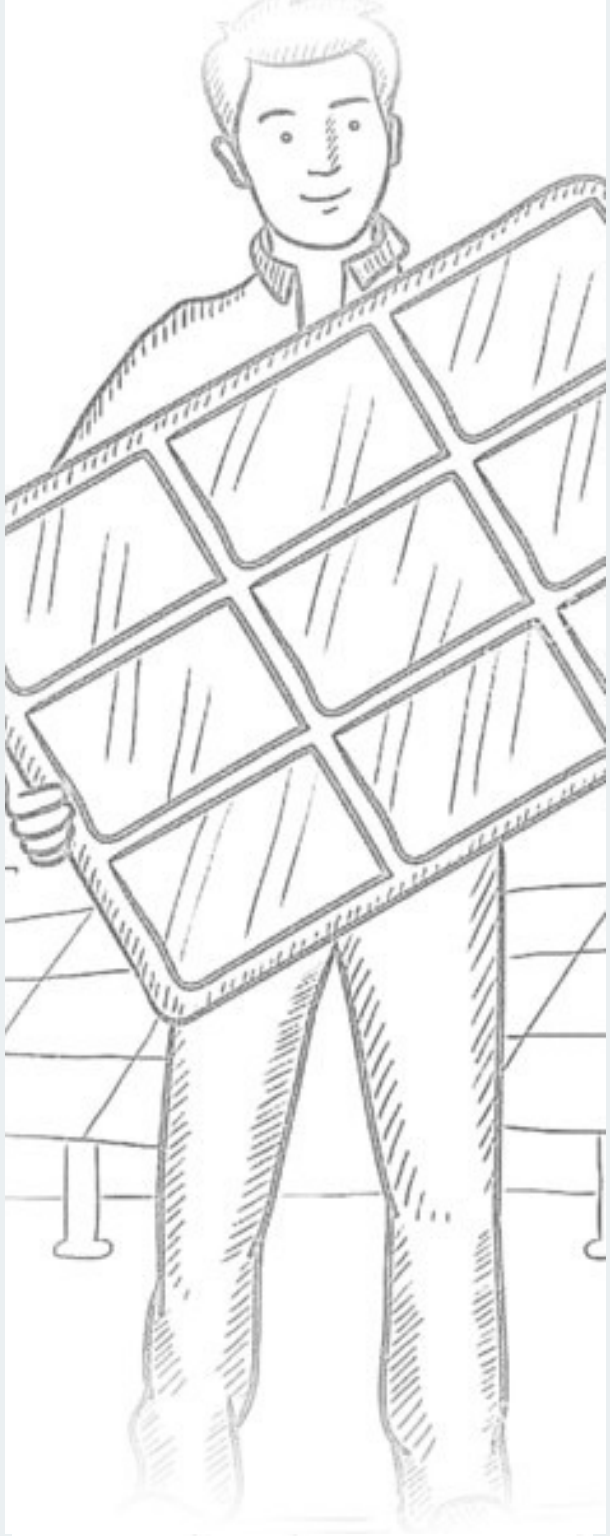
ARCHITECTURE AND ENGINEERING



01

Photovoltaics in Buidlings

Presented by Joanna Andraos

DISCUSSION OVERVIEW

Why Photovoltaics in Buildings?
Photovoltaic System Description
Architecture and Photovoltaics
Photovoltaic Modules Suitable for Building Integration
Design Concepts

KEY TOPICS

WHY PHOTOVOLTAICS IN BUILDINGS?

- Building continue to play a significant role in the global energy balance. With increasing awareness of the ecological consequences of energy consumption, the need for energy and environment conscious building design has become more and more pressing.

- A new technology, photovoltaics, has emerged as a viable option which can be installed on or at the actual building, giving a new dimension to energy conscious design.

Photovoltaic System Description

PV systems used on buildings can be classified into two main groups: Building attached Pvs (**BAPVs**) and **BIPVs**. It is rather difficult to identify whether a PV system is a building attached (BA) or building integrated (BI) system, if the mounting method of the system is not clearly stated.

BUILDING ATTACHED PV

BAPVs are added on the building and have no direct effect on structure's functions.

BUILDING INTEGRATED PV

BIPVs have an impact on the building's functionality and can be considered as an integral part of the energy system of the building.

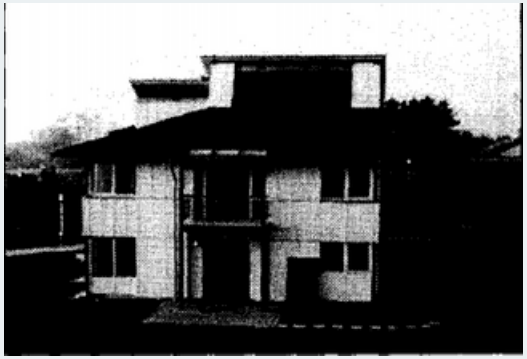
Lebanese Center for Energy Conservation • Jul. 2019

Architecture and Photovoltaics

Photovolaic is a truly elegant means of producing electricity on site, without concern for energy supply or environmental harm.
Interest in BIPV, where the PV elements actually become an integral **part of the building**, often serving as the exterior weathering skin, is growing world-wide.

