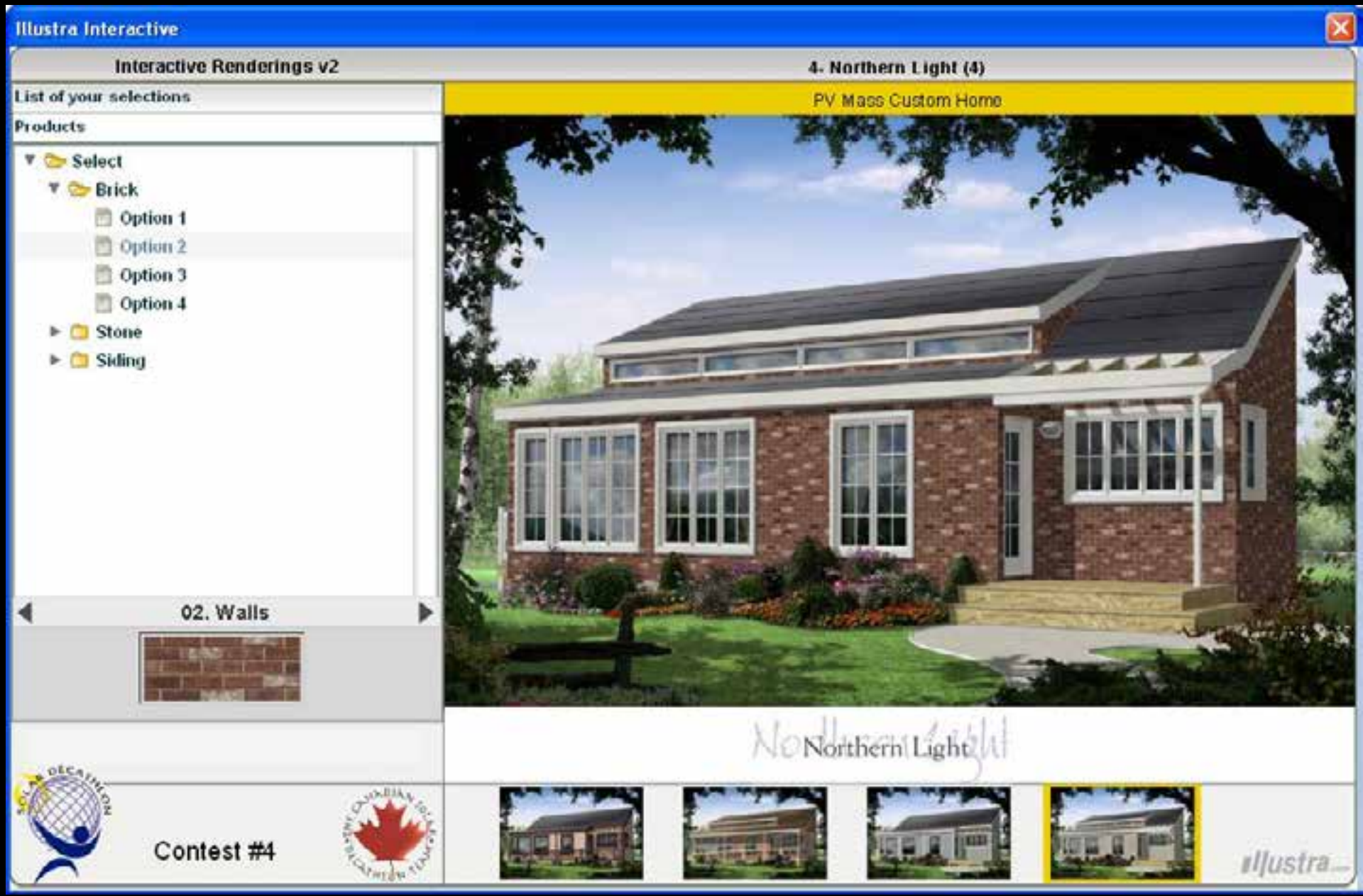

Illustra Interactive
Interactive Renderings v2
Northern Light (1)
List of your selections
Products
Select
Aluminum
01. Aluminum
PV Mass Custom Home
Northern Light
Contest #4
Illustra


Illustra Interactive
Interactive Renderings v2
Northern Light (2)
List of your selections
Products
Select
Aluminum
01. Aluminum
Click on a region of the picture to change the material
Northern Light
Contest #4
Illustra

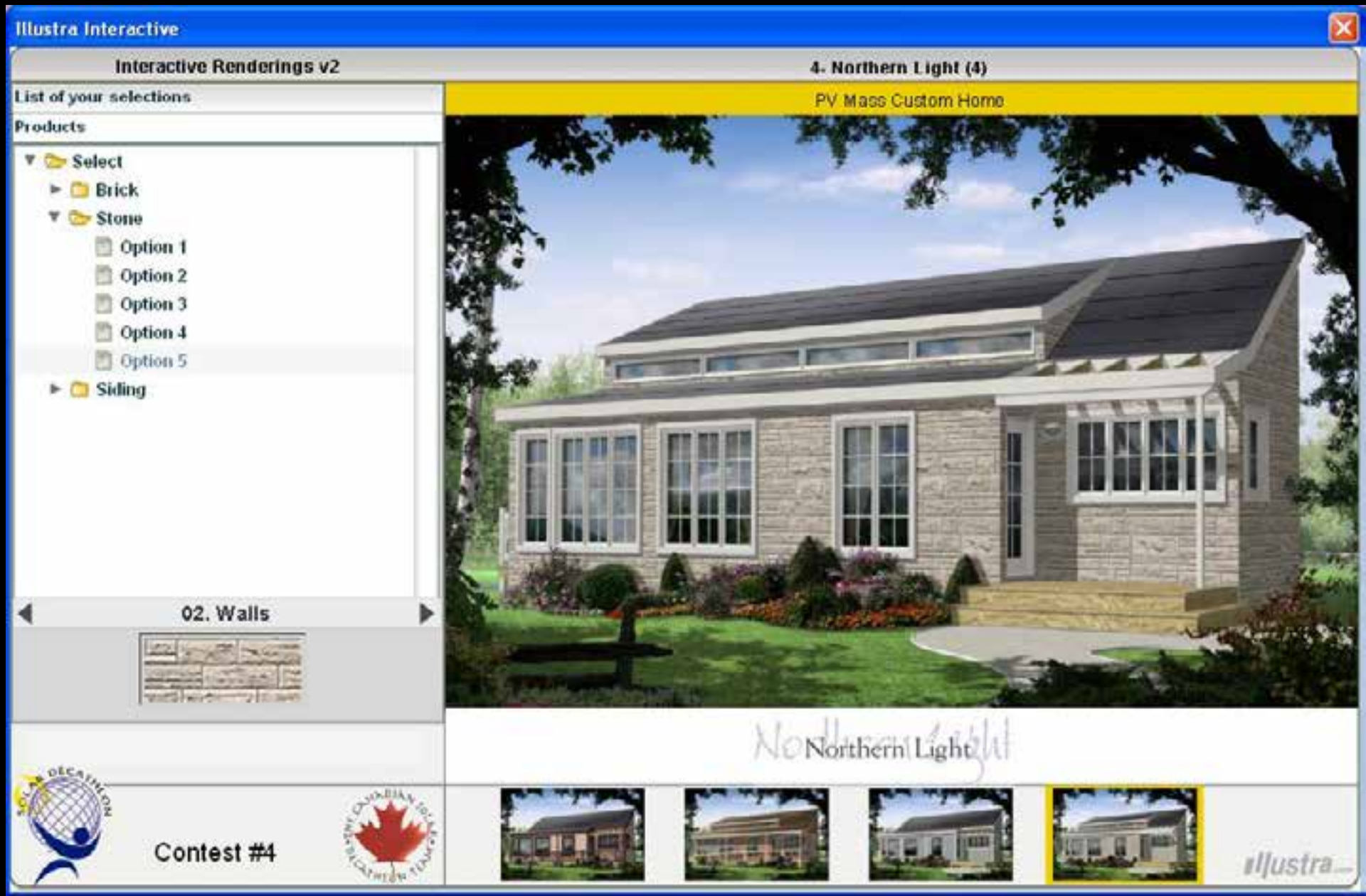

Illustra Interactive
Interactive Renderings v2
Northern Light (3)
List of your selections
Products
Select
Aluminum
01. Aluminum
PV Mass Custom Home
Northern Light
Contest #4
Illustra

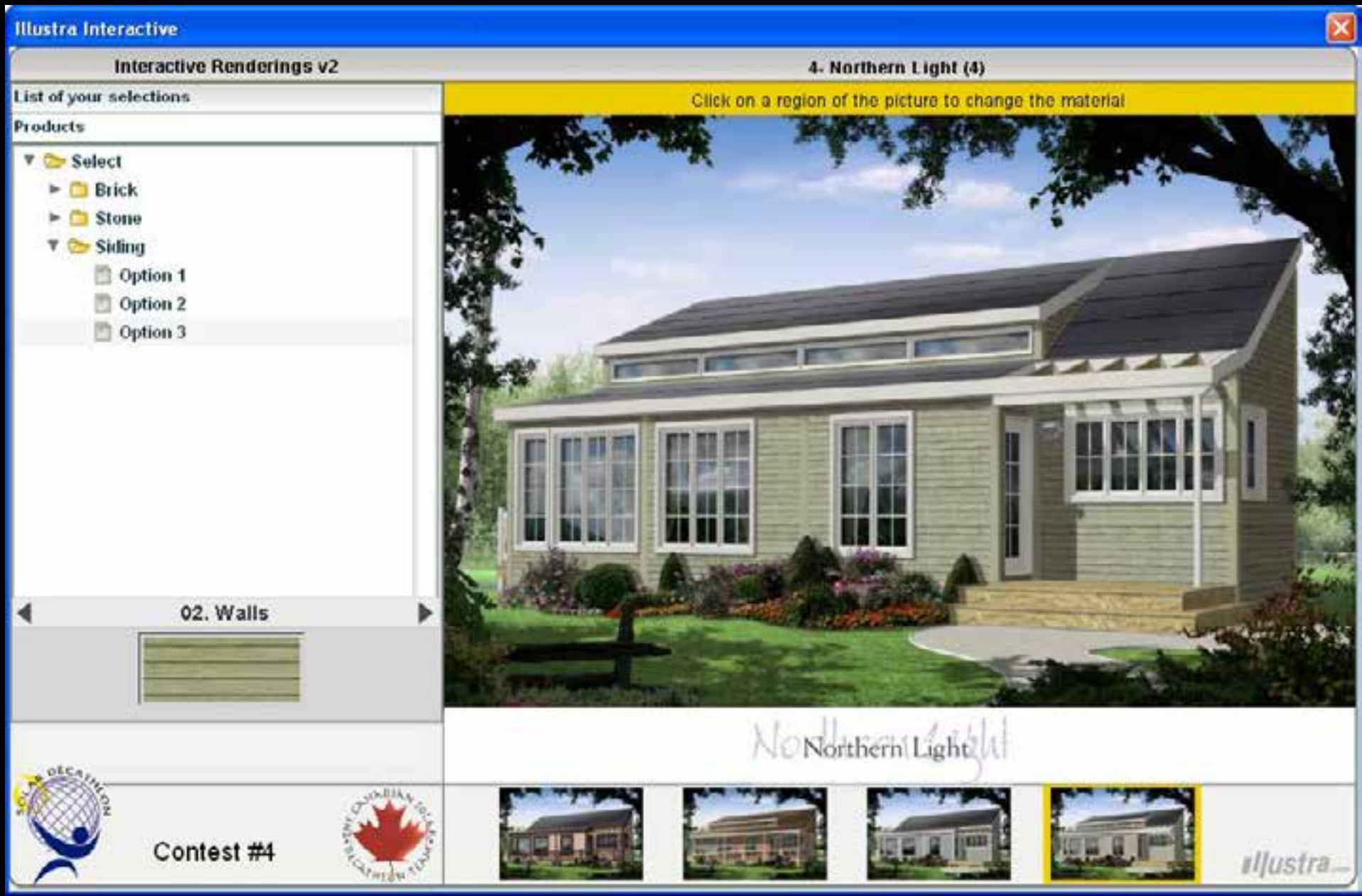

Illustra Interactive
Interactive Renderings v2
Northern Light (4)
List of your selections
Products
Select
Aluminum
01. Aluminum
PV Mass Custom Home
Northern Light
Contest #4
Illustra

