

# THE DEEP-PERFORMANCE DWELLING

ASHRAE Presentation  
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**TEAM MONTREAL**  
**DEEP-PERFORMANCE DWELLING**

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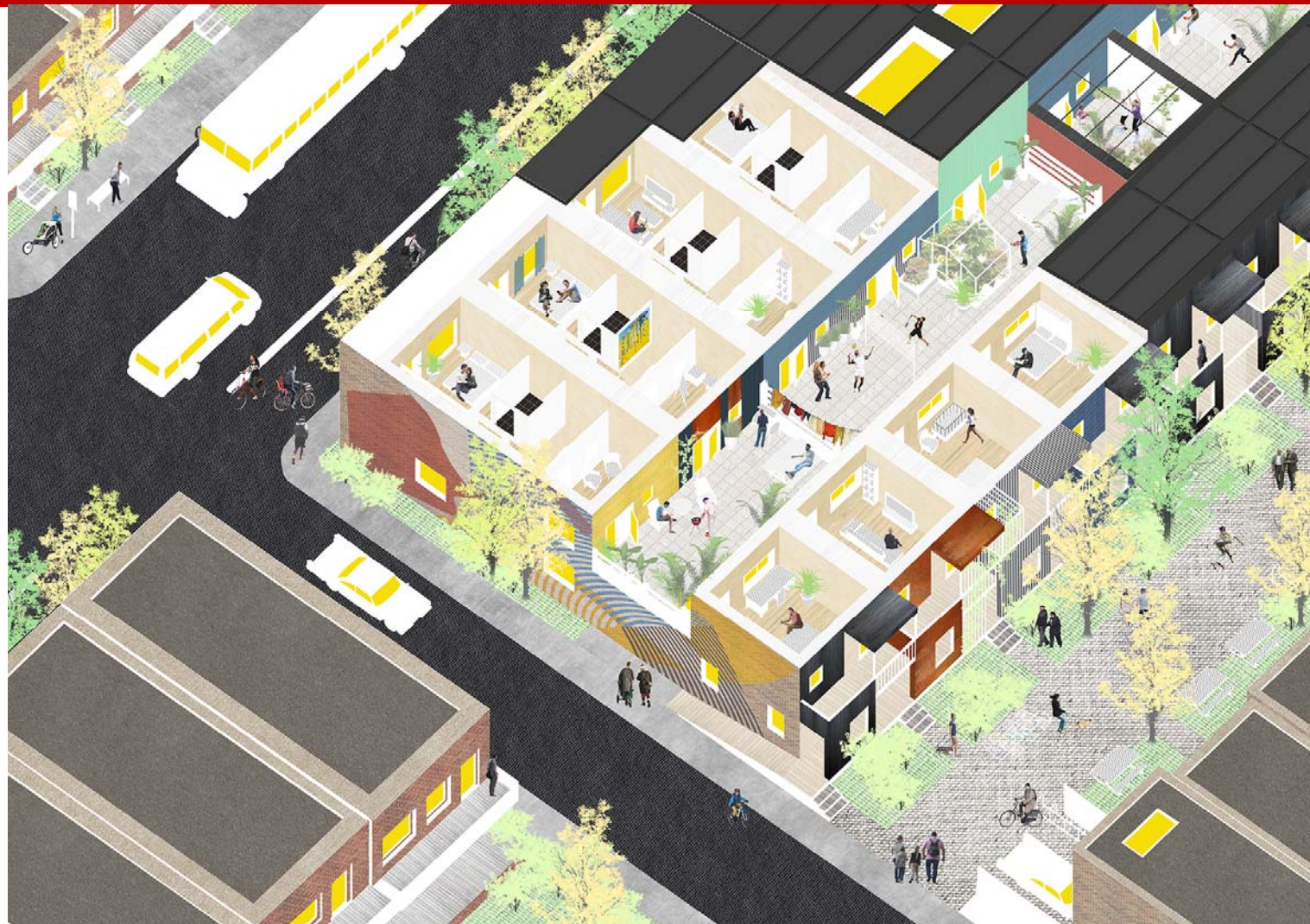


