P4

Van Gendt Halls with Solar Energy
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Tutors

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Energy strategy of my proposal can be arranged in a 4-step pyramid that also follows the procedure of design process.
Renewable energy goals for Amsterdam 'Islands

Sun: Cleanest Cheapest Natural Climate Comfort Sustainable

Background Research Program Integration of Solar Energy -(ZEB)
Renewable energy goals for Amsterdam Islands

City and Context: New Energy Program for Islands
Renewable energy goals for Amsterdam 'Islands

City and Context: Need to add another layer in Van Gendthallen: Solar Energy
**Goals:** To promote the use of active solar energy into high quality architecture

**Solar Technologies for Building**

- Active
  - Solar Thermal
  - DHW/Space Heating
  - Photovoltaic
    - Electricity

**Background**

Research    Program    Integration of Solar Energy -(ZEB)
**Problem Statement:** Architectural Integration of BIVP  
(Implementation of Integration Criteria)

- **High Quality of Architecture**
  - **Formal (Aesthetic)**
    - transparent/opaque – monolayer/ multilayer – moving/fixed
  - **Function**
    - Multifunction/Envelope function
  - **Construction**
    - Load bearing/resistance/ safety

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**Back ground**

Research Program Integration of Solar Energy -(ZEB)
BIPV Integration in Building Envelope
Building Analysis

Façade Problems

South Façade (Hall.1)

A. Recessed windows with single glass – one closed with bricks – Broken Glass

B. Rotten wooden Cornice

C. Rotten wooden door

D. Masonry cracks and graffiti

Photo source: http://desp-o-ina.com/ongoing/Van-Gendt-Hallen-HUB-offices-12/

Back ground Research Program Integration of Solar Energy -(ZEB)
Building Analysis

1896 construction - Bricks with single glass windows and steel frame

Photo Source: RMIT Group
Building Analysis

Van Genthallen second entrance (new addition)

West Façade (Hall 1)

Latest added windows – different pattern

West façade’s Openings towards water, Photos: Willem Velthoven album

Façade Problems
Energy losses through Skin (No Insulation)

Section of west facade

U = 4.3

Single glass window with steel frame (Without insulation)

Background Research Program Integration of Solar Energy - (ZEB)
Building Analysis

Zinc Gutter joints with tiles – not working

Roof Problems

Wired Glass laid on steel rods -85% broken

On the top part of the top ridge lead slabs are used to take care of the rain. Presently heavy leakage.

Heat losses in winter

Photo Source: RMIT Group
Overall Energy Losses and Overheating in %age

**Conclusion:**
Facades and roofs have significant potential for solar systems integration. Much PV cladding can be considered to be
- Vertical walls
- Slanting Roofs
- Panes of glass to which PV cells are applied.
Solar Energy Design/ Strategy

Passive Techniques: Energy Conservation

1. Optimizing Orientation

Placement of functions for light/ventilation
Solar Energy Design/ Strategy

2. Insulation

3. Air/Water tightness

4. Day Light
Solar Energy Design/ Strategy

5. Ventilation

6. Thermal Mass
Solar Energy Design/ Strategy

Active Techniques: Energy Production

**Building Integrated Photovoltaic (BIPV)**

*Photo - Volt
Light – Electricity*

PV system can be designed to meet any type of electrical requirements regardless the size.

**Electricity production/Grid Connected System**
Optimization of Solar Irradiance Intensity

Using software Metonorm

Solar irradiance in Amsterdam, Research Program

Integration of Solar Energy - (ZEB)
Suitable Technology/Product to gain Maximum results
Van Gendthallen, Amsterdam History

Transformation of building mass (1845 -1922)
Van Gendthallen, Amsterdam History

Material/Impression Changes (1845 -1922)
Use of Space/Functions Changes (1845 -1922)

Former: Factory of Steam engines /railways tools/and iron ships

At Present
Temporary Use of Space
Introducing the new Program

Program Objective: The building is conceived with two primary objectives
1. To serve as a laboratory for the integration of Solar Technologies in existing buildings.
2. To be a hub for the study of Solar energy efficiency and potential application of Innovative Active Solar Technology.
Introducing the New functions

Program: Added Functions

**Primary Functions**
- Offices/research
- Conference
- Labs.
- Expo.

**Secondary Functions**
- Auditorium
- Restaurant
Inspiration

Building 42 ECN Petten
4 Steps Strategy

1. Layout and Flow
2. Skin
3. Systems
4. Self-Sufficiency (ZEB)
Using design to create more area efficient spaces to increase the number of people using the building without compromising comfort levels.

Placing the new function respond to Sun context.