PV specialists from some 15 countries are working to:
- optimize these systems
- architects to explore innovative ways of incorporating solar electricity into their building designs.

EXAMPLE 1: BUILDING ENVELOPE

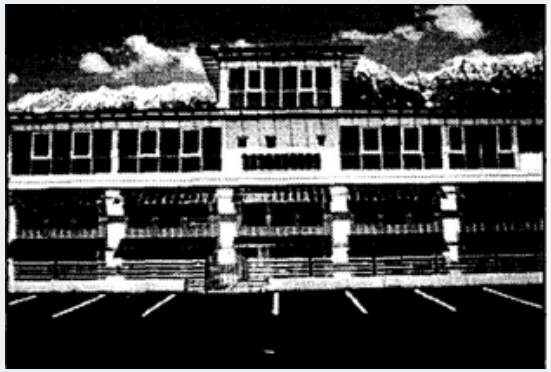


SOS Kinderdorf, Zwickau, Germany: 2.9 kWp, roof-integrated PV system. Frameless architectural laminated glass with amorphous silicon cells.

EXAMPLE 2: PLANNING CONTEXT OF AN ENERGY CONSCIOUS DESIGN PROJECT

Laukaa autonomous house, Finland.

EXAMPLE 3: PLANNING CONTEXT OF AN ENERGY CONSCIOUS DESIGN PROJECT



Commercial building (A. Wild) in Innsbruck, Austria

Photovoltaic Modules Suitable for Building Integration

Today's technology of module design has lead to several solutions for BIPV systems.
The following table shows the advantages and disadvantages of different types of PV modules:

Module construction technique	Typical dimension [cm²]	Application suitability				
		Sloped roof	Flat roof	Wall	Window	Shading
Standard modules with plastic or metal frame (glass multi-layer non-transparent back sheet)	33 x 130 45 x 100 55 x 115	+	o	o	-	o
Standard laminates as above without frames	33 x 130 45 x 100 55 x 115	+	+	+	-	+
Glass-glass modules with predefined transparency	all dimensions between 15 and 200	o	o	+	+	+
Glass modules with transparent plastic back sheet (predefined transparency possible)	all dimensions between 15 and 200	o	o	+	+	+
Modules with metal back sheet and plastic cover	15 x 150	+	+	+	-	+
Roofing modules (tiles/slates)	to fit with standard roofing systems	+	-	-	-	o
Custom-designed modules	various dimensions	+	+	+	+	+

+ =high suitability
o =low suitability
- = not suitable

Design Concepts

The problem of architecturally integrating photovoltaic technology requires an interdisciplinary design approach since it introduces a sensitivity to problems that go beyond the building itself.
These inhabit a sphere that is even broader, including **social, economic, environmental, energetic and ecological issues**.

OUTLINE FOR THE DESIGN PROCEDURE

1- Climate consideration and orientation
2- The site
3- Zoning regulation and building codes
4- Types of panels
5- Installation
6- Structure, negineering and details