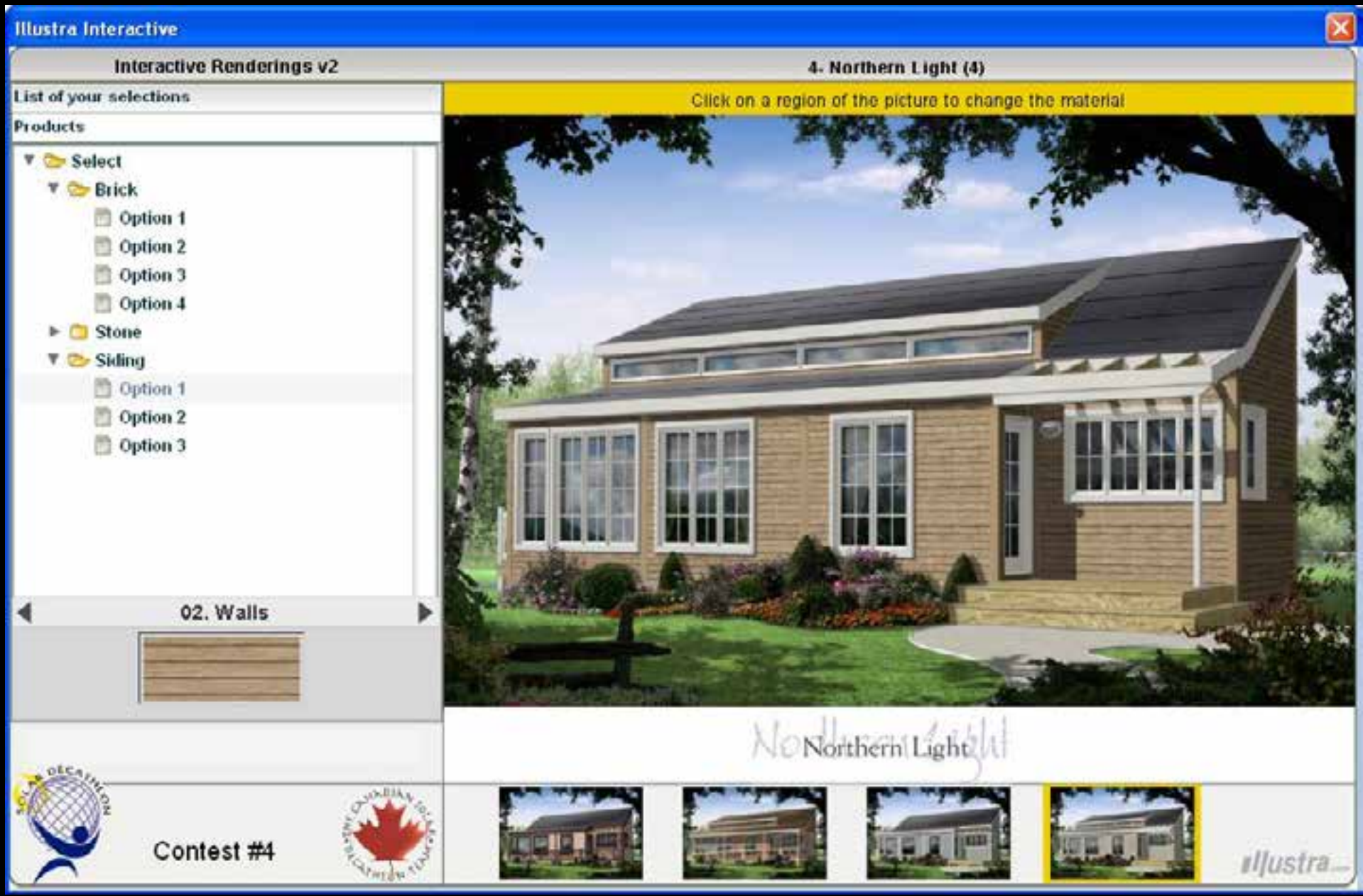

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Stone
Siding
02. Walls
PV Mass Custom Home
02. Walls
Product: Brick
Colour: Option 1
Northern Light
Contest #4
Illustra

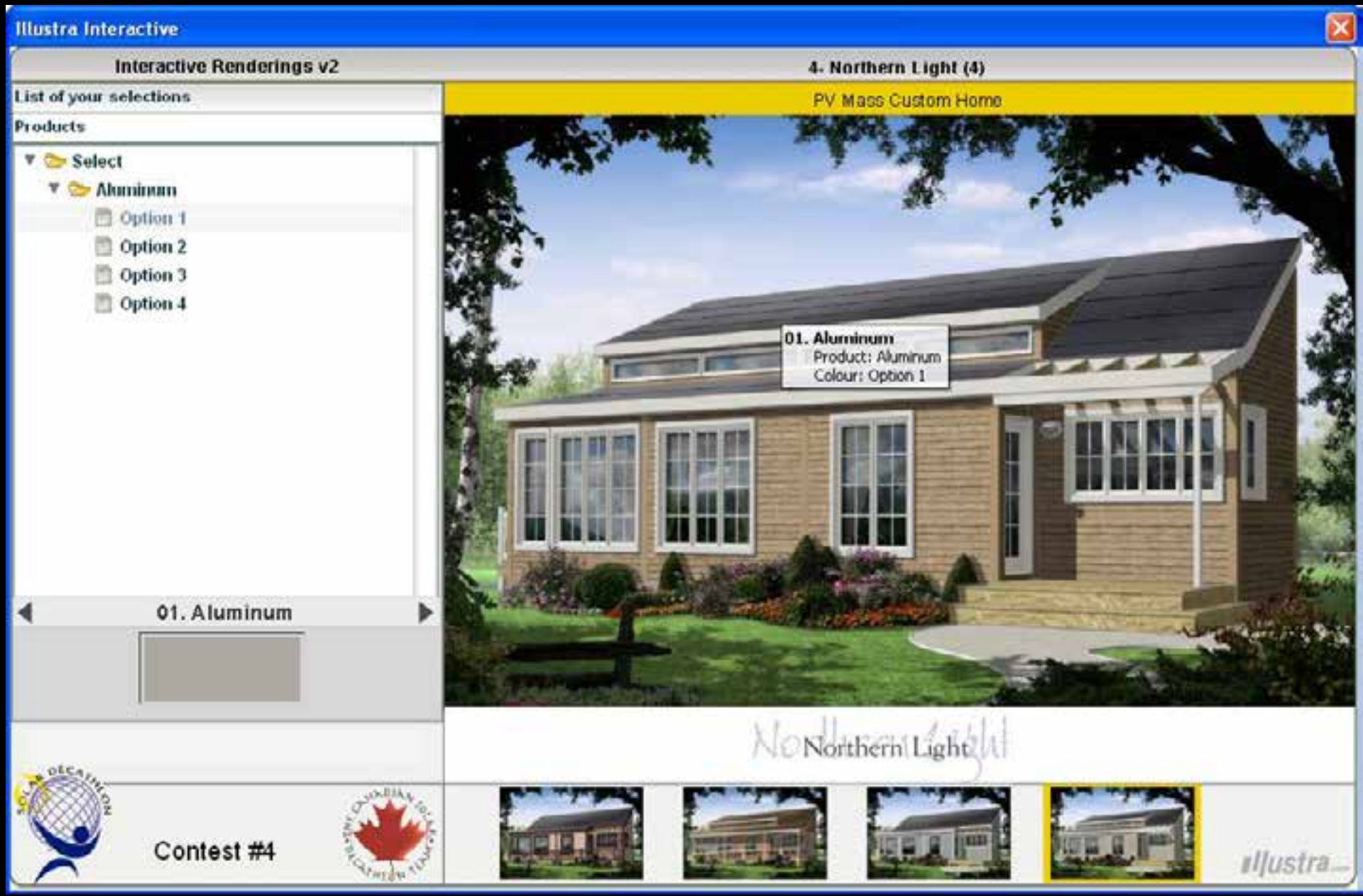

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Option 1
Option 2
Option 3
Option 4
Stone
Siding
02. Walls
PV Mass Custom Home
Northern Light
Contest #4
Illustra

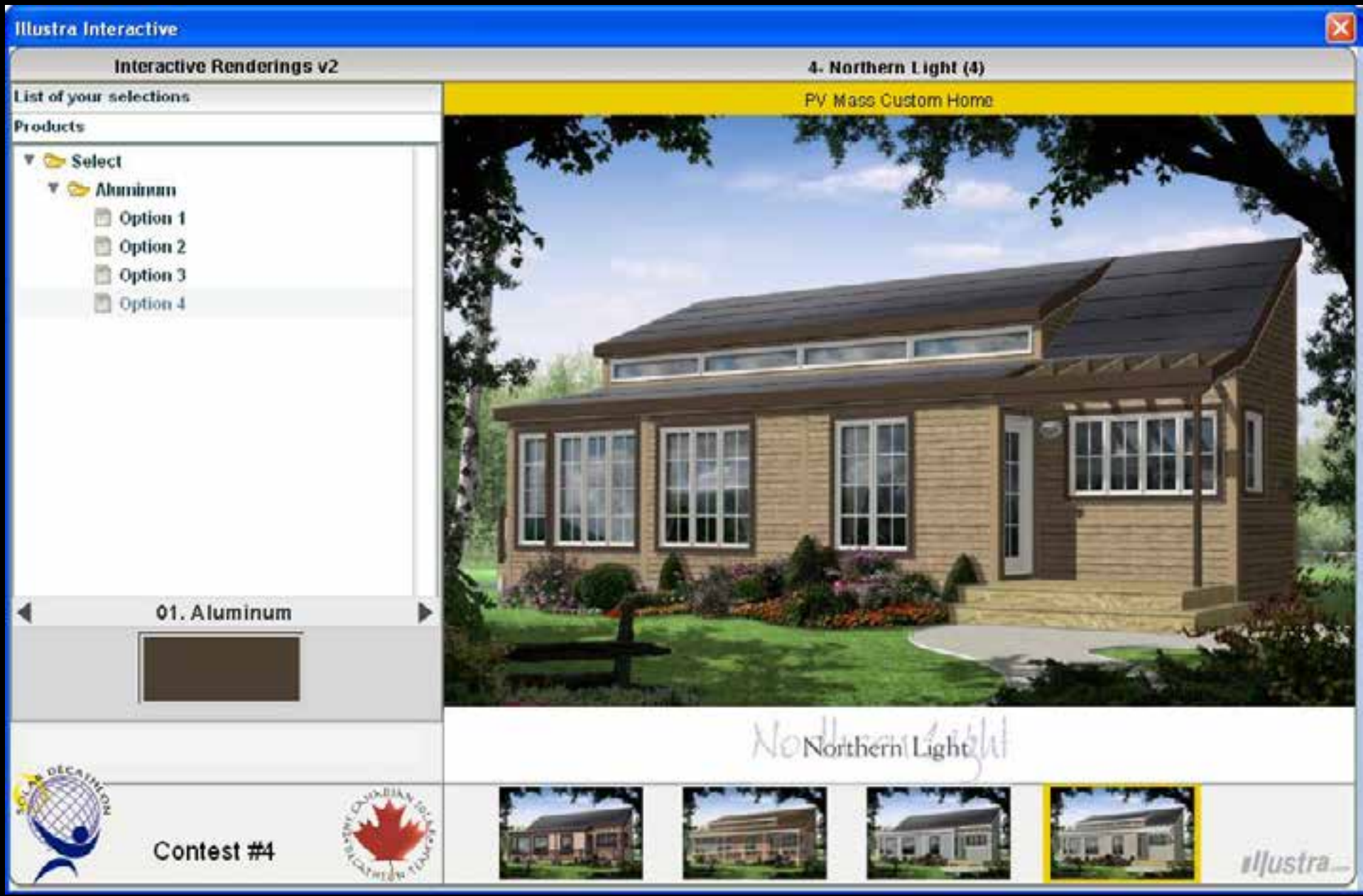

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Stone
Option 1
Option 2
Option 3
Option 4
Option 5
Siding
02. Walls
PV Mass Custom Home
Northern Light
Contest #4
Illustra