## DEEP-PERFORMANCE DWELLING URBAN DENSITY & RESILIENCE

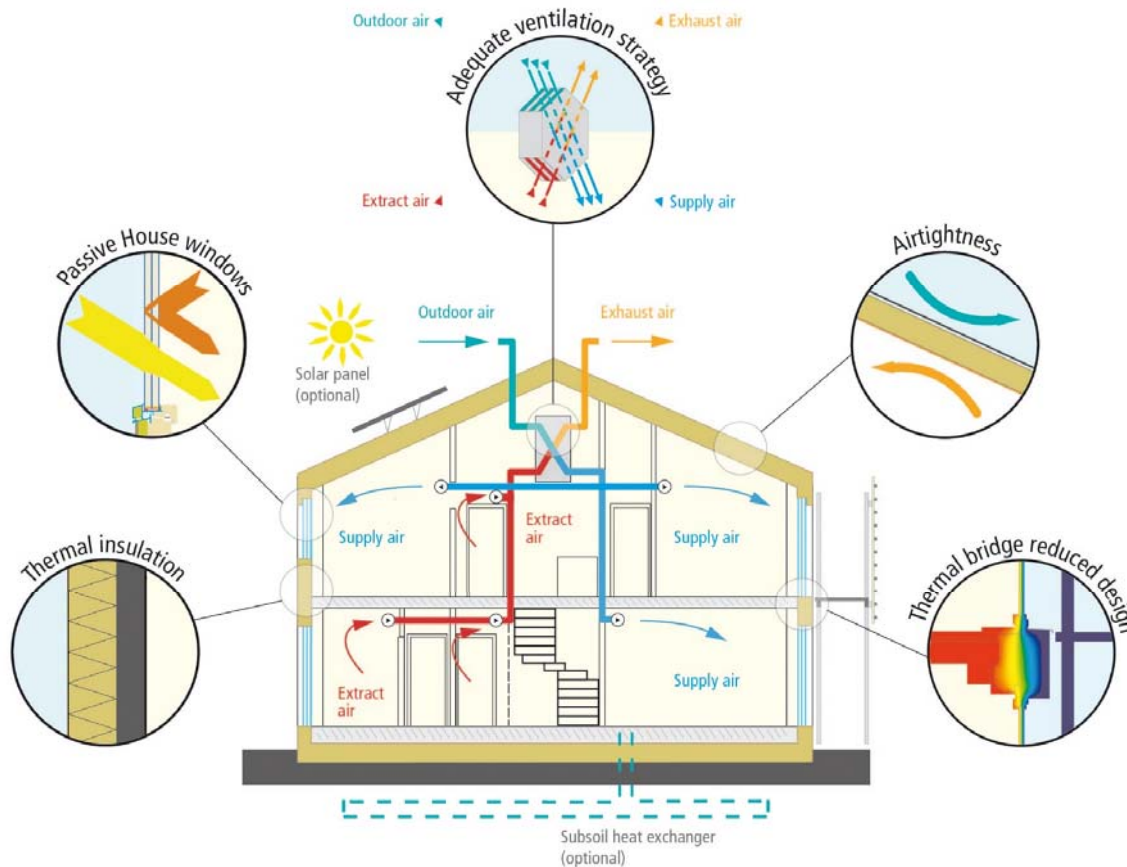
### URBAN DENSITY AND AFFORDABLE HOUSING

The majority of the world's population now lives in cities and the rapid urbanization shows no indication of abating. A 2010 study for UN Habitat, estimated that by 2030 there will 3.5 times the amount of new construction worldwide as the current building stock in the US. In North America, movement to urban centers has outpaced that to suburbia for the first time since the mid-twentieth century. The Deep-Performance Dwelling is intended as an urban single-family home that answers the pressing **global challenge to provide affordable and robust housing in cities that must achieve greater environmental and cultural sustainability, livability, and social equity**. It includes layers of private/shared/public space (designed for high quality, healthy urban living).