Design Concepts

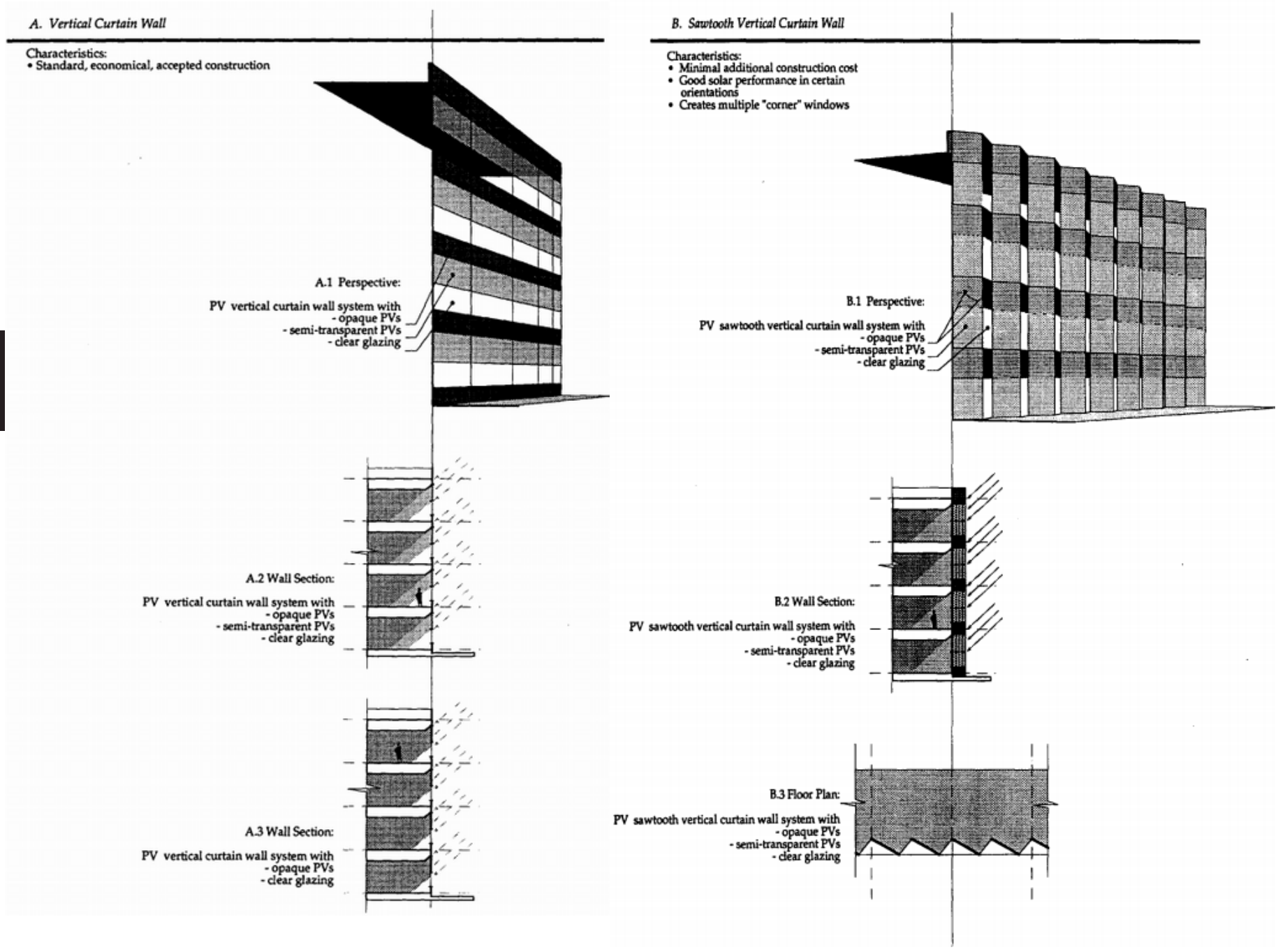
Before starting to design a PV building, it is very important to analyze each possible applicable solution of application:
- to determine its overall **impact on the building's energy balance**
- the energy efficiency performance of the overall system

The following examples offer a panorama of configurations for PV integration, selected by three main architectural application typologies:

CONFIGURATIONS FOR PV BUILDING INTEGRATION

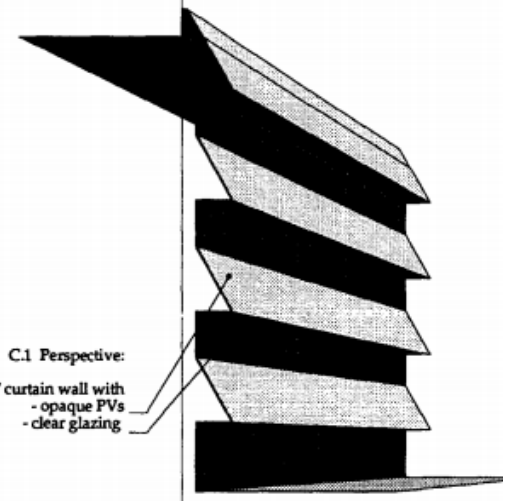
1- walls and facades
2- roofs and large coverings
3- light filtration and screening elements

1- walls and facades



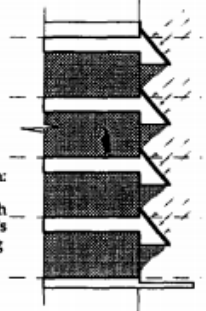
C. PV Sawtooth Curtain Wall

Characteristics:
- PVs as building skin
- Complex curtain wall construction
- Good PV efficiency
- Passive shading/daylight control
- Potential cleaning problems



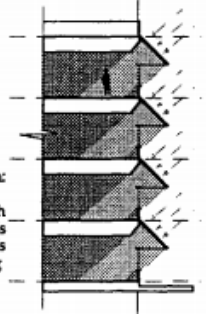
C.1 Perspective:

'Sawtooth' PV curtain wall with
- opaque PVs
- clear glazing



C.1 Wall Section:

'Sawtooth' PV curtain wall with
- opaque PVs
- clear glazing

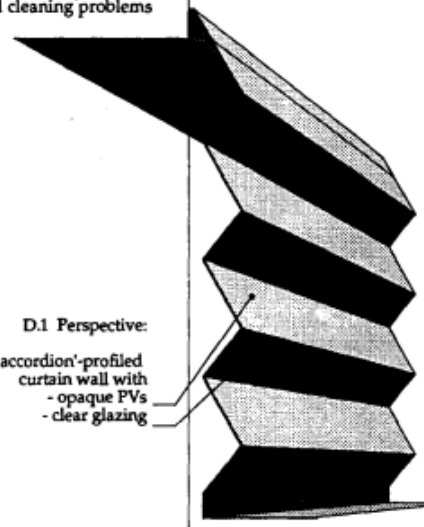


C.2 Wall Section:

'Sawtooth' PV curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing

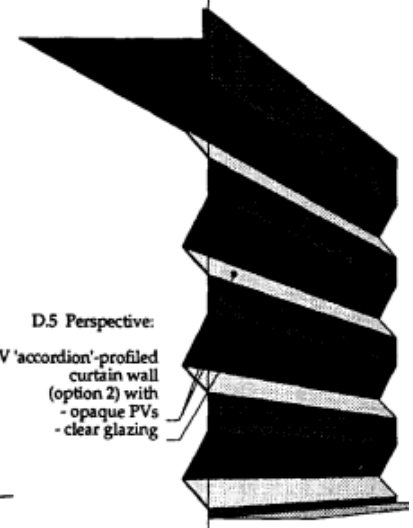
D. PV Accordion Curtain Wall

Characteristics:
- PVs as building skin
- Complex curtain wall construction
- Good PV efficiency
- Potential cleaning problems



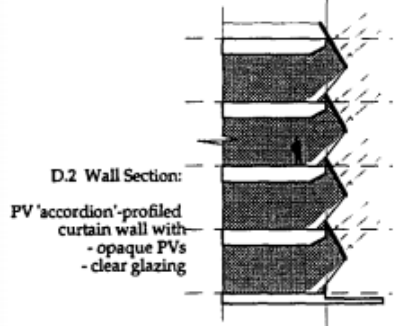
D.1 Perspective:

PV 'accordion'-profiled
curtain wall with
- opaque PVs
- clear glazing



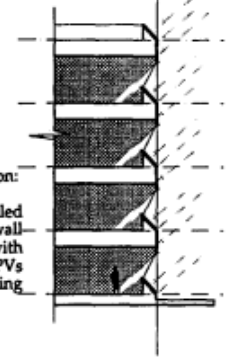
D.5 Perspective:

PV 'accordion'-profiled
curtain wall
(option 2) with
- opaque PVs
- clear glazing



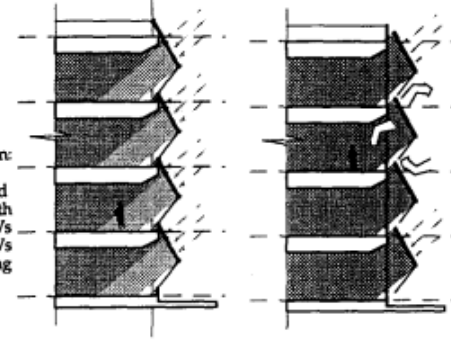
D.2 Wall Section:

PV 'accordion'-profiled
curtain wall with
- opaque PVs
- clear glazing



D.6 Wall Section:

PV 'accordion'-profiled
curtain wall
(option 2) with
- opaque PVs
- clear glazing



D.3 Wall Section:

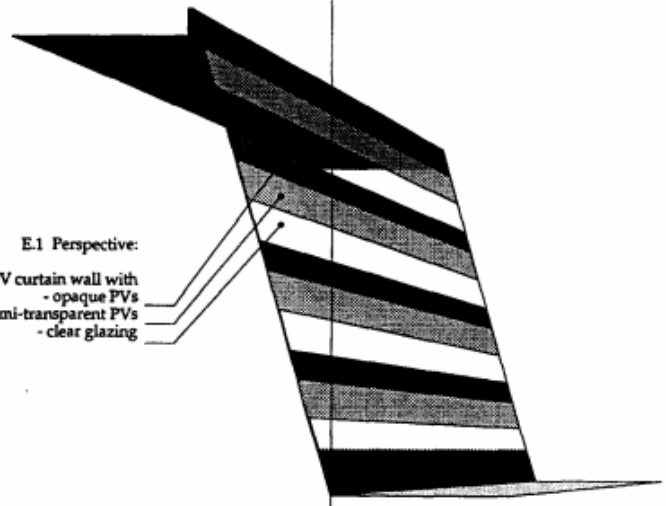
PV 'accordion'-profiled
curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing

D.4 Wall Section:

PV 'accordion'-profiled
curtain wall with double wall system:
- inner layer as weather seal
- outer layer as active/passive solar source (opaque PVs)
- double wall providing PV-powered ventilation for thermal build-up from PVs