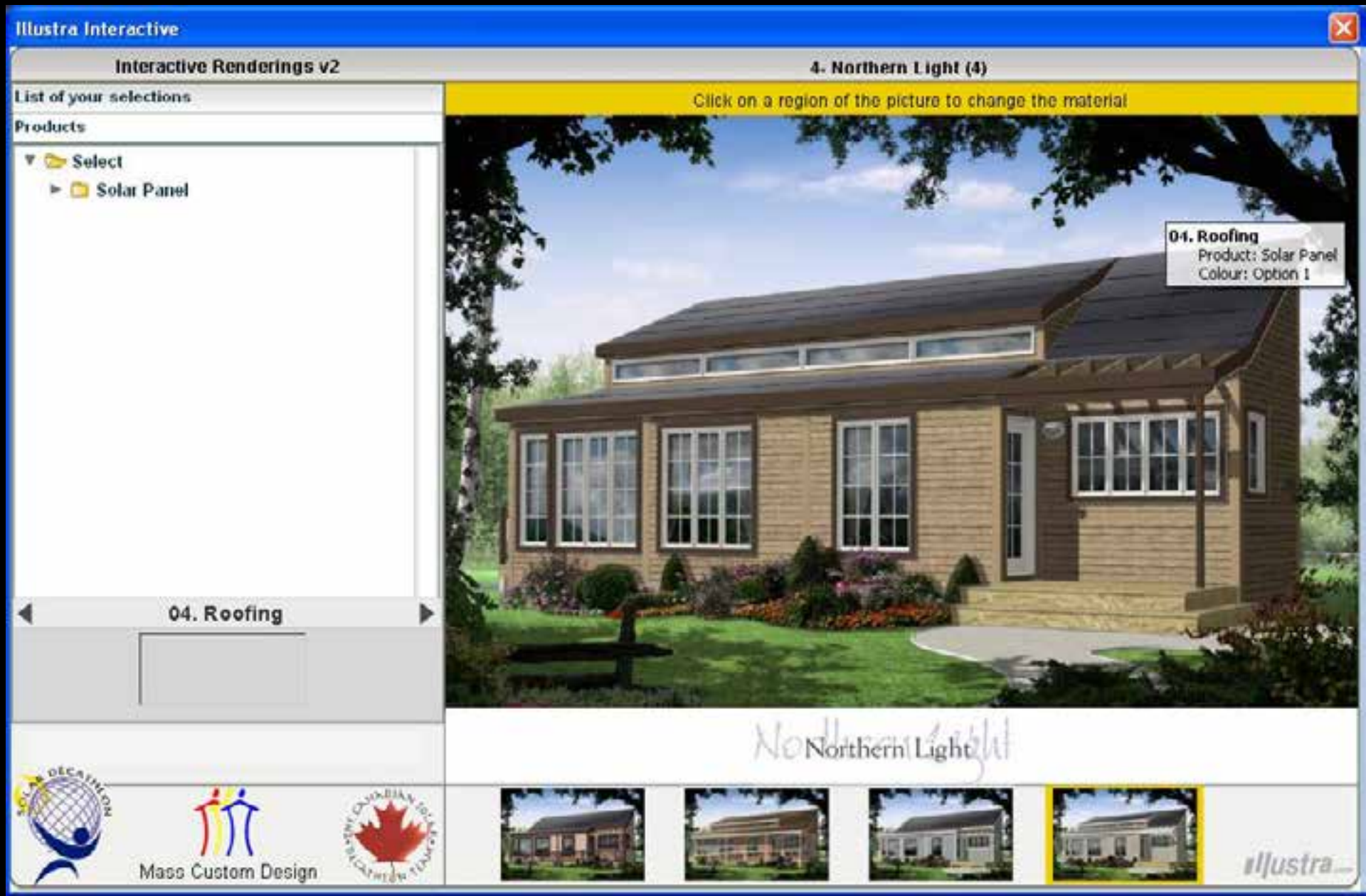

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Stone
Option 1
Option 2
Option 3
Option 4
Option 5
Siding
02. Walls
PV Mass Custom Home
Northern Light
Contest #4
Illustra

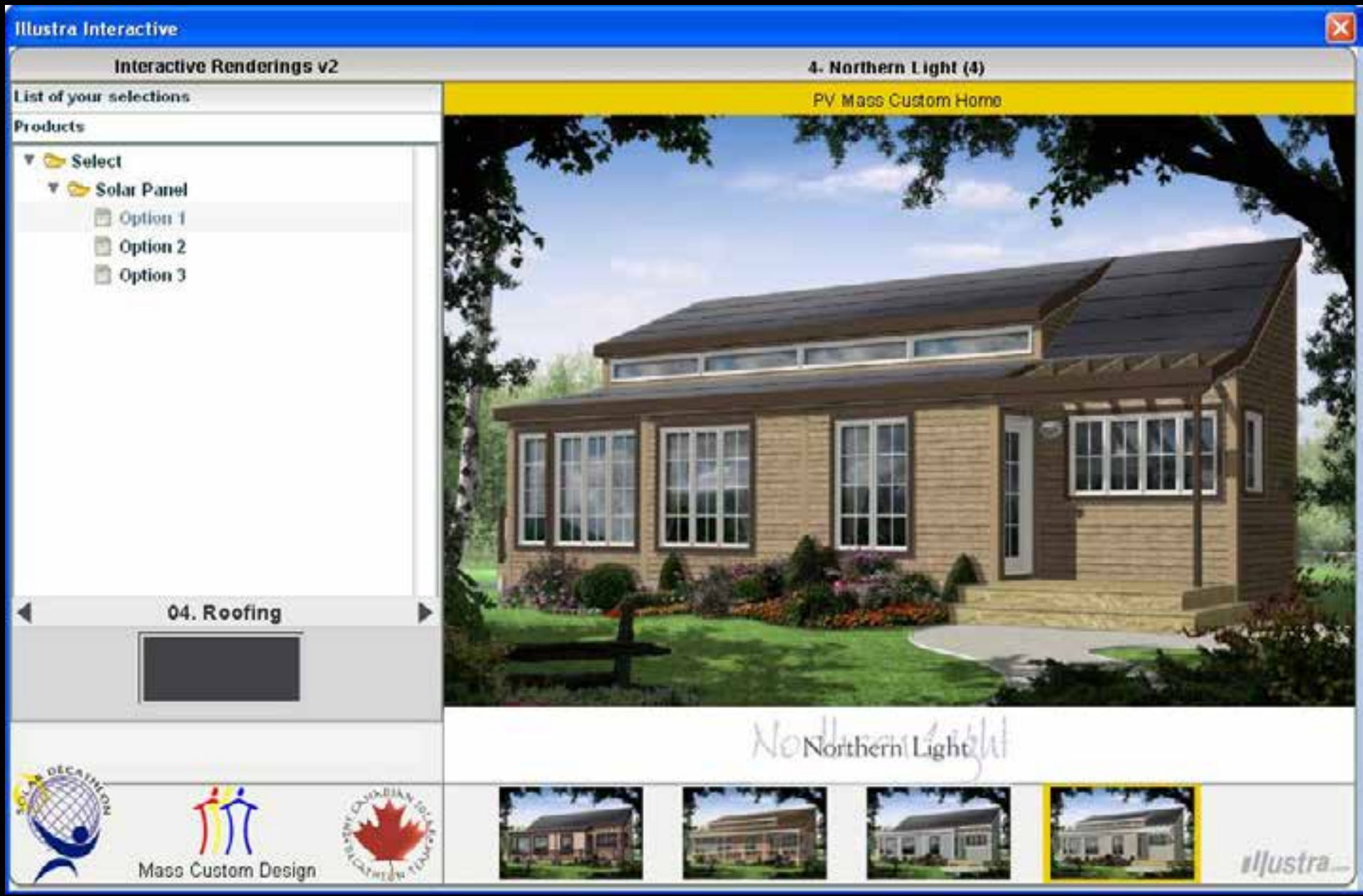

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Stone
Siding
Option 1
Option 2
Option 3
02. Walls
Click on a region of the picture to change the material
Northern Light
Contest #4
Illustra

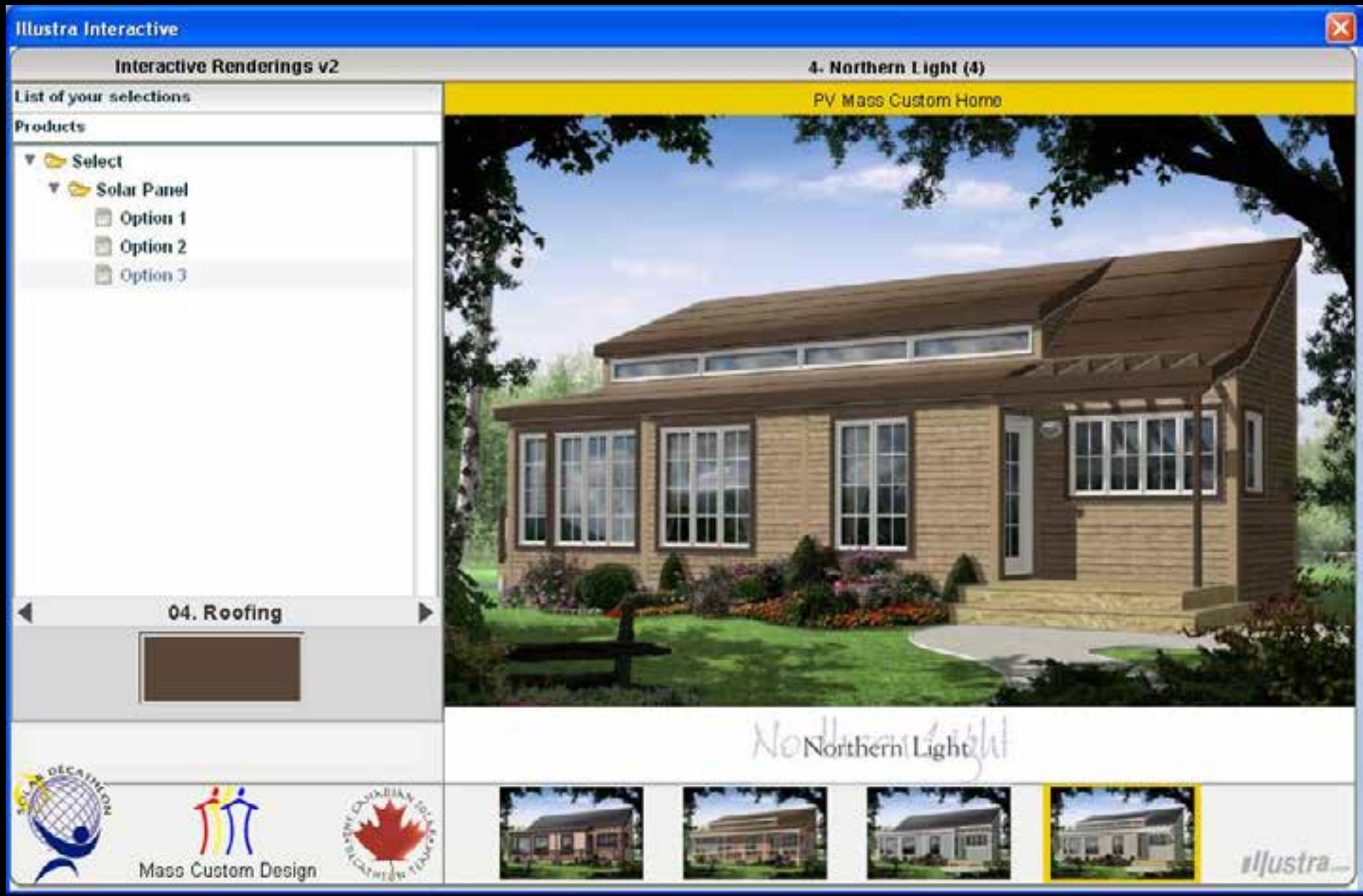

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Brick
Option 1
Option 2
Option 3
Option 4
Stone
Siding
Option 1
Option 2
Option 3
02. Walls
Click on a region of the picture to change the material
Northern Light
Contest #4
Illustra


Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Aluminum
Option 1
Option 2
Option 3
Option 4
01. Aluminum
PV Mass Custom Home
01. Aluminum
Product: Aluminum
Colour: Option 1
Northern Light
Contest #4
Illustra


Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Aluminum
Option 1
Option 2
Option 3
Option 4
01. Aluminum
PV Mass Custom Home
Northern Light
Contest #4
Illustra


Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Solar Panel
04. Roofing
Click on a region of the picture to change the material
04. Roofing
Product: Solar Panel
Colour: Option 1
Northern Light
Mass Custom Design
Illustra


Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Solar Panel
Option 1
Option 2
Option 3
04. Roofing
PV Mass Custom Home
Northern Light
Mass Custom Design
Illustra

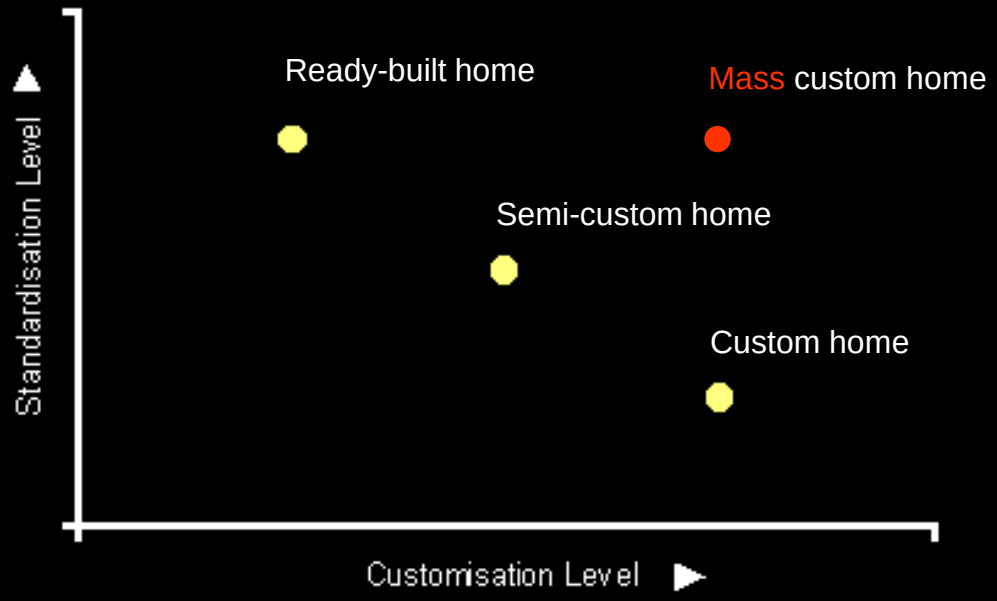

Illustra Interactive
Interactive Renderings v2
4- Northern Light (4)
List of your selections
Products
Select
Solar Panel
Option 1
Option 2
Option 3
04. Roofing
PV Mass Custom Home
Northern Light
Mass Custom Design
Illustra