**“DEEP” performance means a socially, culturally, and technologically sophisticated architecture built for 21st century urban life.**



## DEEP-PERFORMANCE DWELLING PASSIVE HOUSE PRINCIPLES



### **BUILDING FORM**

A compact building form with a low thermal envelope surface area to building volume ratio. Orientation is significant.

### **SUPER INSULATION**

Continuous high R value insulation across the floors, walls, and roof of the thermal envelope.

### **AIRTIGHTNESS**

Continuous air barrier ensures that the building does not 'leak' beyond 0.6 ACH at 50 pascals of pressure.

### **HIGH-PERFORMANCE DOORS AND WINDOWS**

Superior insulation values and solar heat gain coefficients. Opening size and orientation significant.

### **MITIGATION OF THERMAL BRIDGING**

Careful detailing to prevent compromise of envelope by thermally conductive materials.

### **VENTILATION WITH HEAT RECOVERY**

High-efficiency Heat Recovery Ventilation or Energy Recovery Ventilation system controls air circulation.



## DEEP-PERFORMANCE DWELLING PASSIVE HOUSE PRINCIPLES

### THERMAL ENVELOPE COMPOSITION

#### ROOF ASSEMBLY (INTERIOR TO EXTERIOR)

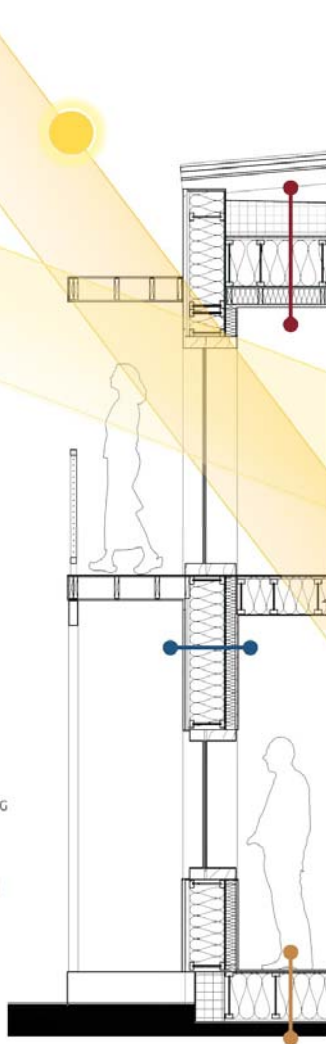
- 5/8" PLYWOOD PANELING CEILING FINISH
- 2X6" RAFTER, 24" O.C.,  
WITH 5.5" MINERAL WOOL INSULATION
- 3.4" ZIP SHEATHING (AIR AND VAPOR BARRIER)
- 16" OPEN-WEB I-JOIST, 24" O.C.,  
WITH 15.5" MINERAL WOOL INSULATION
- 3.4" ZIP SHEATHING
- TAPERED RIGID INSULATION (12" TO 2.3" THICK)

#### WALL ASSEMBLY (INTERIOR TO EXTERIOR)

- 5/8" PLYWOOD PANELING INTERIOR FINISH
- 3/4" OSB PANEL
- 2X4" STRUCTURAL STUD WALL, 24" O.C.,  
WITH 3.5" MINERAL WOOL INSULATION
- 3.4" ZIP SHEATHING (AIR AND VAPOR BARRIER)
- 12" OPEN-WEB I-JOIST, 24" O.C.,  
WITH 1 1.5" MINERAL WOOL INSULATION
- 1X3" VERTICAL STRAPPING
- 1X3" HORIZONTAL STRAPPING
- 1/2" CHARRED EASTERN WHITE CEDAR CLADDING