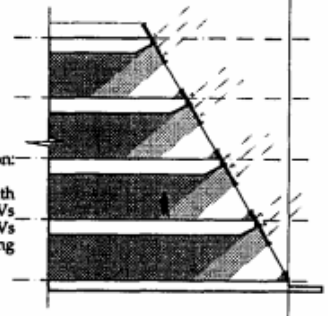
E. PV Sloping Curtain Wall

Characteristics:
- Good PV max efficiency
- Less efficient use of building footprint



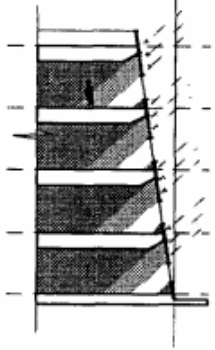
E.1 Perspective:

70° sloping PV curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing



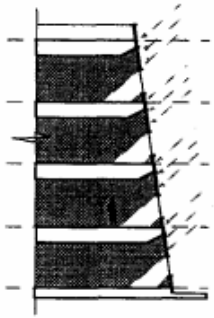
E.2 Wall Section:

60° sloping PV curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing



E.3 Wall Section:

80° sloping PV curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing

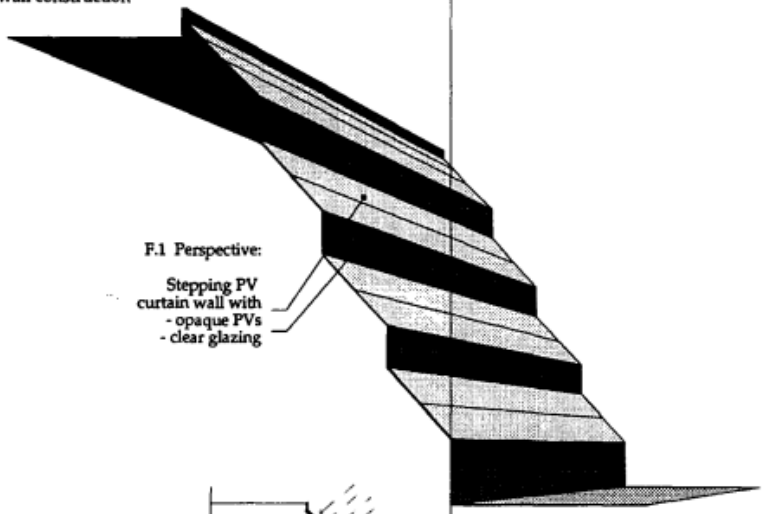


E.4 Wall Section:

80° sloping
PV curtain wall with
- opaque PVs
- clear glazing

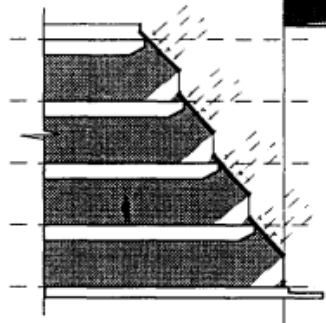
F. PV Sloping/Stepped Curtain Wall

Characteristics:
- Good PV max efficiency
- Less efficient use of building footprint
- Complex curtain wall construction



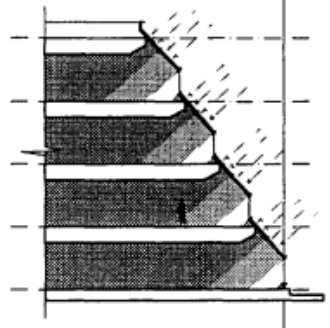
F.1 Perspective:

Stepping PV
curtain wall with
- opaque PVs
- clear glazing



F.2 Wall Section:

Stepping PV curtain wall with
- opaque PVs
- clear glazing

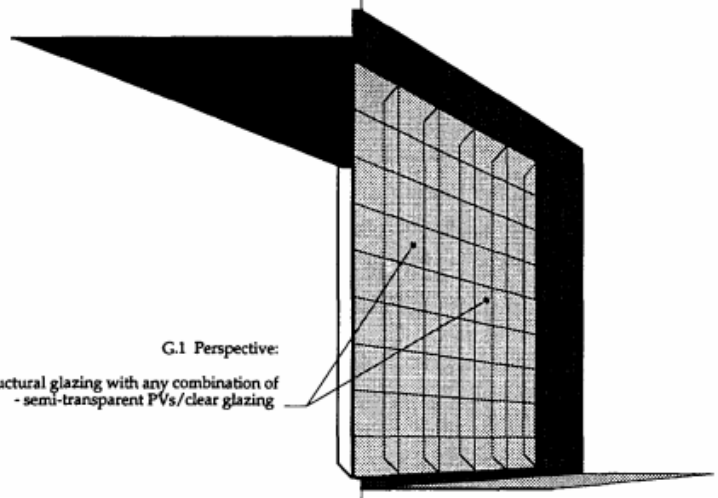


F.3 Wall Section:

Stepping PV curtain wall with
- opaque PVs
- semi-transparent PVs
- clear glazing

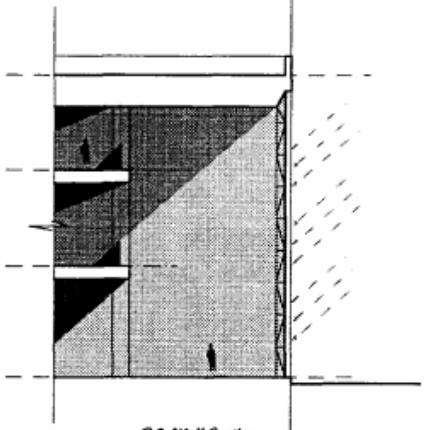
G. PV Structural Glazing

Characteristics:
- Standard, economical , accepted construction
- Difficult sealing problems for PV edges



G.1 Perspective:

Vertical PV structural glazing with any combination of
- semi-transparent PVs/clear glazing



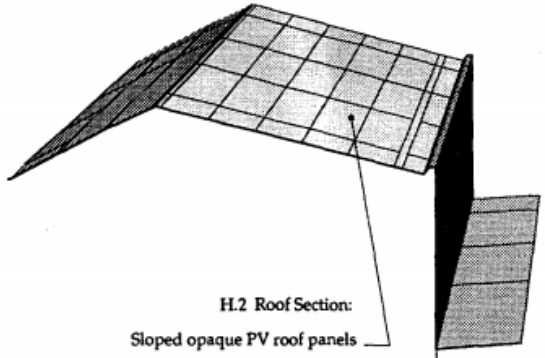
G.2 Wall Section:

Vertical PV structural glazing with any combination of
- semi-transparent PVs/clear glazing

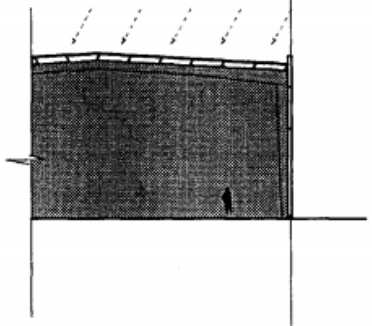
2- roofs and large coverings

H. PV Roof Panels

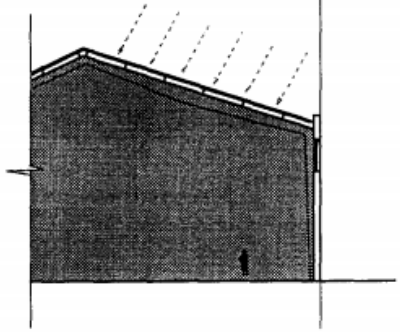
Characteristics:
- PVs as building skin
- Combined with rooftop structural system (panelized units with insulation, fastened directly to roof structure)
- Weatherproofing and structural issues must be carefully resolved
- Snow accumulation considerations