ECOTERRA
Atmosphère


ECOTERRA
Atmosphère

Standardisation vs. Customisation

	STANDARDISATION LEVEL	CUSTOMISATION LEVEL
Ready-built home	High	Low
Semi-custom home	Medium	Medium
Custom home	Low	High




Funded by:
Communities Scotland
Donside Urban Village
Devanha Ltd is proud to announce a new neighbourhood of 21st century sustainable housing.
For more information contact Euan Barr at Tenants First Housing Co-operative on 01224 628427
Tenants First
LANGSTANE
GRAMPIAN

Donside Urban Village
Aberdeen, Scotland

Donside Urban Village
Aberdeen, Scotland

Mass Customisation for Experience Design

Product Design

“Book Cart”

User Choice : Shelves

USER SELECTED:
Two sloping
and
Fixed Shelves

User Choice : Handles

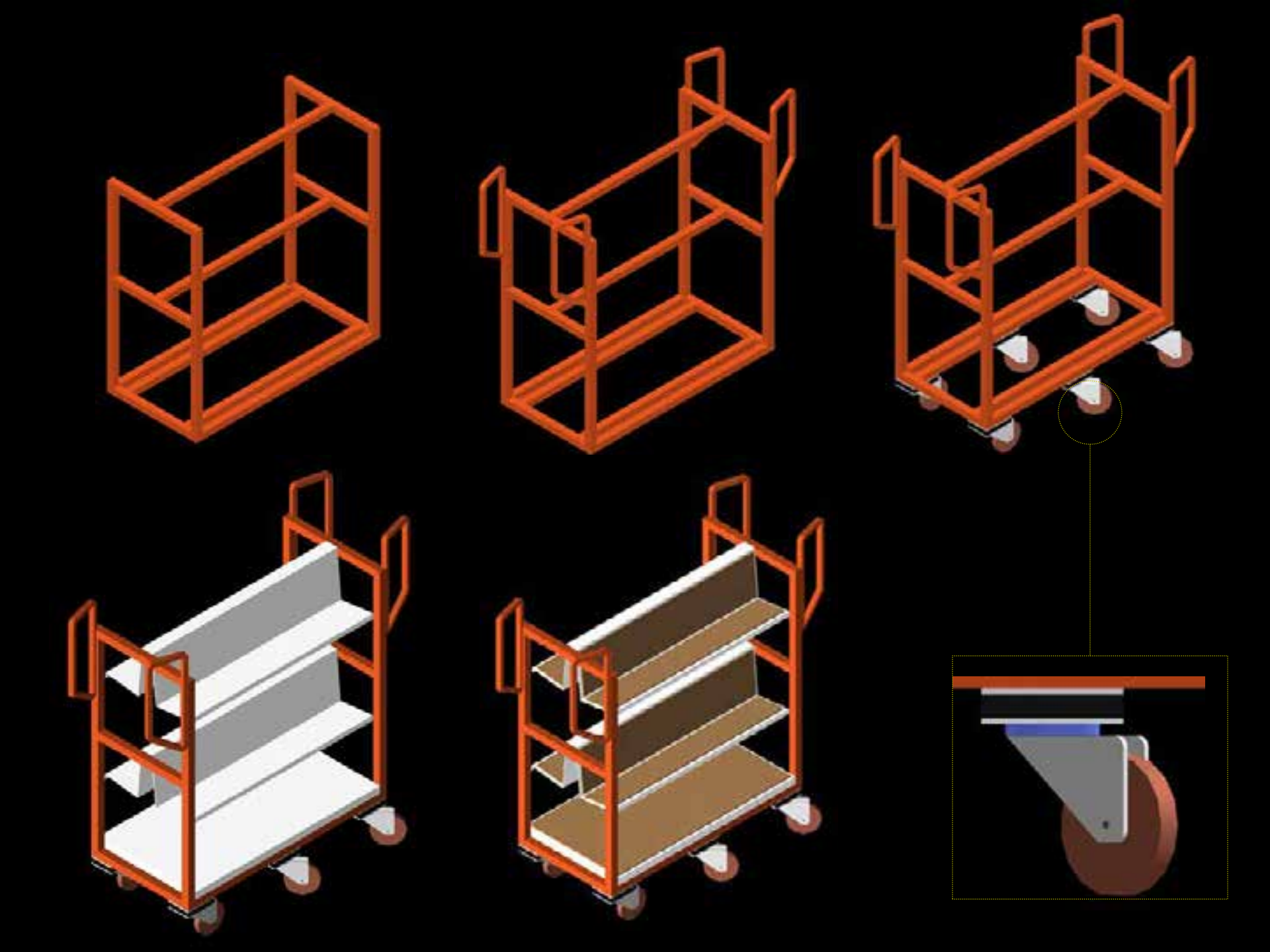
USER SELECTED:
V-shaped, Vertical Handles

User Choice : Wheels

USER SELECTED:

Six Wheels and Metal Plate connectors

Book cart
designed through
mass customisation
of user experiences

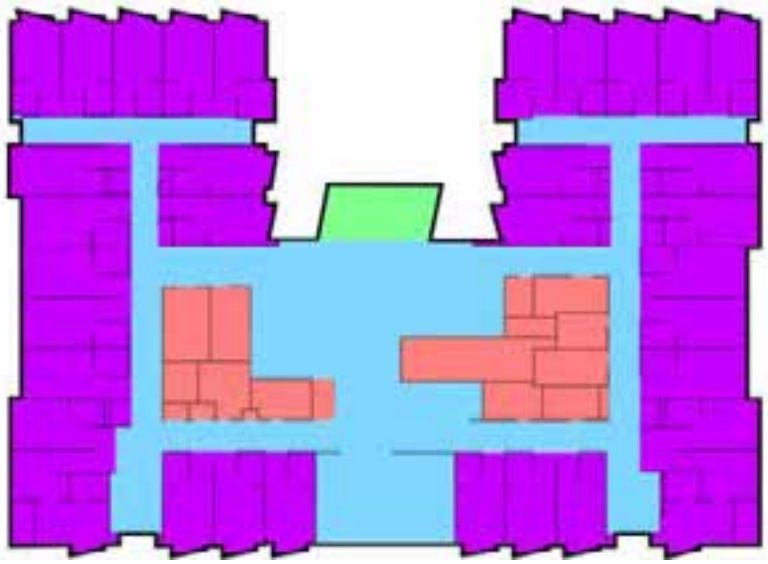


RATHDOWNE PLACE AGED CARE CENTRE Melbourne, Australia

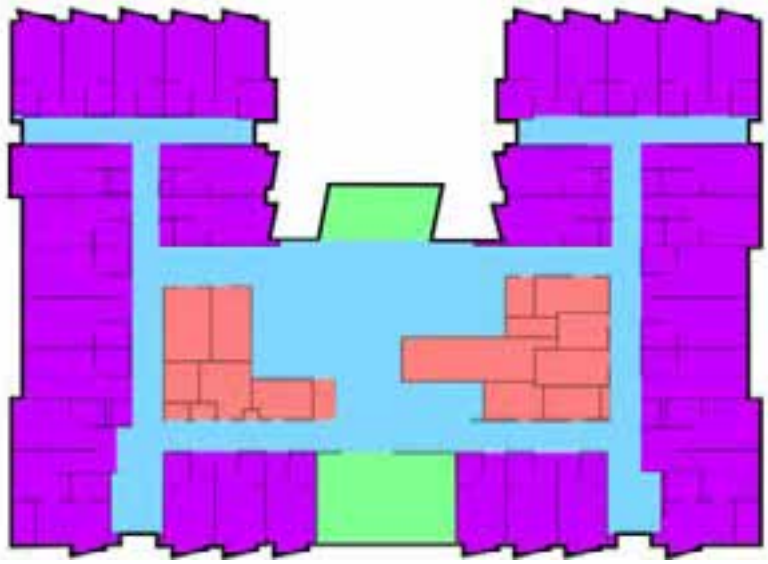
- 162 beds
- 12 Levels
- Care available
  - Permanent residential care
  - Memory support
  - Palliation
  - Respite care
- Better Together® model

SPATIAL ZONES

OUTSIDE COMMUNAL STAFF RESIDENTIAL



Level 2 - 4



Level 5

Level 5 Rooftop Balcony

Typical Reception, Dining and Kitchenette

Level 5 Rooftop Balcony

American Journal of Environmental Experience Design (AJEXD)

Zero Energy Mass Custom Home (ZEMCH) Network

VOLUME 1 ISSUE 1 (2022)