#### FLOOR ASSEMBLY (INTERIOR TO EXTERIOR)

- 3/8" ENGINEERED WOOD FLOORING
- 3/4" ADVANTECH SUBFLOOR
- 3.4" ZIP SHEATHING (AIR AND VAPOR BARRIER)
- 16" I-JOIST, 24" O.C.,  
WITH 15.5" MINERAL WOOL INSULATION
- 3.4" ZIP SHEATHING



### R VALUES

Walls: **60**

Floor: **60**

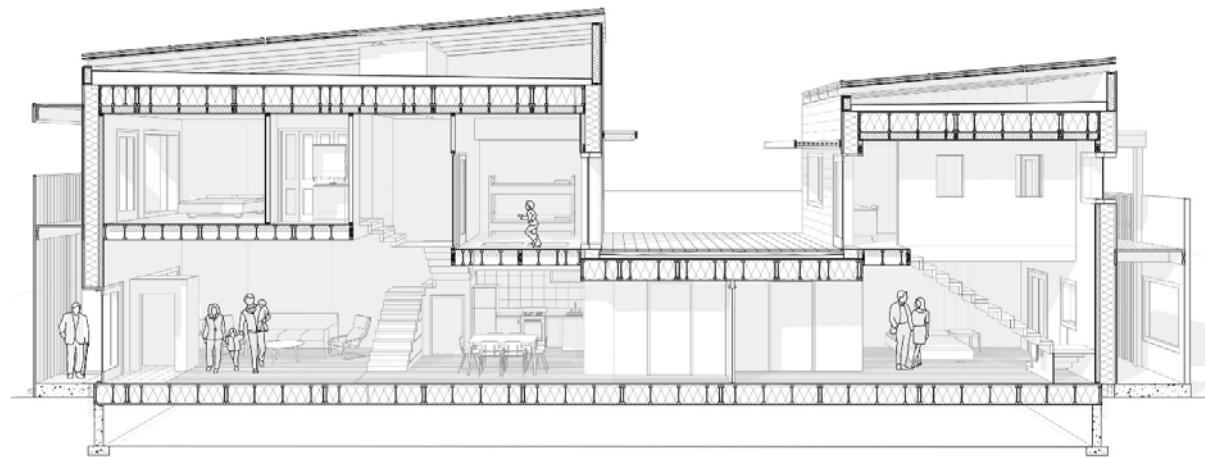
Roof: **100**

Exposed surface area to volume ratio: **0.6**

Air Changes per Hour @ 50 Pascals: **0.35**

ERV SRE @ 64CFM & 0°C: **84%**

Space Heating Energy Demand: **<15 kWh/m²yr**



DEEP-PERFORMANCE DWELLING  
**PASSIVE HOUSE PRINCIPLES**



**HIGH-PERFORMANCE DOORS AND WINDOWS**

Triple glazed  
Argon fill  
Low emissivity glazing  
Thermally broken  
U value (window): 0.9  
G value (window): 0.35  
Visual Light Transmittance: 55%

**HIGH-PERFORMANCE SKYLIGHT**

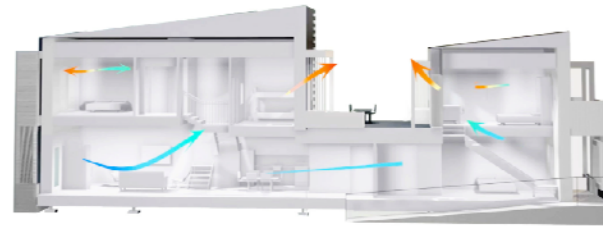
Aerogel fill  
Thermally broken  
U value (window): 0.05  
G value (window): 0.27  
Visual Light Transmittance: 20%