Make it accessible for general public to promote the Solar technology.
Available Space

- The building is open on North-South East-West Axis
- A Pedestrian Promenade is present
Layout and Flow: design process

Add volume/Mass
- All users enjoy abundant access to the outdoors, daylight and a healthy indoor environment to promote productivity.
• Creating flows through the Public and Private /Semi private zones of the building and mark the building entrances.
Accessibility from neighboring context and people flows in the North-South
Layout and Flow: design process

Placement of New Function – Optimize Sun/Natural Climate

- Day Light
- Natural ventilation
- Solar Irradiances
Increasing area: Exploiting height

- Optimizing the existing positioning of windows and roof heights
The new activities are aimed to transform existing the Industrial building into a sustainable, integrated workplace environment and creating the spaces for **Sharing & Promoting Innovative Technology in Public**

**Mixed use of space:**
- Work: Offices
- Public: Conference, lectures, exposition
Office Concept

- Management
- Research
- Technical research

Source: Toronto solar education centre
Office/Space Concept

Open planning – Flexible space
- Open layout
- No corridors

1. Day light

2. One function approach for Ease in Flow in movements

3. Available space for future planning
Open space: Improved technical performance organizational communication and knowledge sharing

Ground Floor  More height available: Relatively occupies more no. of people + equipment
Layout and Flow: design process

Technical Research – West Ground Floor
The office layout - flexible workplace with minimal Close offices

*Easy to exchange of information among co-workers in an open environment*

**First Floor:** Less height available: Relatively occupies lesser no. of people + equipment
Layout and Flow: design process

One function – One floor
Taking shape around the Commons, a variety of open, closed and hybrid meeting spaces accommodate a wide range of work styles, provides maximum flexibility for different project need.
Climate Comfort – Relative positioning of functions

- Passive strategies

East – glare control by blinds

North – Movement

South – set back

West – Buffer zone
Layout and Flow: design process

- Buffer space: Avoiding overheating + Glare

Ground Level layout - West

Technical research place - Buffer zone

Indirect Sun Light
Layout and Flow: design process

Ground level:
More height: more people + equipment

Open able Windows towards courtyard

Quality of air

Summer days

Summer Nights

Technical Research Place

BIPV – Integration
Energy production

Floor height

Layout and Flow

Envelope

Systems
First Level: Research office
Small Height – Lesser work places

Quality of air

Single one sided windows open to courtyard

Floor Height

BIPV – Integration
Energy production

Envelopes

Layout and Flow

Systems
Layout and Flow: design process

- Set back: Avoid overheating
- Curtain Wall: More day light - Openness

Courtyard

South Ground Level
Public access - Movement

Envelopes
Systems
BIPV - Integration
Energy production

Set back + Curtain wall
South Lobby + Conference: A set back layout to avoid over warming
Layout and Flow: design process

- More activity - Cross ventilation

North – Ground Floor Plan
Lobby – Lectures – Public Access
Courtyard

Lobby at ground level

Technology information for Public

Environment
Systems
BIPV – Integration
Energy production
Layout and Flow: design process

- Daylight
- Cross-ventilation

Cross ventilation + east–west day light

Offices on first level
Restaurant at South - West corner

- Access to the Context/Public access
- View
- Adjacent outdoor sitting
Atrium

- The central atrium is the Social Core of the building
- Public space - exposition

Two floors are wrapped around the central shared atrium/courtyard space
Atrium

- Passive Climatization function

Raised Roof for:
- Sun Exposure
- Climate Control

1. Cross ventilation
2. Single-sided ventilation
3. Daylight

A. Sun in Winter, Shade in Summer
B. Pre-Heated ventilation
C. Reduced conduction loss
D. Useful Public space
Layout and Flow: Construction process

Atrium

- Lesser Columns for circulation easement
- Additional columns for support
Atrium
Construction

- Exploit the existing assembly of steel profiles
Layout and Flow: Construction process

Atrium Construction

- Elongate the existing columns
Layout and Flow: Construction process

Atrium
Construction

BIPV - Integration
Energy production
Layout and Flow: Construction process

Atrium Construction

Column Type -D

Deep Plate
Layout and Flow: Construction process

Atrium
Construction
Stiffen the structure – hor./Vert.

- Existing beams
- Elongated beams
- Added column/ beams/bracing
Layout and Flow: Construction process

- Place the existing trusses on raised columns
Layout and Flow: Construction process

- Place the TRANSPARENT cladding
Layout and Flow: Construction process

- Operable glazing all around

Atrium Construction

- Envelope
- Systems
- BIPV - Integration
- Energy production
Layout and Flow: Construction process

- New proposed Sky Light
Open space and view of existing steel structure creates a warm and sustainable environment that reflects and repurposes the historic context of the building.
Transparent (photovoltaic) Skylight is perfectly suitable to maintain the Green Environment