PUBLISHED BY: E-PALLI, DELAWARE, USA

Editorial Team

Co-Editors-in-Chief

Masa Noguchi

The University of Melbourne

Australia

Kheira Anissa Tabet Aoul

United Arab Emirates University

United Arab Emirates

My home improvement project through "Environmental Experience Design" theme

Edible Garden for Healthy Affordable Food & Children's Green Experience

Fresh Breakfast from Garden













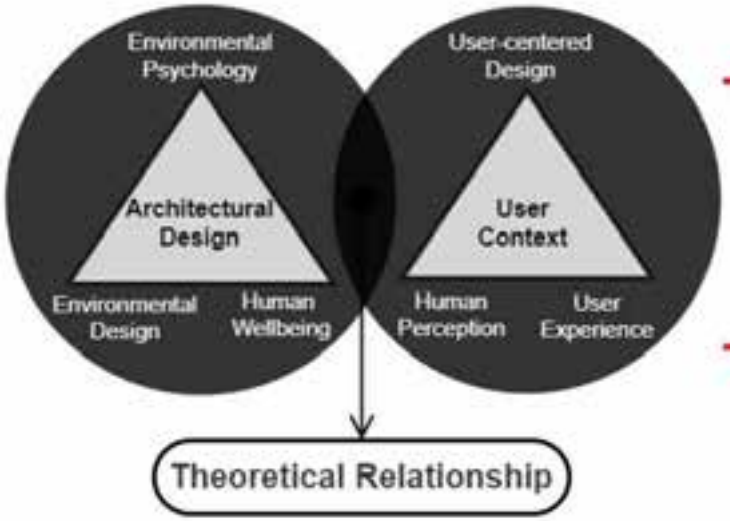

E
X D

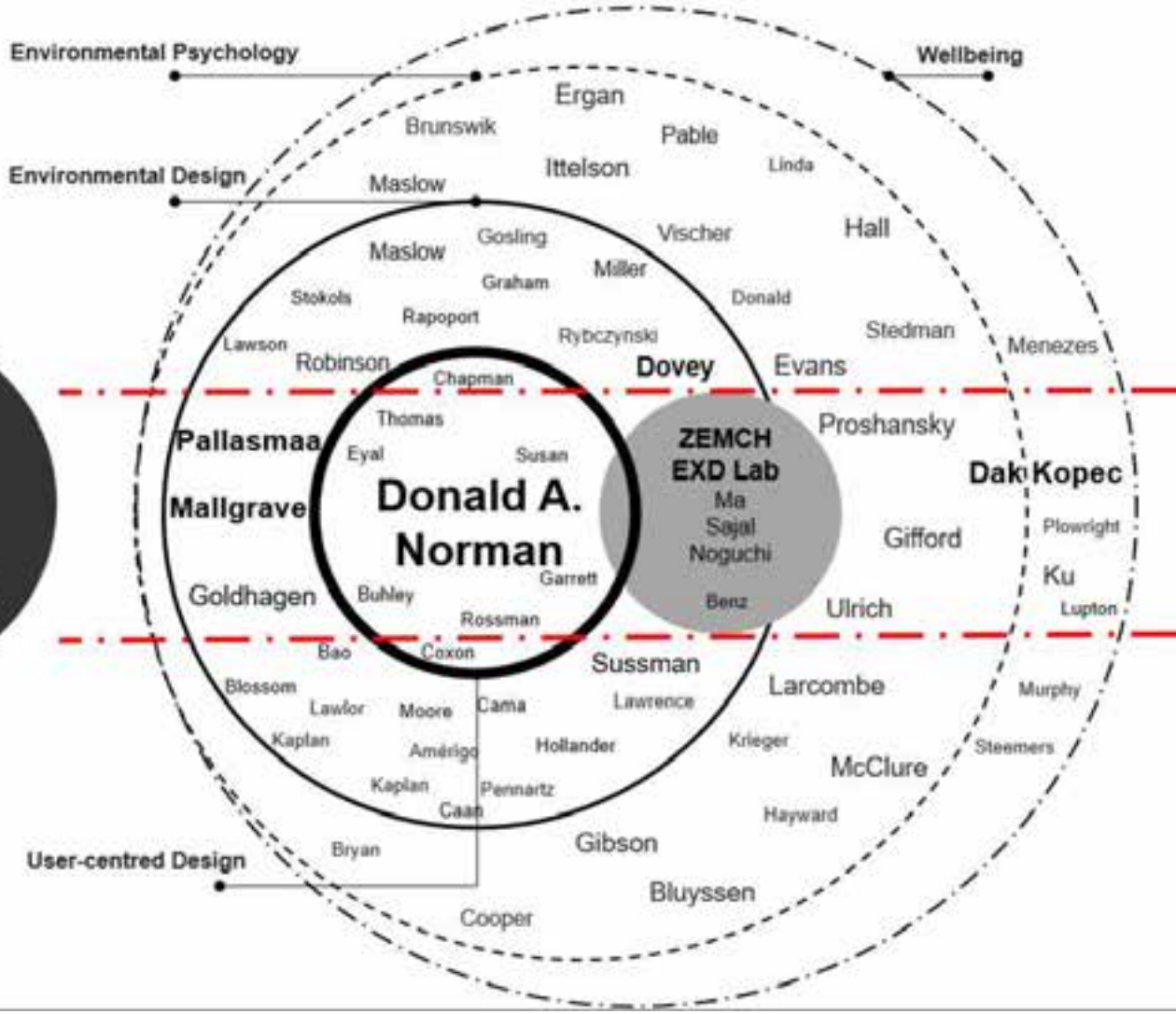
Garden Stroll in the Evening Rain

msd

Literature

ZEMCH EXD Lab





Dr Sajal Chowdhury

E
X D

High Density Housing Development

- Urban Scenario, Dhaka

- Uttara Residential Model Town, Dhaka

- Japan Garden City, Dhaka

- Concord Lake City, Dhaka

- Shopno-Nagar Housing, Dhaka

(Photos: Chowdhury, Web source)









Field Data Collection

CASE 5

A: Floor plan

Master Bedroom

Child Bedroom

Living

Dining

Kitchen

Attached Toilet

Common Space

Study

Balcony

GENERAL INFORMATION

Address	607/1, Block-c, Khilgaon, Dhaka.
Flat Size (sqft)	900
Family Member	4
Total Floor	6
Flat Location	4
Orientation	East
Living Duration (Years)	1
Ownership	Rent

CASE 9

A: Floor plan

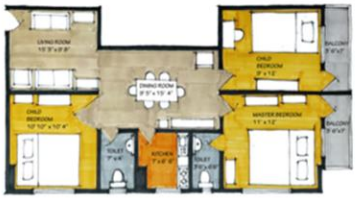
ttached Toilet

Common Toilet

GENERAL INFORMATION

Address	13/Ga, Dhaka City Corporation Staff Quarter, Dhaka 1203
Flat Size (sqft)	950
Family Member	4
Total Floor	2
Flat Location	2
Orientation	East
Living Duration (Years)	17
Ownership	Rent

CASE 10



A: Floor plan

Master Bedroom

Child Bedroom 1

Child Bedroom 2

Balcony

Living

Dining

Kitchen

Attached Toilet

Balcony

GENERAL INFORMATION

Address	200,Amena garden. Amatol bazar. 60 feet mirpur. Dhaka
Flat Size (sqft)	1000
Family Member	4
Total Floor	8
Flat Location	6
Orientation	East
Living Duration (Years)	4
Ownership	Rent

Field Data Collection

Field Data Collection

Data Samples

Total sample collections (nos) 95

Total sample Selections (nos) 50

Climate	Summer
Final selection for analysis (nos)	50

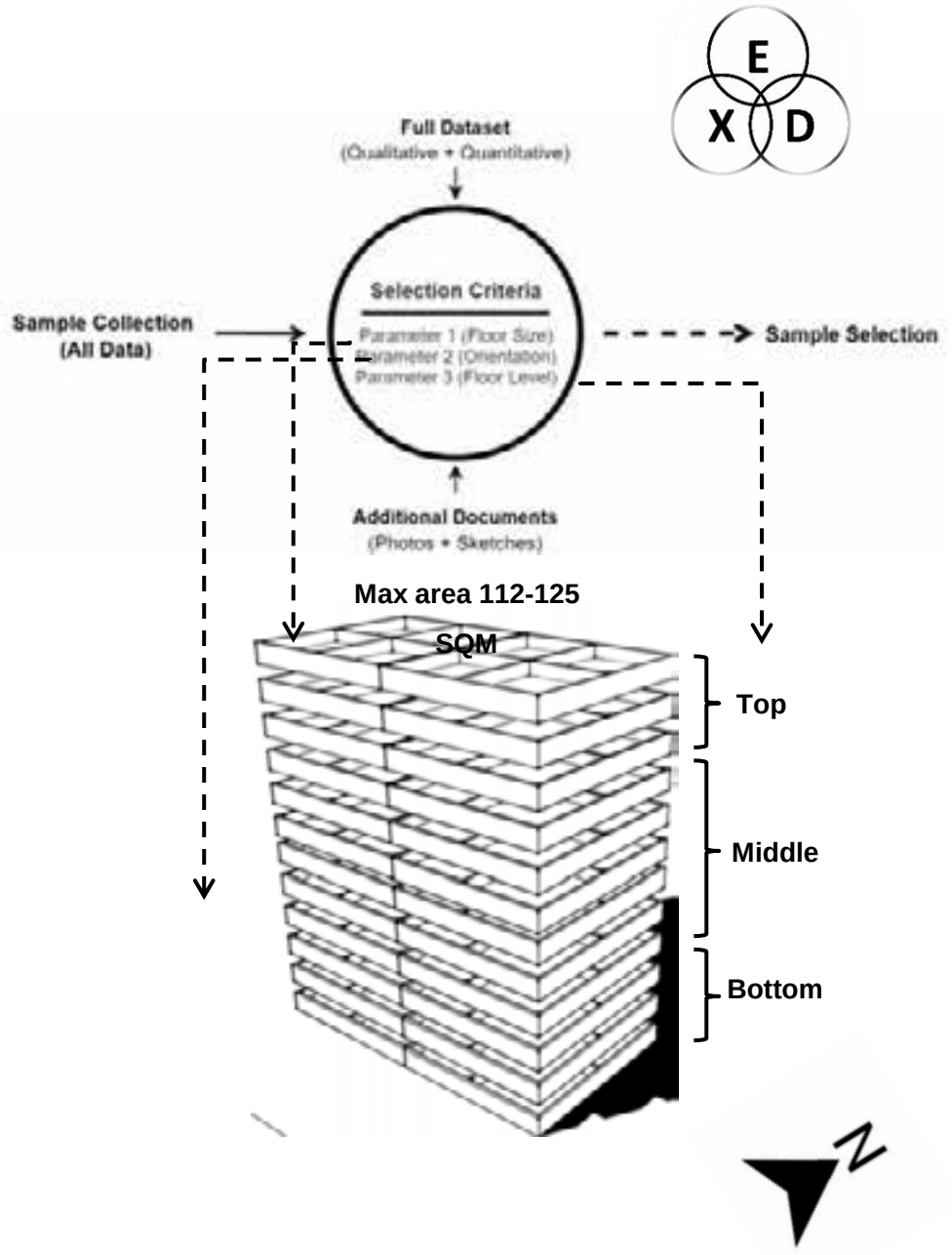
Criteria		Criteria	
Orientation	Data consideration (nos)	Floor level	Data consideration (nos)
East	11	Top	16
West	14	Middle	23
North	11	Bottom	11
South	14		

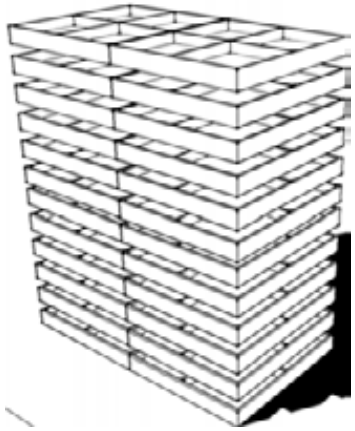
Climate	Winter
Final selection for analysis	25

Criteria		Criteria	
Orientation	Data consideration (nos)	Floor level	Data consideration (nos)
East	9	Top	9
West	9	Middle	9
North	3	Bottom	7
South	4		

Criteria		Criteria	
Flat size (sqft)	Sample (nos)	Building height (storied)	Sample (nos)
400 - 600	4	1 to 6	20
(+) 800 - 800	3	7 to 10	21
(+) 800 - 1000	25	11 to 15	7
(+) 1000 - 1200	16	up to 15	2
(+) 1200 - 1400	2		

Participants: +18 years old





Master Bedroom

Orientation

East

West

North

South

Floor Level

Top

Middle

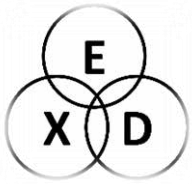
Bottom

Climate

Summer

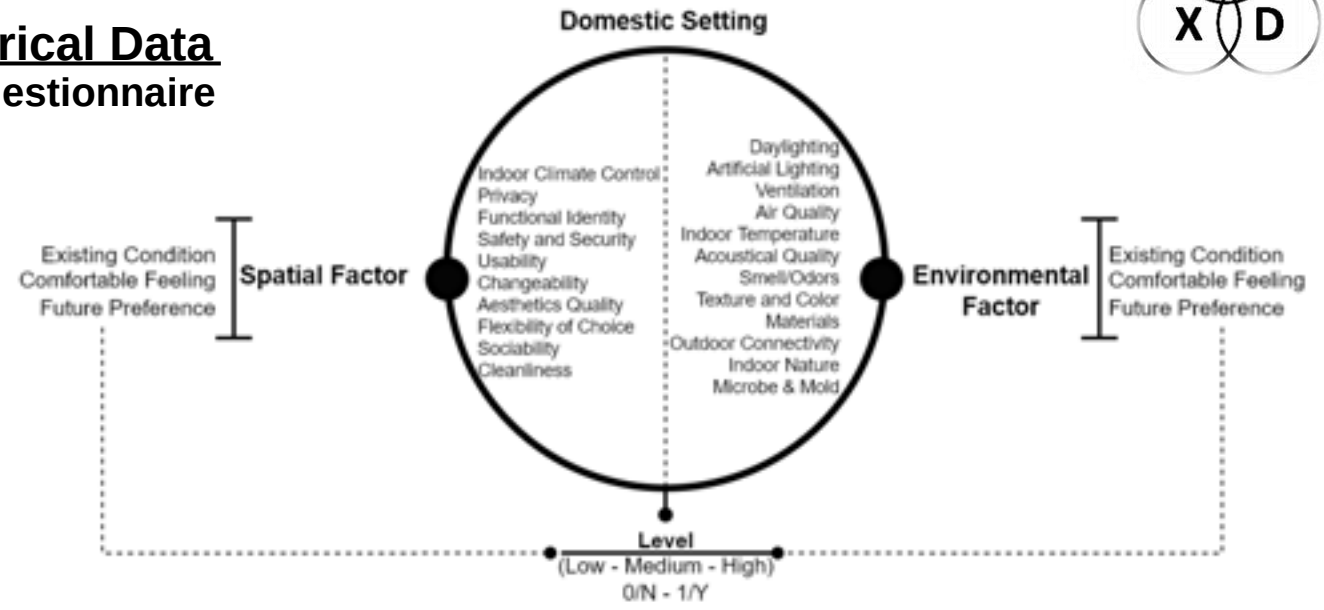
Winter

Associations



Numerical Data

Structured Questionnaire



Master Bedroom

SN	Spatial Indicators	Existing Condition			Feeling Comfortable			Future Preference		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
1	Indoor climate Control	□	■	□	□	■	□	□	□	■
2	Privacy	□	□	■	□	□	■	□	□	■
3	Functional Identity	□	■	□	□	■	□	□	□	■
4	Safety and Security	□	■	□	□	■	□	□	□	■
5	Space Usability	□	□	■	□	□	■	□	□	■
6	Changeability (Variety)	■	□	□	□	■	□	□	■	□
7	Aesthetics Quality	■	□	□	■	□	□	□	□	■
8	Flexibility of Choice	■	□	□	■	□	□	□	■	□
9	Interaction and Sociability	■	□	□	□	■	□	□	■	□
10	Cleanliness	□	■	□	□	■	□	□	□	■