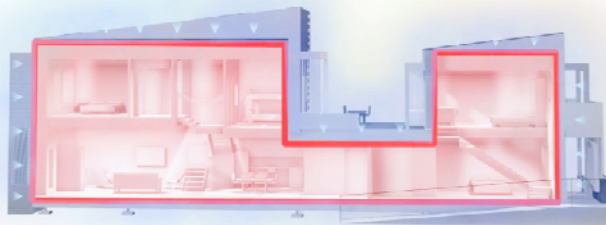
## DEEP-PERFORMANCE DWELLING PASSIVE HOUSE PRINCIPLES



AIR-TIGHTNESS



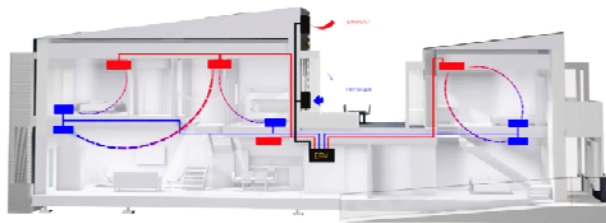
NATURAL VENTILATION



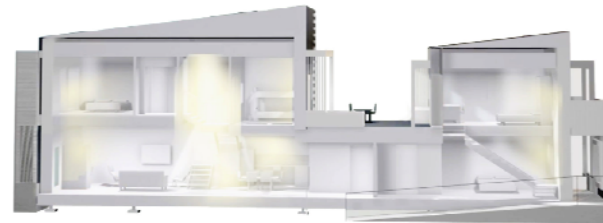
SUPER-INSULATED



SOLAR HEAT GAINS

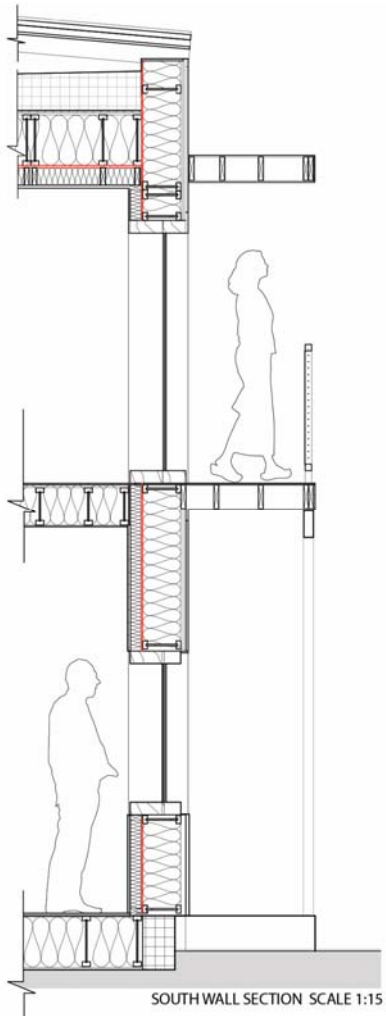


ENERGY RECOVERY SYSTEMS



NATURAL LIGHT

## DEEP-PERFORMANCE DWELLING PASSIVE HOUSE PRINCIPLES



The DPD fits into today's sharing economy while providing resilient architectural solutions to urban density and sustainability challenges.

BY 2050,

**82%**

OF THE WORLD POPULATION  
IS EXPECTED TO LIVE IN  
CITIES

THE DPD CONSUMES

**70-80%**

LESS ENERGY THAN  
CONVENTIAL  
CONSTRUCTION

TeamMTL has designed a **high performance envelope** that results in superior, **healthy indoor air quality & comfort** (air tightness + low flow, continuous, filtered fresh air exchange). The **"fabric first"** and Passive House inspired approach results in a **70-80% reduction in energy demand** (super insulated, no thermal bridging, airtight, high-performance windows/doors).

The 'rain screen' tectonic strategy addresses **infinite variability in cladding** options that is flexible and adaptable for aesthetic preferences, neighbourhood by-laws, local materials, context, and so on.

The Deep-Performance Dwelling is an innovative exemplar that represents a possible **future of affordable housing** in Montreal, Quebec, Canada, and abroad.