H.2 Roof Section:
Sloped opaque PV roof panels

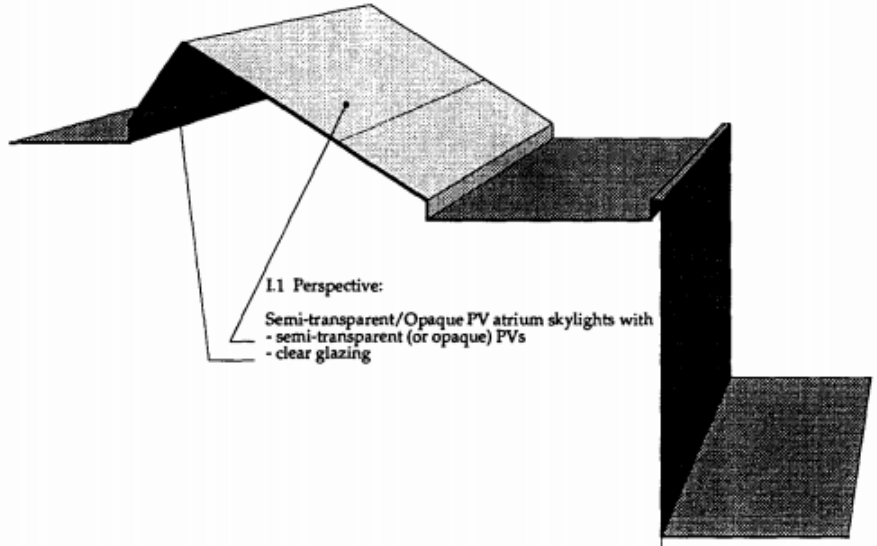


H.2 Roof Section:
Horizontal opaque PV roof panels

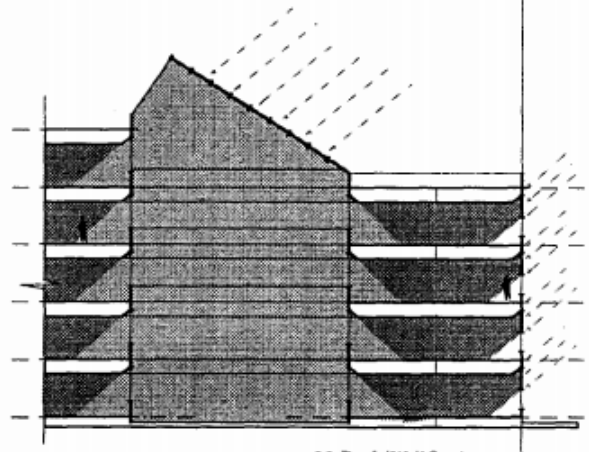


H.3 Roof Section:
Sloped opaque PV roof panels

I. PV Atriums



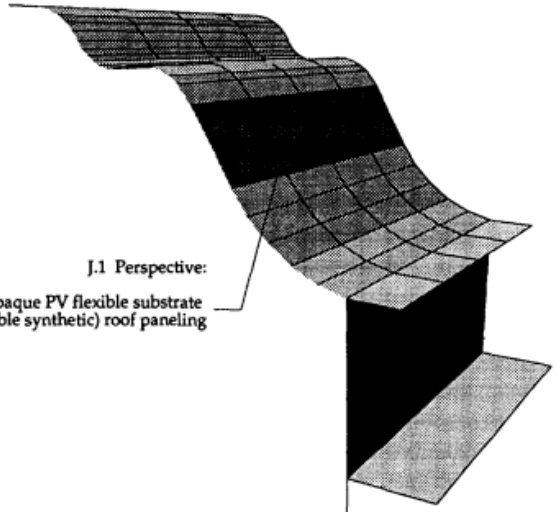
I.1 Perspective:
Semi-transparent/Opaque PV atrium skylights with
- semi-transparent (or opaque) PVs
- clear glazing



I.2 Roof /Wall Section:
Opaque &/or transparent PV atrium skylights with
- semi-transparent (or opaque) PVs
- clear glazing

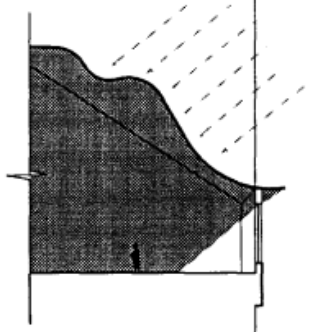
J. Flexible/ Metal PV Substrates

Characteristics:
- For roofs and/or wall applications
- Good design flexibility
- Light-weight
- Possible integral weather barrier



J.1 Perspective:

Opaque PV flexible substrate
(sheet metal or flexible synthetic) roof paneling

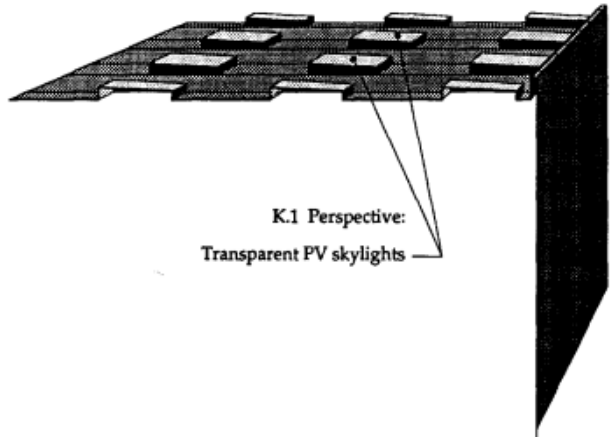


J.2 Wall Section:

Opaque PV flexible substrate
(sheet metal or flexible synthetic) roof paneling

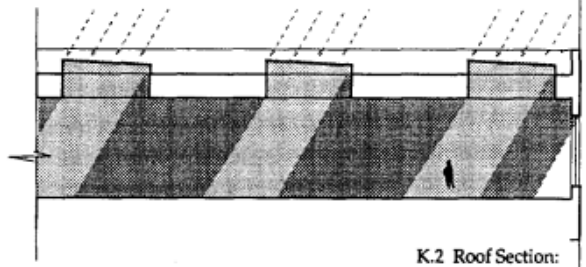
K. PV Skylights

Characteristics:
- PV system as indiv. roof openings
- New construction or retrofit
- Tilted or horizontal orientation
- Numerous configurations possible
- Daylighting benefits
- Snow accumulation considerations