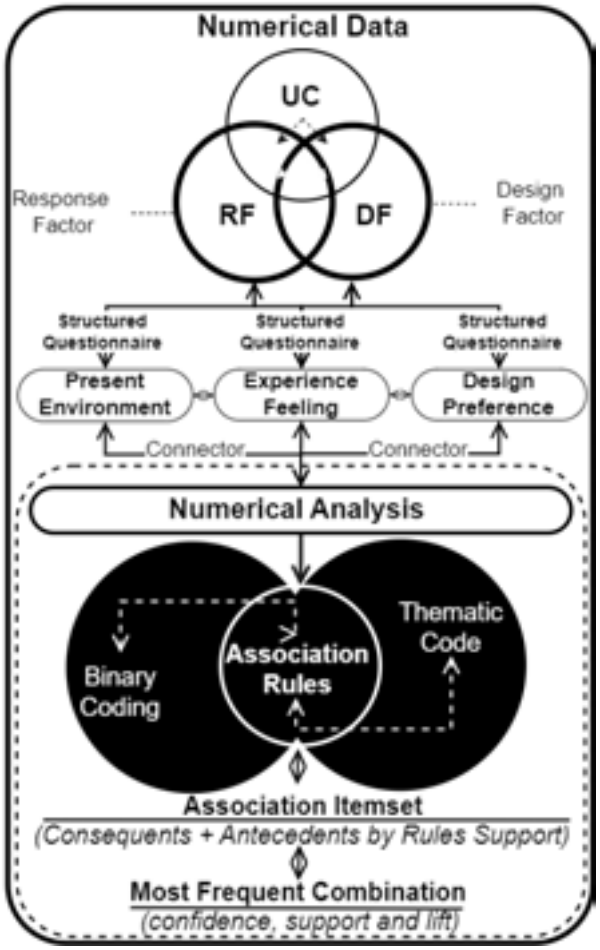
Binary Coding

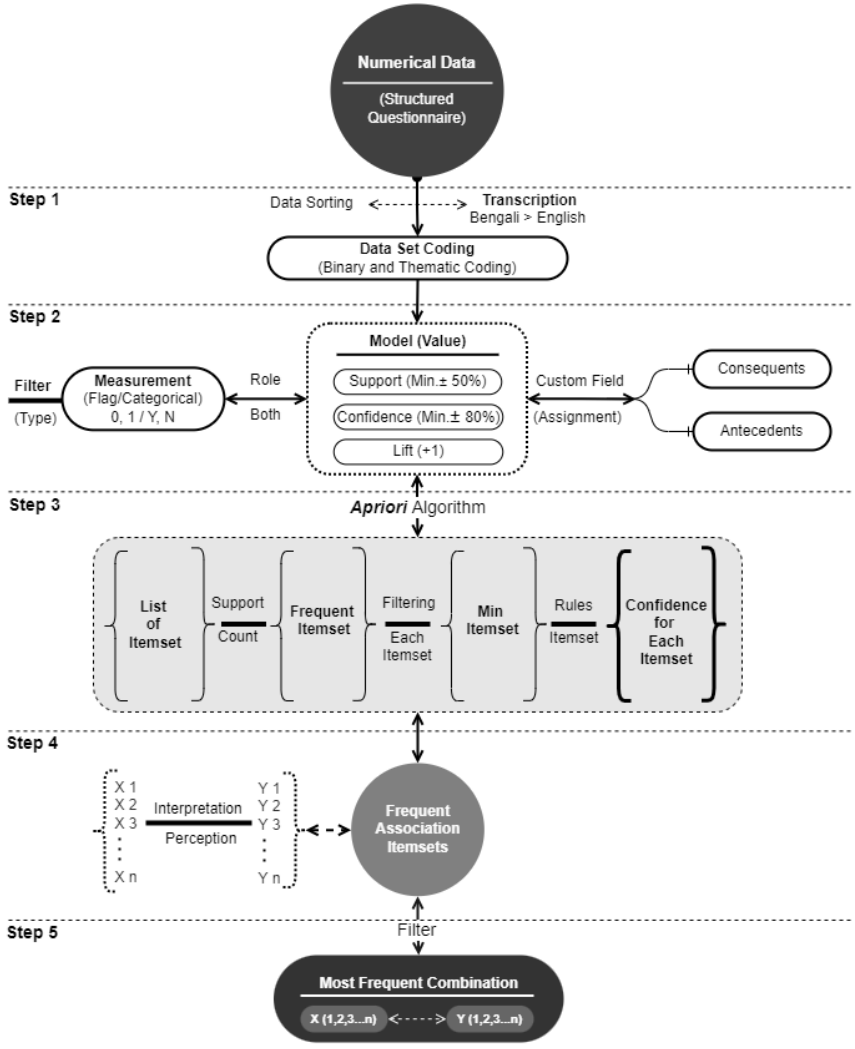
Master Bedroom

SN	Spatial Indicators	Existing Condition			Feeling Comfortable			Future Preference		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
1	Indoor climate Control	0	1	0	0	1	0	0	0	1
2	Privacy	0	0	0	0	0	1	0	0	1
3	Functional Identity	0	1	0	0	1	0	0	0	1
4	Safety and Security	0	1	0	0	1	0	0	0	1
5	Space Usability	0	0	1	0	0	1	0	0	1
6	Changeability (Variety)	1	0	0	0	1	0	0	1	0
7	Aesthetics Quality	1	0	0	1	0	0	0	0	1
8	Flexibility of Choice	1	0	0	1	0	0	0	1	0
9	Interaction and Sociability	1	0	0	0	1	0	0	1	0
10	Cleanliness	0	1	0	0	1	0	0	0	1

1 Sample Set
= ± 1800 Data

50 Samples
= ± 90,000 Input


Numerical Data
UC
Response Factor
RF
DF
Design Factor
Structured Questionnaire
Structured Questionnaire
Structured Questionnaire
Present Environment
Experience Feeling
Design Preference
Connector
Connector
Numerical Analysis
Binary Coding
Association Rules
Thematic Code
Association Itemset
(Consequents + Antecedents by Rules Support)
Most Frequent Combination
(confidence, support and lift)


Numerical Data
(Structured Questionnaire)
Step 1
Data Sorting
Transcription
Bengali > English
Data Set Coding
(Binary and Thematic Coding)
Step 2
Model (Value)
Filter
(Type)
Measurement
(Flag/Categorical)
0, 1 / Y, N
Role
Both
Support (Min.± 50%)
Confidence (Min.± 80%)
Lift (+1)
Custom Field
(Assignment)
Consequents
Antecedents
Step 3
Apriori Algorithm
List of Itemset
Support
Count
Frequent Itemset
Filtering
Each Itemset
Min Itemset
Rules
Itemset
Confidence for Each Itemset
Step 4
X 1
X 2
X 3
X n
Interpretation
Perception
Y 1
Y 2
Y 3
Y n
Frequent Association Itemsets
Step 5
Filter
Most Frequent Combination
X (1,2,3...n)
Y (1,2,3...n)

Mathematical modelling of **Apriori** algorithm

Apriori =

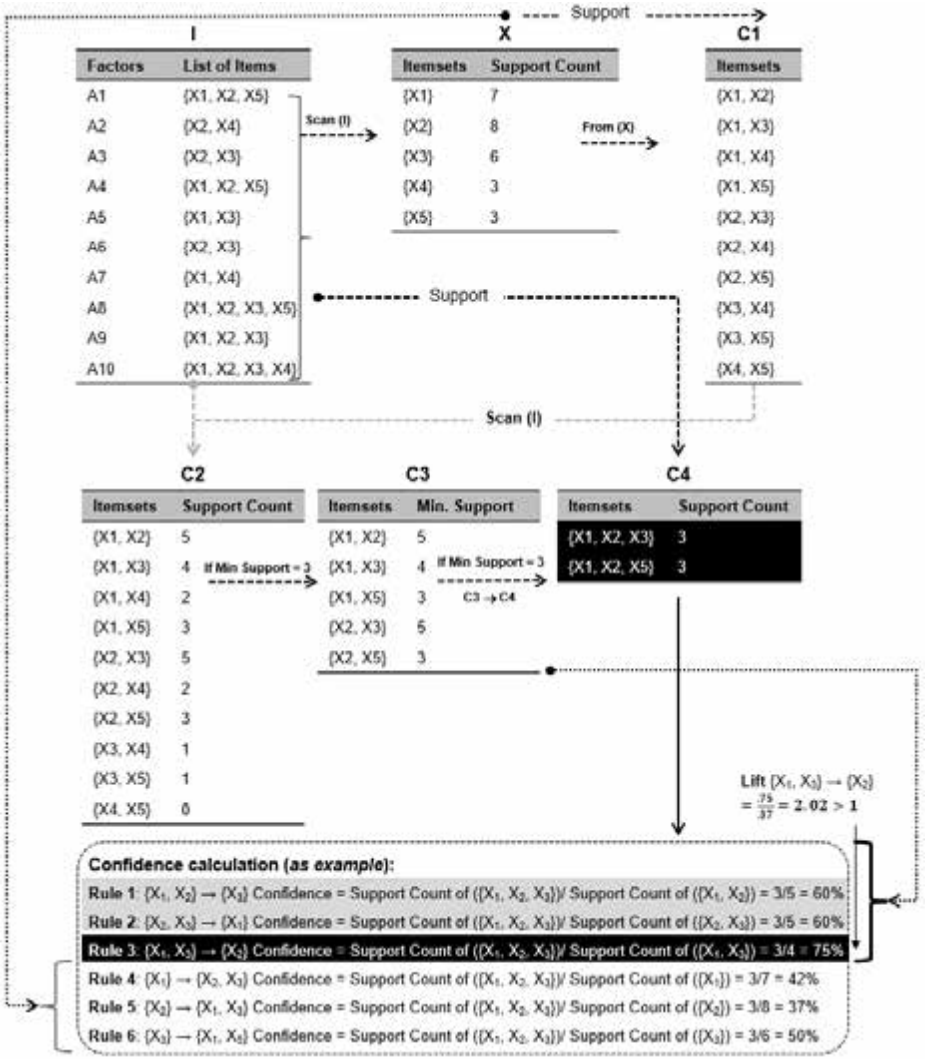
$$Support\ (x) = \frac{N_x}{N}$$

$$Confidence\ (x \rightarrow y) = \frac{\text{Support}\ (x, y)}{\text{Support}\ (x)}$$

$$Lift\ (x \rightarrow y) = \frac{\text{Support}\ (x, y)}{\text{Support}\ (x) \times \text{Support}\ (y)}$$

Consideration, support (50%), confidence (min. 80%), lift (+1)
N = Number of Records

Source: (Nisbet et al. 2009: 35-56)

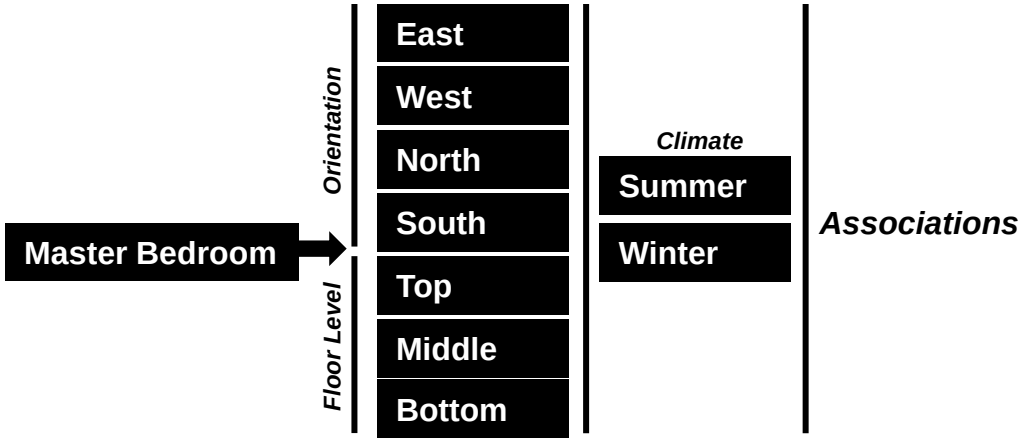


Master Bedroom (Summer)