Atrium View from South: Labs windows and green roof
Proposing the new alternative
Transport/connections towards the city
• Designing for easy assembly and disassembly on-site as well as using materials with Low emission
• Ensuring thermal properties and robust detailing that reduces heat loss, balancing thermal properties with daylight availability.
• Designing for building integration rather than attaching of energy producing building elements.
Material
The existing façade combined with new materials with multiple benefits including:
- energy production,
- heat recovery
- and act as integral part of the building

Thermal properties
Ensuring thermal properties and robust detailing that reduces heat loss

Construction
- Internal Insulation
- The glazing elements are BIPV-a modular system that includes frame: easy assembly/disassembly on site.
- Roofs are replaced with lightweight -self-supported panels – BIPV- easily assemble on site.
- Floors: precast panels – can easily install on the existing floors
Envelope: External Wall

Proposed External Wall plan

- **Existing wall**
- **Internal Insulation**
  - Cavity to avoid thermal bridges

Assembly of insulated layers:
- Existing brick wall
- Drained Cavity
- Hydrothermal Material
- Concrete Block
- Metal Stud/Beams
- Cavity Insulation
- Vapour Retarder
- Gypsum board with lites steel
- OSB board
- Metal Stud
- Cavity Closer
- Wood Bush

**Properties of material used**
- Materials with low embodied emissions – wool insulation
- Thermal mass to improve comfort conditions
- **Hydrothermal Material**
  - Protect masonry from damp.
  - Improve the thermal resistance
  - Saving up to 30% energy

**Internal view at insulation breaking point**

**Layout and Flow**
- **Envelope**
- **Systems**
- **BIPV—Integration Energy production**
Envelopes: Windows

- 263 windows with single glass and Steel frame
  Challenge to thermal envelope

**Layout and Flow**

- Envelope
- Systems
- BIPV – Integration
  Energy production

**Insulated Glass Units (IGU)**

- Aluminum Frame
- Wall
- Insulation
Envelope: Windows

Window wall Plan
Envelope: Windows

- **Passive Solar optimization**

- **U-value improved**

Ensure good daylight conditions.

Window height is a result of thermal and daylight optimization.

Optimized the quality of window to avoid heat loss.
Envelop :Floor

- Sound absorption 10 dB
- Weight approx. 18 kg/m²

**Insulated -Concrete Floor System-**

Composite metal deck concrete - radiant floors and traditional rib floors have been combined in this flooring system - reduced the construction weight

U-Value = 0.25 W.m² K
Material - Saving construction

Material: Insulated Glass with Units Building Integrated photovoltaic
Part of the façade – Offers highly efficient window

- Thermal mass to improve comfort conditions
  Leaving exposed concrete ceiling and parts of concrete cores to reduce cooling demand

- Materials with low embodied emissions
  Using glass wool insulation that has lower embodied emissions and low density compared to its thermal performance

- Aluminum Framing
  Using large Aluminum Framing save framing material (aluminum) and reduce thermal bridges

- Insulated – Concrete Floor System
  Composite metal deck concrete - radiant floors and traditional rib floors have been combined in this flooring system - reduced the construction weight
• Building envelope is made to comply with Passive Strategy in terms of heat loss from transmission, infiltration and normalized thermal bridge values.

- U-value for walls: 0.15 W/m²K
- U-value for glass: 0.60 W m²K

Well-insulated, airtight envelope
Facades

Keeping the existing facade cladding is one of the most visible strategies of the design proposal.
Envelope

Layout and Flow

Envelope

Systems

BIPV – Integration
Energy production

South elevation

North elevation
• Using natural flows and biological systems to increase the efficiency of technical systems.
• Using the core of the building for climate control
Systems: Ventilation

- **ERV** (Energy recovery ventilation): to ensure optimal indoor air quality and control moisture

- An integral part of the proposed technical system solution is suspended ceiling and raised floor system for displacement air.

- The proposed external insulated wall has gaps on specific intervals for technical purposes.
**Quality of Air**: The stored warm air in the atrium recirculate down and pre-heat the offices.
Summer strategy

- The higher roof acts as exhaust – stack ventilation, sucking warmed air from office spaces
Systems: Space heating
Concrete/Radiant Floor

- With thermal mass is little fluctuation in temperature
Passive Heating

**Ventilation air heat recovery**
Pre-heated air from the atrium supplied to the spaces.

**ERV ventilation**
Air is supplied at the bottom around the insulation gap in the internal wall to remove stale air, pollutants and humidity.

**Waterborne radiant heating**
A radiant system requires only low water temperature while being highly efficient.
• Integrating energy-producing elements in the building façade to fulfill more than one function, thus reducing material use (e.g. PV as Windows or cladding material).