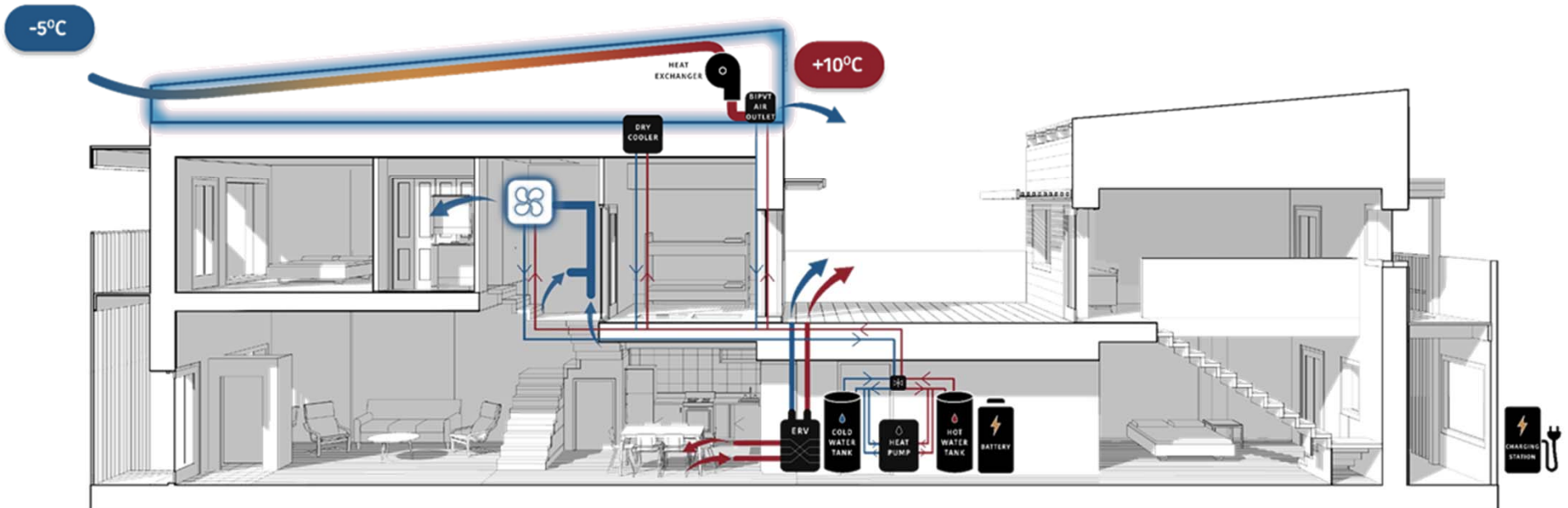


## REDUCE

Reducing energy consumption at the source is the first step towards NZEBs (DPD total gross electricity consumption: 50 kWh/m<sup>2</sup>/year, space heating energy demand: 10 kWh/m<sup>2</sup>/year)