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	PE-M	IF-M	38.00	**94.74**	1.32
2	FE-M	FF-M	38.00	**94.74**	1.48
3	HC-L	IF-M	32.00	**93.75**	1.30
4	PC-M	IF-M	42.00	**90.48**	1.26
5	FC-L	IF-M	40.00	**90.00**	1.25
6	QE-M	FF-M	34.00	**88.24**	1.38
7	QE-M	IF-M	34.00	**88.24**	1.23
8	TC-M	IF-M	34.00	**88.24**	1.23
9	TE-M	IF-M	32.00	**87.50**	1.22
10	AC-M	EF-H	48.00	**87.50**	1.46
11	CE-M	IF-M	46.00	**86.96**	1.21
12	KE-M	IF-M	30.00	**86.67**	1.20
13	EC-M	IF-M	44.00	**86.36**	1.20
14	CC-M	IF-M	42.00	**85.71**	1.19
15	GC-M	IF-M	54.00	**85.19**	1.18
16	FC-L	EF-H	40.00	**85.00**	1.42
17	GE-M	IF-M	50.00	**84.00**	1.17
18	MC-M	VF-L	36.00	**83.33**	1.54
19	MC-M	FF-M	36.00	**83.33**	1.30
20	GE-L	MF-H	36.00	**83.33**	1.19
21	UE-L	MF-H	48.00	**83.33**	1.19
22	EE-M	IF-M	48.00	**83.33**	1.16
23	RE-M	IF-M	70.00	**82.86**	1.15
24	LC-M	IF-M	70.00	**82.86**	1.15
25	HE-L	IF-M	46.00	**82.61**	1.15
26	GC-L	JF-H	34.00	**82.35**	1.58
27	GC-L	MF-H	34.00	**82.35**	1.18
28	CC-H	VF-L	34.00	**82.35**	1.53
29	CC-H	TF-H	34.00	**82.35**	1.33
30	QE-M	EF-H	34.00	**82.35**	1.37
31	BC-M	IF-M	44.00	**81.82**	1.14
32	ME-M	FF-M	44.00	**81.82**	1.28
33	SE-M	IF-M	76.00	**81.58**	1.13
34	NC-M	IF-M	54.00	**81.48**	1.13
35	FE-L	IF-M	54.00	**81.48**	1.13
36	HC-L	UF-M	32.00	**81.25**	1.31
37	JE-M	IF-M	42.00	**80.95**	1.12
38	HC-M	IF-M	52.00	**80.77**	1.12
39	NE-M	IF-M	52.00	**80.77**	1.12
40	LE-M	IF-M	62.00	**80.65**	1.12
41	SC-M	IF-M	72.00	**80.56**	1.12
42	NC-L	MF-H	30.00	**80.00**	1.14
43	KE-M	FF-M	30.00	**80.00**	1.25
44	EE-H	NF-H	30.00	**80.00**	1.54
45	FC-M	FF-M	50.00	**80.00**	1.25

if* – – – – → *then

Antecedent	Consequent	Support %	Confidence %	Lift
Indoor Climate Control Comfort Feelings Medium	Space Usability Future Preference **High**	48	85	1.42
Aesthetics Quality Comfort Feelings Low	Cleanliness Future Preference **High**	34	82	1.58
Air Quality (Dust) Comfort Feelings Low	Natural Ventilation Future Preference **High**	30	80	1.14
Daylighting Physical Condition Medium	Social Interaction Future Preference Medium	30	86	1.20



BE-H = Privacy of Existing condition >>> High

BC-M = Privacy of Perceived comfort level >>> Medium

BF-L = Privacy of Future preference >>> Low

First Letter				Second Letter		Third Letter	
Code	**Spatial Factors**	**Code**	**Environmental Factors**	**Code**	**Factors**	**Code**	**Factors**
A	Indoor Climate Control	K	Daylighting Quality	E	Existing Condition	L	Low
B	Privacy	L	Artificial Lighting Quality	C	Comfort Feeling	M	Medium
C	Functional Identity	M	Natural Ventilation	F	Future Preference	H	High
D	Safety and Security	N	Air Quality (Dust/Pollution)				
E	Space Usability	O	Indoor Temperature				
F	Changeability (Variety)	P	Acoustical Quality				
G	Aesthetics Quality	Q	Smell/Odors Quality				
H	Flexibility of Choice	R	Texture & Color Quality				
I	Interaction and Sociability	S	Quality of Materials				
J	Cleanliness	T	Outdoor Connectivity				
		U	Indoor Natural Elements				
		V	Microbe & Mold Growth				

Antecedent <> **Physical Condition** / **Psychological Condition**

Consequent <> **Future Preferences**

East

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	VC-H	KF-H	54.55	100.00	1.83
2	IC-M	EF-H	63.64	85.71	1.35
3	IC-M	JF-H	63.64	85.71	1.35
4	IC-M	CF-H	63.64	85.71	1.35
5	AC-M	DF-H	54.55	83.33	1.53
6	AC-M	EF-H	54.55	83.33	1.31
7	AC-M	JF-H	54.55	83.33	1.31
8	AC-M	CF-H	54.55	83.33	1.31
9	JE-H	KF-H	54.55	83.33	1.53
10	FC-M	KF-H	54.55	83.33	1.53
11	CE-M	KF-H	54.55	83.33	1.53

West

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	TE-L	MF-H	50.00	100.00	1.17
2	AC-M	MF-H	50.00	100.00	1.17
3	EC-M	MF-H	50.00	100.00	1.17
4	UE-L	MF-H	71.43	90.00	1.05
5	RC-M	MF-H	71.43	90.00	1.05
6	LC-M	MF-H	71.43	90.00	1.05
7	VE-L	MF-H	71.43	90.00	1.05
8	NC-M	MF-H	71.43	90.00	1.05
9	RE-M	AF-H	71.43	90.00	1.26
10	RE-M	MF-H	71.43	90.00	1.05

South

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	IE-M	TF-H	78.57	90.91	1.16
2	IE-M	MF-H	78.57	90.91	1.16
3	VE-L	GF-H	78.57	90.91	1.16
4	FC-M	SF-M	71.43	90.00	1.40
5	IC-M	TF-H	71.43	90.00	1.15
6	IC-M	MF-H	71.43	90.00	1.15
7	UC-M	TF-H	71.43	90.00	1.15
8	UC-M	MF-H	71.43	90.00	1.15

North

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	QE-M	EF-H	54.55	100.00	1.57
2	LC-M	EF-H	72.73	87.50	1.38
3	SC-M	EF-H	63.64	85.71	1.35
4	IC-M	EF-H	63.64	85.71	1.35
5	IE-M	EF-H	63.64	85.71	1.35

Master Bedroom (Summer)

Top

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	LE-M	MF-H	62.50	100.00	1.23
2	KC-H	MF-H	62.50	90.00	1.11
3	LE-M	TF-H	62.50	90.00	1.20
4	SC-M	EF-H	68.75	81.82	1.45
5	SC-M	CF-H	68.75	81.82	1.31
6	OE-M	MF-H	68.75	81.82	1.01
7	LC-M	MF-H	68.75	81.82	1.01

Middle

SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	HE-L	JF-H	43.48	80.00	1.84
2	AC-M	EF-H	43.48	80.00	1.42
3	PC-L	MF-H	43.48	80.00	1.31

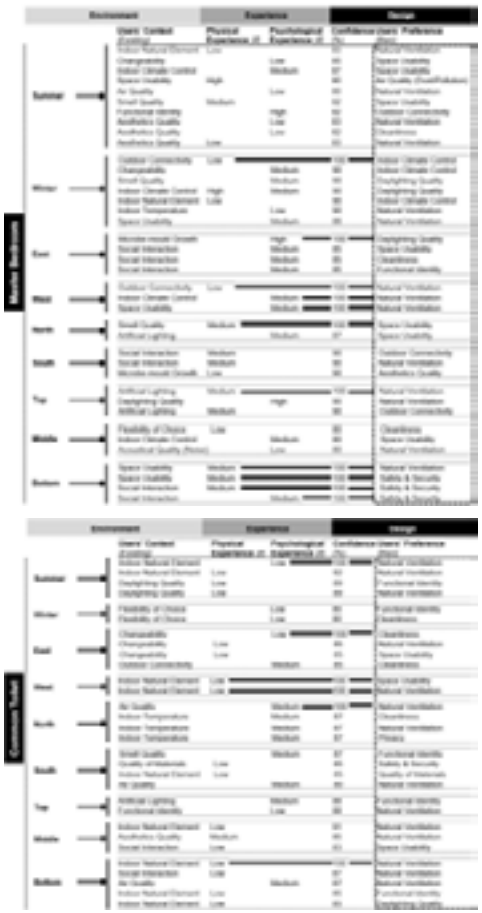
Bottom

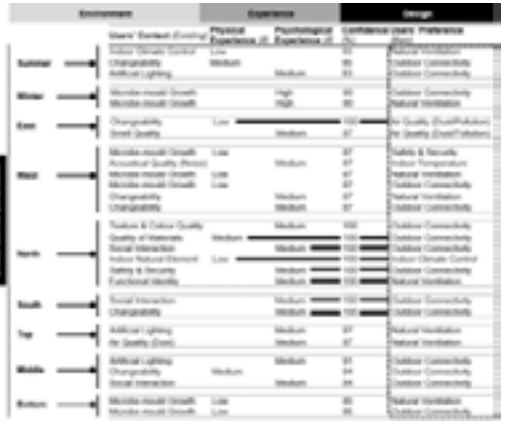
SN	Antecedent	Consequent	Support %	Confidence %	Lift
1	EE-M	MF-H	63.64	100.00	1.38
2	EE-M	DF-H	63.64	100.00	1.22
3	IE-M	DF-H	72.73	100.00	1.22
4	IC-M	DF-H	72.73	100.00	1.22
5	SC-M	DF-H	81.82	88.89	1.09
6	LE-M	DF-H	81.82	88.89	1.09

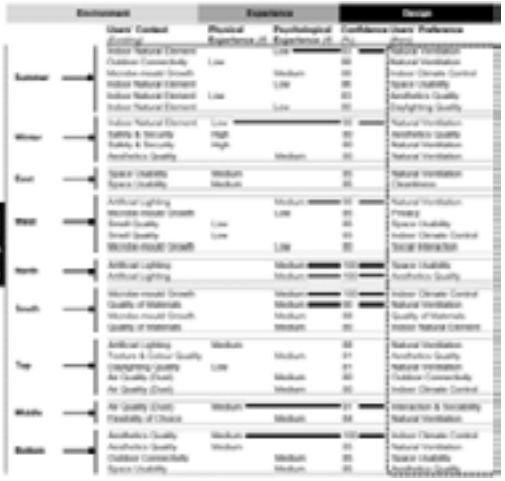
Interpretation

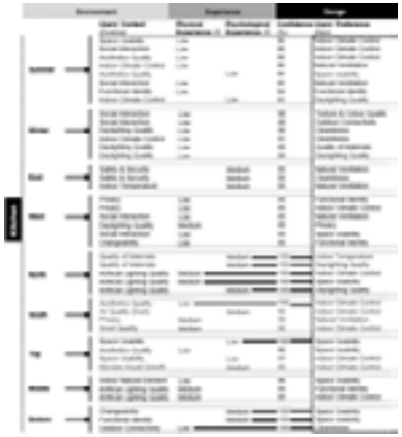
From Occupants' Experience to Design Customisation