• Reaching the highest possible level of self-sufficiency (e.g. zero energy building)
BIPV-Envelope: Window

- Old windows replaced by performing windows

**Thin Film Photovoltaic Cells Specifications**

- Incident solar radiations
- PV Cell
- Recovered Electricity
- Recovered heat
- Air gap
- Transparent Glass
- Tampered Glass

**Layout and Flow**

**Envelope**

**Systems**

**BIPV—Integration**

**Energy production**
BIPV-Envelope: Window

- The outer appearance is same as a standard glass used for windows – making it suitable for historical building.

Electricity generation

BIPV Thin film Integration in East-West windows
Envelope: Roof Cladding

Self-supporting Insulated (polyurethane) sandwich panel

U Value = 0.19 W/m²K
BIPV-Envelope: Roof

- Self-supporting Insulated (polyurethane) sandwich panel
- A roof covering system – fully integrated with (BIPV) photovoltaic Modules

Material data:
- Top metal sheet: pre-painted galvanized steel 0.80 mm thick
- Insulating layer: Self-extinguishing polyurethane foam (λ=0.022 W/m K – average density 40 kg/m³)
- Bottom metal sheet: pre-painted galvanized steel
- Junction box: Multi contact line

Technical data:
- Technology: Thin film Triple Junction
- Power (W): 68-144
- Size (mm L.w.t.): 2849 * 5486 * 394 * 4
- Specific power (W/m²): 61.8 - 65.5
- Module weight (Kg/m²): 3.5

Triple Function: Insulation + Photovoltaics + Cladding
BIPV-Envelope: Atrium Skylight

Self supporting Insulated Photovoltaics  Transparent Roof

Building Integrated Photovoltaics
Photovoltaic Glass Skylight- BIPV

Thin Film (a-Si) - Degree of Transparency 40%

Material Data
Cell Type: Polycrystalline
Dimensions: 1640x950x35 mm
Weight: 19 kg
Cell Size: 156x156 mm
Glass Thickness: 3.2 mm

Electrical Data at STC
Maximum Power (Pmax): 121 Wp
Voltage at Maximum Power (Vmp): 140 V
Current at Maximum Power (Imp): 0.87 A
Panel Efficiency: 4 %

Lexicon cuts & Sections
1. Flat Aluminium hood
2. Insulation
3. Double glazing
4. Photovoltaics (Glass-glass)
5. Protected Wiring and Mask
BIPV-Envelope: South Curtain walls

[Diagram of a building with solar panels on the facade]

[Diagram of a sectional plan showing solar panels and electrical connections]

[Diagram of a close-up view of solar panels and wiring connections]

[Diagram of a South Facade view of the building]
Thermal Comfort
With Passive and Active Strategies

With natural Ventilation

- Offices/conferences Air-conditioning consumes 40% of the total electricity. Natural ventilation will reduce this load 2-4%
Thermal Comfort
With Passive and Active Strategies

Winter Behavior
Thermal Zones:
- 21° - Comfort level
  T1 - Heat control by radiant floor
- 24° - 26° - Comfort level
  T2 - Closed units heat control
- 18° - Comfort level
  T3 - Closed units heat (PV controlled)

T1: Offices, Conference, Lecture
T2: Kitchen, Toilet
T3: Walkway/circulation, Expo/Central gathering
Internal Climate Control

- Energy Requirements

With

- good insulation
- Day light
- Ventilation
- Radiant floor

The building needs = 797.0 KWh/year

<table>
<thead>
<tr>
<th>Building Energy Requirements:</th>
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<tbody>
<tr>
<td>Conference (22°C)</td>
<td>365,007 BTU/hour or 106,973 watt.</td>
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<tr>
<td>Offices North (22°C)</td>
<td>314,675 BTU/hour or 92,222 watt.</td>
</tr>
<tr>
<td>Offices on E/W (22°C)</td>
<td>1,145,353 BTU/hour or 335,670 watt.</td>
</tr>
<tr>
<td>Expo. (18°C)</td>
<td>1,235,916 BTU/hour or 362,211 watt.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3050951</strong> BTU/hour or <strong>797066</strong> watt.</td>
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Note: The Energy use include
- Air Conditioning
- Building Internal Lighting
- Building Internal Plug Loads
- Common Area Lighting and Power
Insulated Opaque Roof
- yield = 23,000 kWh/m²/year

Transparent Sky Light
- yield = 264,000 kWh/m²/year

East west Transparent windows
- yield = 18,000 kWh/m²/year

Curtain wall
- Yield = 37.69 kWh/year

Total Yield = 305,037 kWh/year

The main energy target of the project was to demonstrate that the concept of a zero-energy building is possible even in the Heritage building.
Energy Production/ Consumption

- Active Envelope

The electricity produced by envelope of the building will be consumed for:
  - Air Conditioning in Summer
  - Heat pump (radiant floor)
  - Internal Lightning

Note: The Active energy Integrated envelope will produce surplus amount of energy, much more than building’s demand. The remaining energy will be saved in local grid for NO SUN days or can serve the neighborhood.
Thank you all for being here today