## RE-USE

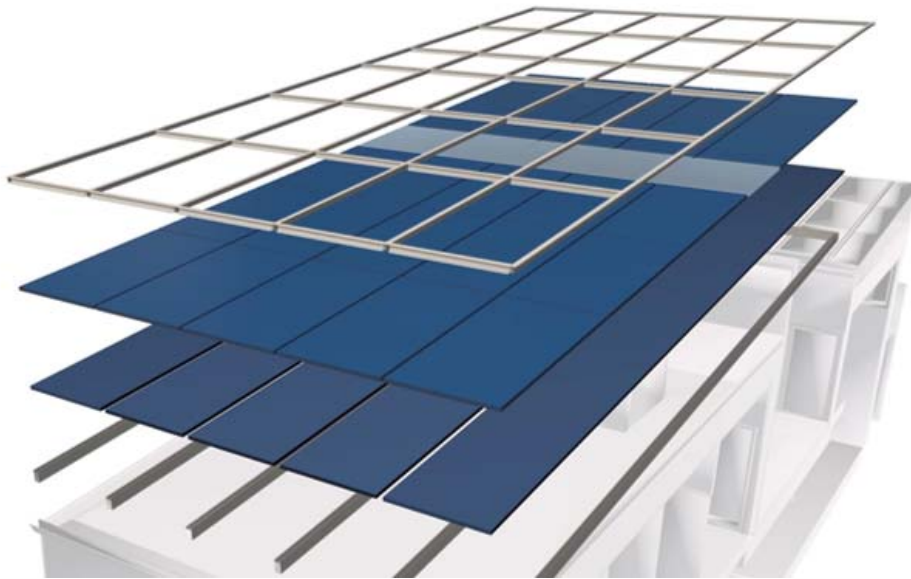
Re-using as much energy as possible: energy recovery ventilator, heat pump domestic hot water heater, desuperheater, solar heat harvesting, grey water heat recovery





DEEP-PERFORMANCE DWELLING

## BUILDING INTEGRATED PHOTOVOLTAIC/THERMAL (BIPV/T)



### Moving towards standardization

- Curtain wall technology applied to BIPV and BIPV/T
- Integrated skylight
- Cutting down installation time
- Full architectural integration
- Heat harvesting capability



## PV & PV/T SYSTEM CHARACTERISTICS

- 40 poly-crystalline modules (12 kW peak capacity)
- 12 000 kWh yearly production (for as-built tilt angle)
- 2x 6.8kW grid-tie inverters
- 10 kWh Li-ion battery
- Custom built manifold coupled to air-to-water heat exchanger



## Buildings are solutions to the problems they create

### OPPORTUNITIES

Resilience

Increased network production capacity

Favorises electrification

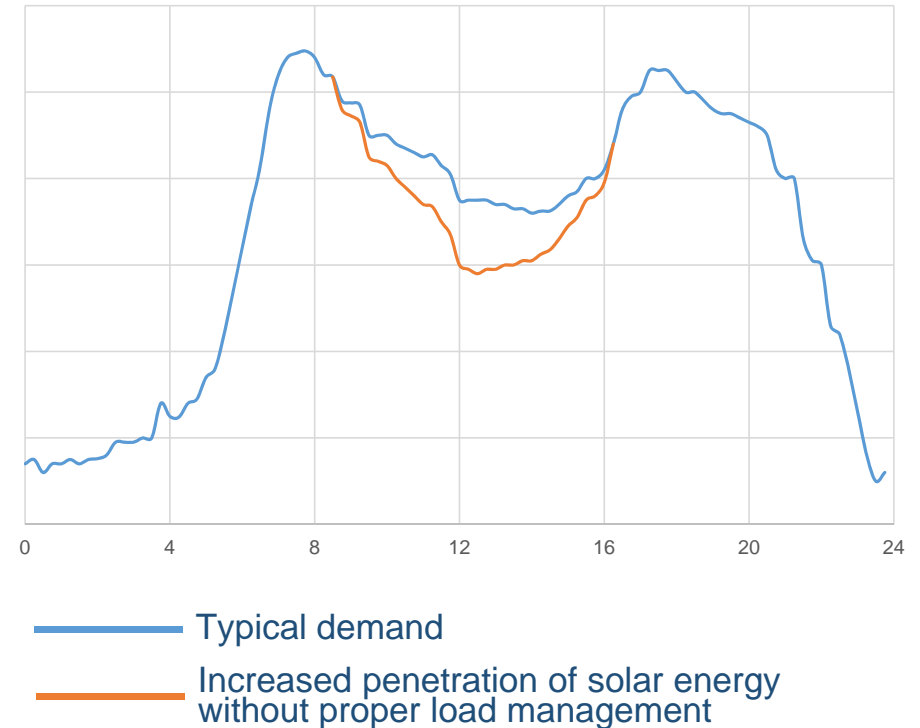
### CHALLENGES

Intrinsic variability of solar resources

Load management

Solution:  
**Flexibility**

Daily Winter Electrical Demand Pattern in Qc





## Dynamic Price Signal Acting on Three Levels

### **THERMAL FLEXIBILITY**

Building mass

Active TES (dual  
450L water  
storage tanks)