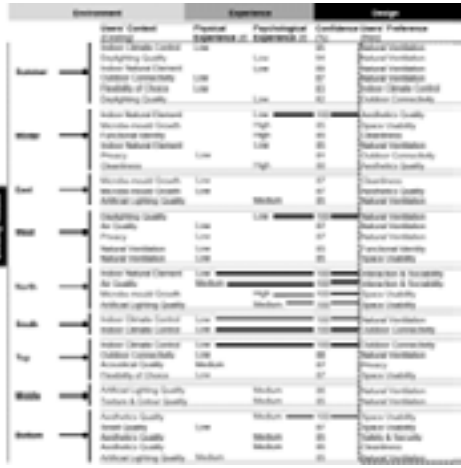
Domestic Environment

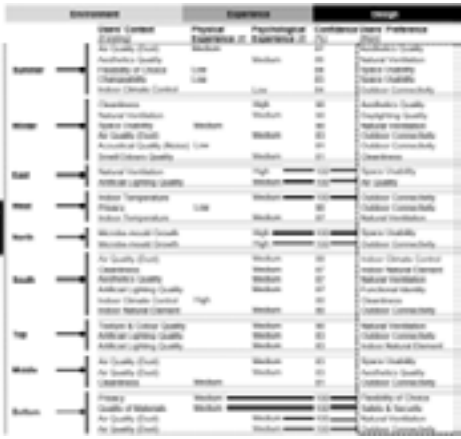






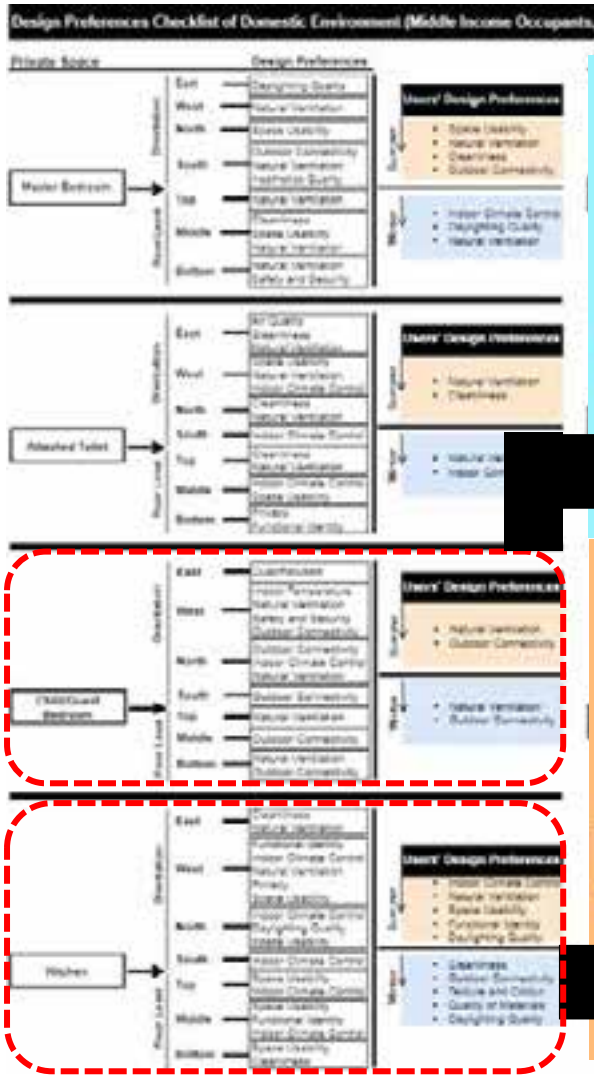


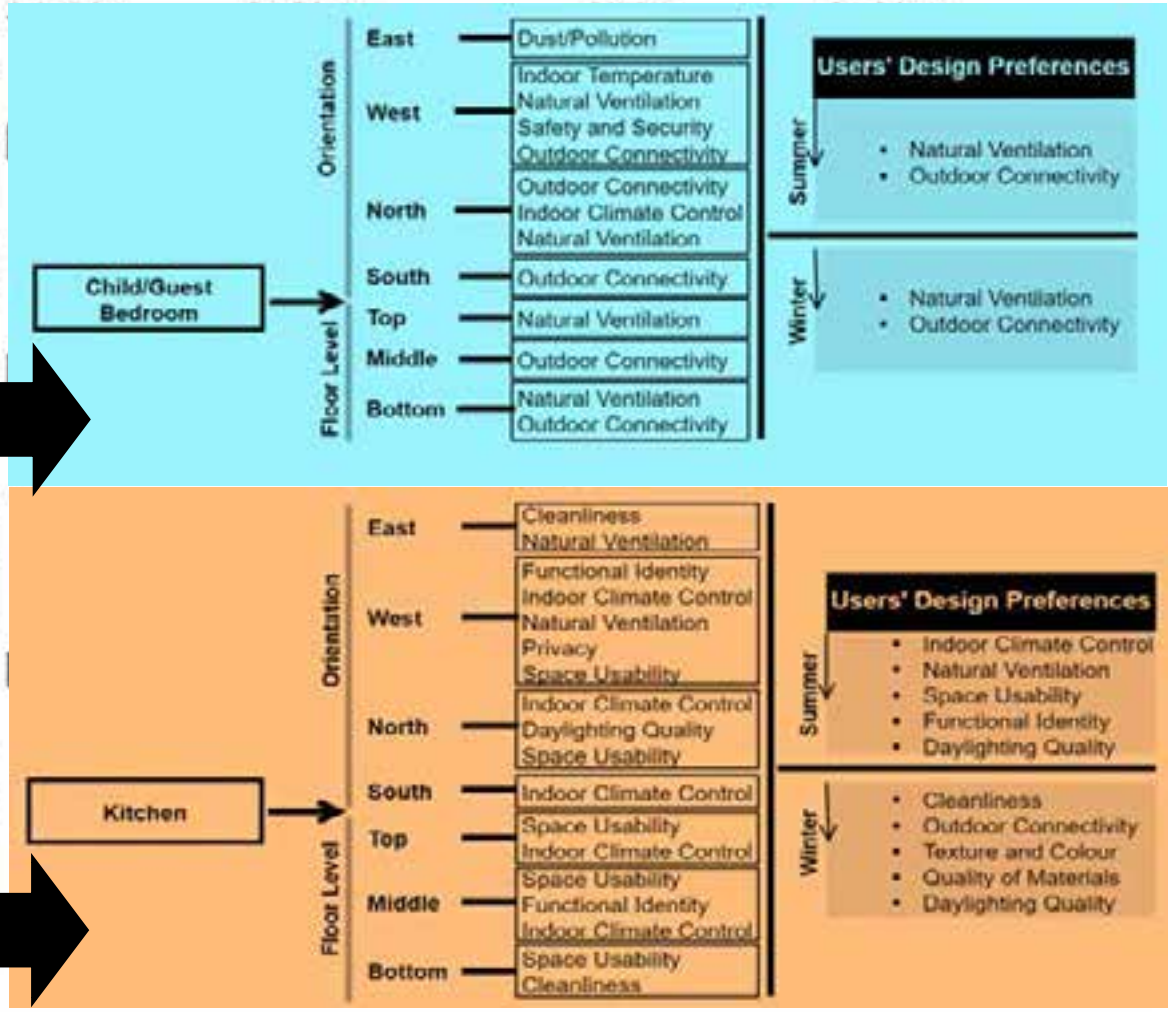




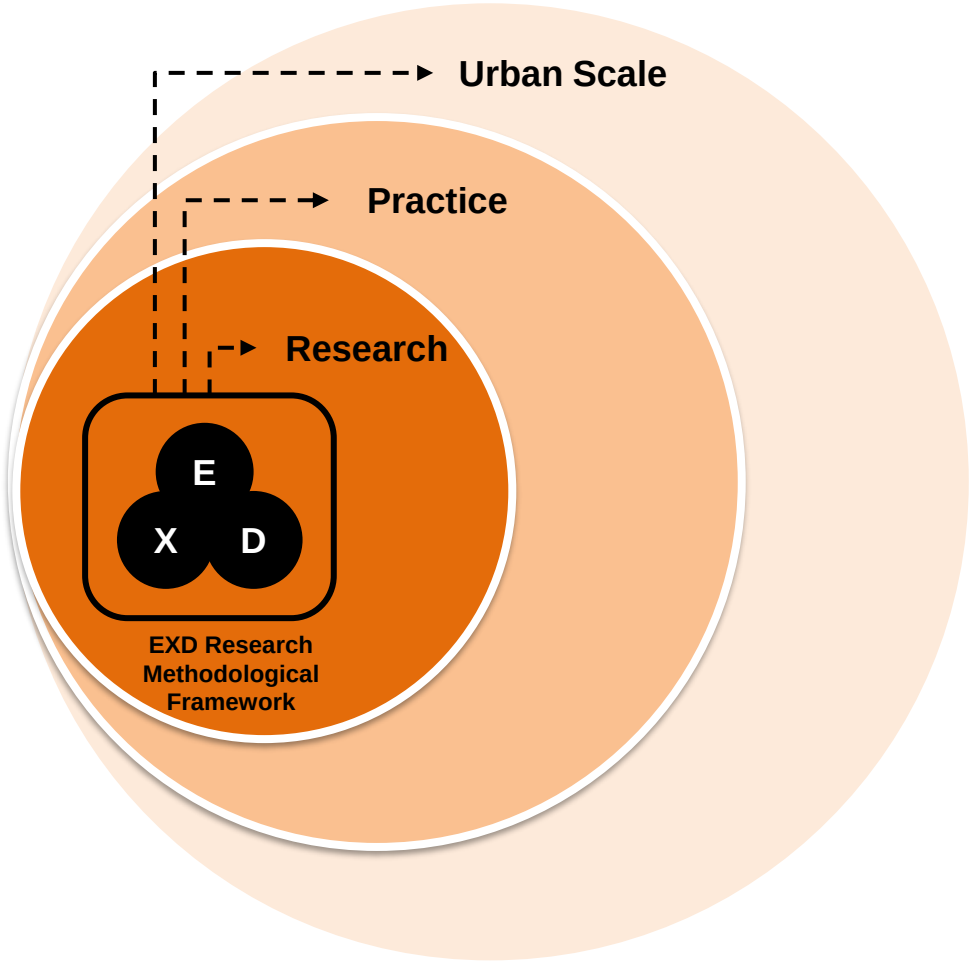
msd

Domestic Environment





Future Environmental Experience Design Research Trajectory



THE UNIVERSITY OF MELBOURNE

ZEMCH EXD Vertical Subdivision R&D

ZEMCH NETWORK

encyclopedia

MDPI

Entry

Re-Conceptualizing Vertical Subdivision Development for Sustainable, Affordable Housing Delivery

Nathan Tetteh * and Masa Noguchi

ZEMCH DDP Lab, Faculty of Architecture, Building and Planning, The University of Melbourne, Melbourne, VIC 3010, Australia; masa.noguchi@unimelb.edu.au

* Correspondence: n.tetteh@unimelb.edu.au

Definition: Research on sustainable, affordable housing is evolving. Yet, its conceptual efficacy in light of the changing needs of today's cities and targeted low-to-middle-income households remains unknown. In today's rapidly urbanizing world, understanding the conceptual relevance and importance of land use planning tools such as vertical subdivision to the delivery of sustainable housing is tenable. In response to this knowledge gap, this entry inquires, how can the delivery of affordable housing be configured in a manner that leverages the potential of a redefined vertical subdivision development to optimize densities and ensure that housing affordability is sustainable? Here, this entry re-defines vertical subdivision development as a housing planning and design tool that allows for the segregation of air spaces into individual volumetric land parcels that mimic the environmental features of the land-on-ground, such that housing construction within such volumetric spaces is a function of the contextually relevant needs of occupants. This entry demonstrates a paradigm shift from existing housing infrastructure planning models and narratives to one that responds to and addresses all three dimensions of sustainability: economic (sustainable affordability), environmental (sustainable densities), and social (occupant wellness) in the housing infrastructure planning and delivery process.

Keywords: vertical subdivision development; sustainable; affordable housing; densities; affordability; wellness

check for updates

Citation: Tetteh, N.; Noguchi, M. Re-Conceptualizing Vertical Subdivision Development for Sustainable, Affordable Housing Delivery. *Encyclopedia* **2024**, *4*, 256–272. https://doi.org/10.3390/encyclopedia4010020

Academic Editor: Raffaele Barretta

Received: 19 September 2023
Revised: 28 January 2024
Accepted: 1 February 2024
Published: 4 February 2024

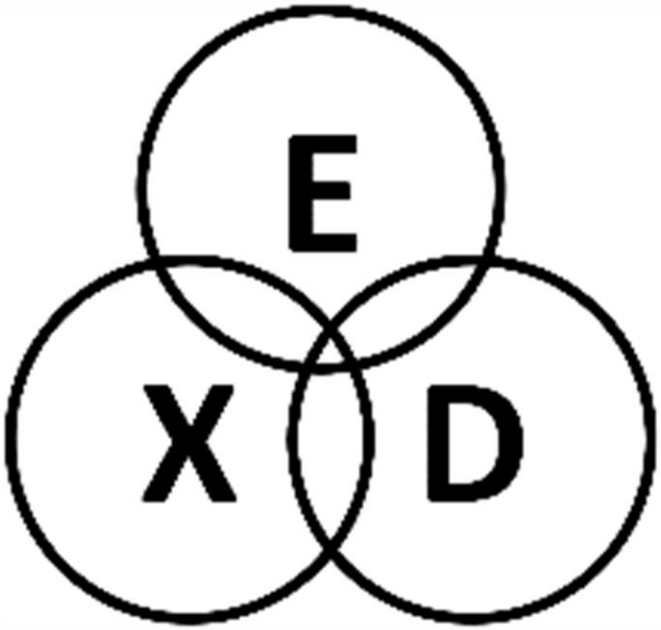
1. Introduction

The trend of urbanization in today's cities complicates the challenges relating to access to housing and poses threats to the well-being of many urban residents. Worldwide, governments often resort to affordable housing as one of the several approaches to providing adequate housing units for their city inhabitants [1,2]. In the literature, affordable housing is often described by its main supply motive of improving housing affordability, often among low-to-middle-income households who are limited in their ability to compete in the mainstream housing market [3–6]. In most cases, this category of target households falls within the bottom 40% of the income distribution spectrum within the city [7,8]. The common measure of housing affordability is that occupants of a given household should ideally spend no more than 30% of their income on housing costs, such that other basic non-housing needs can be afforded [3,6]. The price-to-income index is criticized as overly focused on economic intentions [9–10], yet it still dominates planning decisions today as it allows attention to be paid to the acquisition and operation cost barriers that many low-to-middle-income households face in the housing market [11,12].

With the advent of sustainability thinking toward the end of the 1980s, scholars argue that the science and policy of affordable housing should extend beyond price-to-income affordability assessments to include the extent to which the housing delivery process and its outcome respond to the broader needs of the occupants [13,14]. The concerns stem from the fact that occupants of affordable housing units, like any other urban dweller, require

ZEMCH

Humanity and Sustainability



Big Thank you