### **ELECTRICAL FLEXIBILITY**

10 kWh Li-ion  
Battery in this  
case

Possibility or re-  
using used EV  
batteries

### **OCCUPANTS BEHAVIOR**

Laundrying

Cooking

Dishwashing

Smart Appliances

Imperceptible to the  
occupants

Variable pricing scheme and load-matching will benefit users, communities and utility companies

## Smart-Grid Enablers

Real-time communication with utility

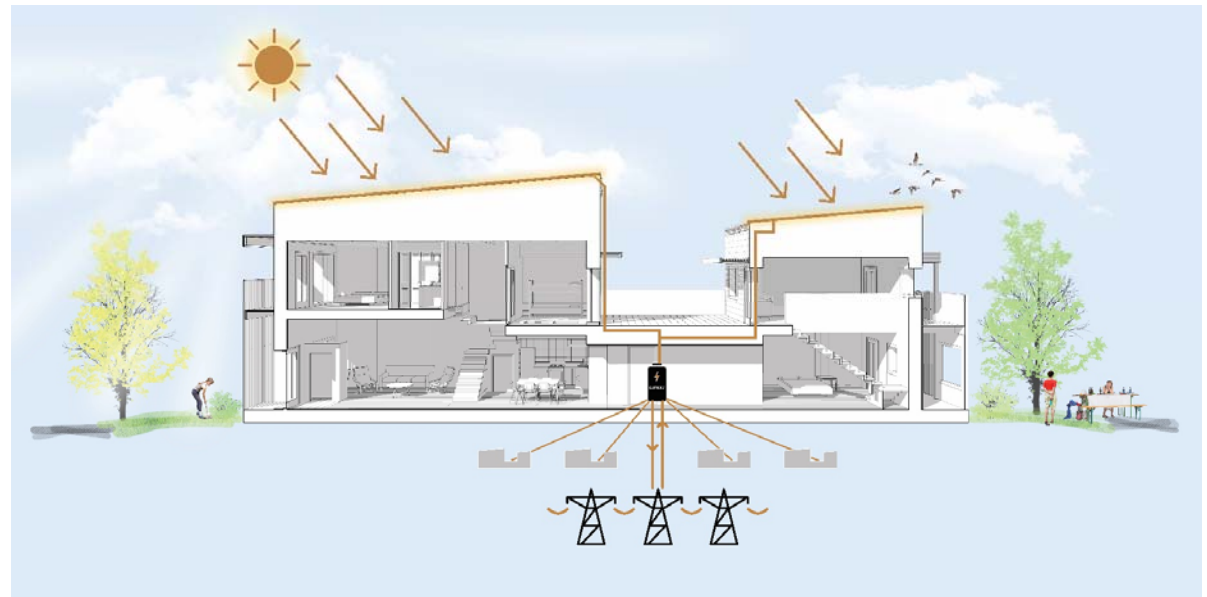
Simplicity

Consumption/production feedback from the building to users and utility

Load shifting capability of buildings and occupants

Price incentives

Minimal to no user discomfort



DEEP-PERFORMANCE DWELLING  
**ACHIEVEMENTS AND LESSONS-LEARNED**

Students training and hands-on experience  
Application and demonstration of research concepts  
Knowledge transfer

Keys to success:  
Collaboration between disciplines at early stages  
Well-rounded professionals

Discussion:  
Integration of new technologies: Who will be in charge?  
Liability, authority, specifications of emerging technologies.  
Less compartmentalization as a solution?