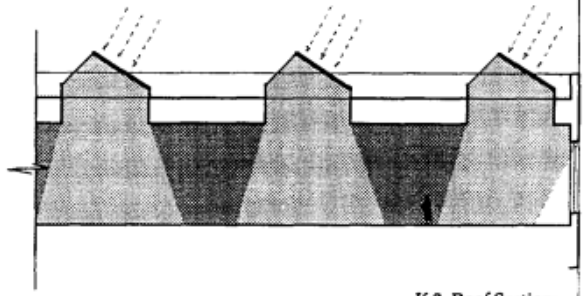
K.1 Perspective:

Transparent PV skylights



K.2 Roof Section:

Transparent PV skylights

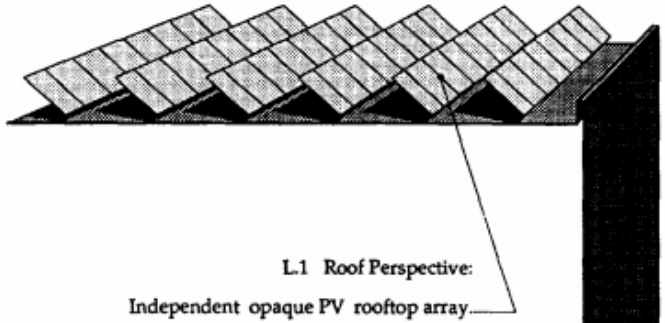


K.3 Roof Section:

Opaque PV skylights

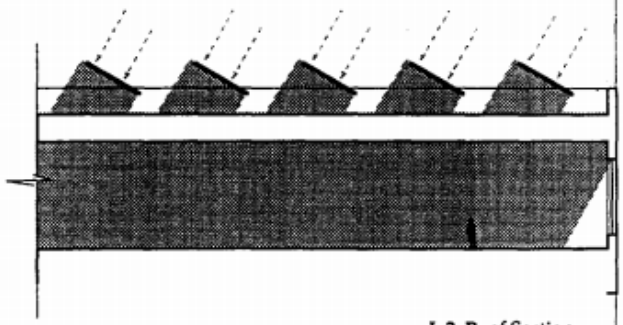
L. Independent PV Rooftop Array

Characteristics:
- PV system independent of bldg skin.
- conventional array configuration installed on rooftop
- Maximal efficiency
- New construction or retrofit
- Potential passive benefit from reduced heat load
- Potential structural costs
- Water proofing issues at roof/structure



L.1 Roof Perspective:

Independent opaque PV rooftop array.

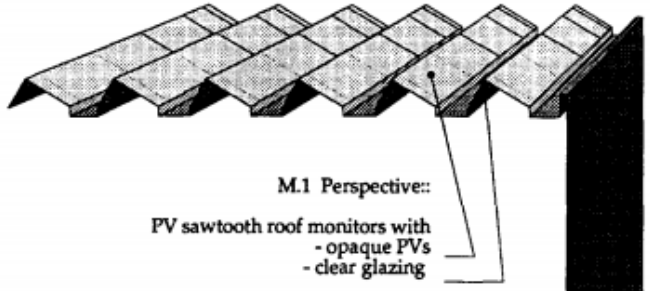


L.2 Roof Section:

Independent opaque PV rooftop array.

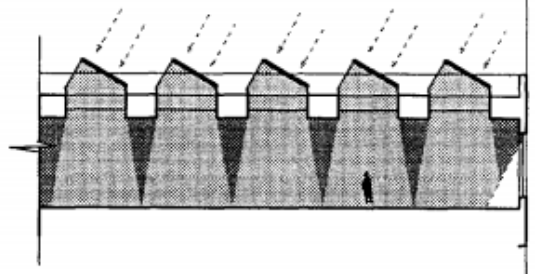
M. PV Sawtooth Roof Monitors

Characteristics:
- PV system as building skin
- Retrofit to exist. industrial buildings
- Good PV efficiency
- Good daylight benefits



M.1 Perspective::

PV sawtooth roof monitors with
- opaque PVs
- clear glazing



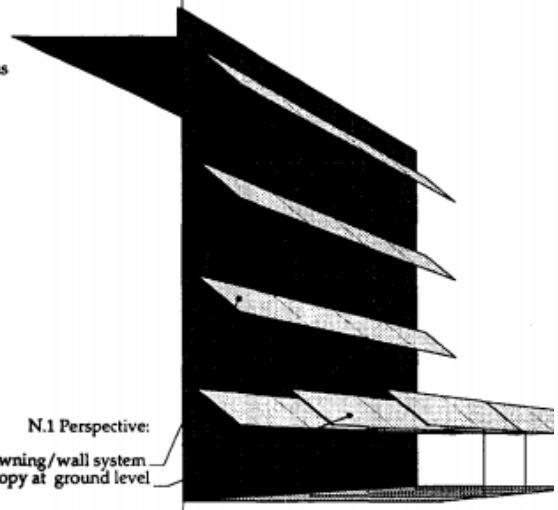
M.2 Roof Section:

PV sawtooth roof monitors with
- opaque PVs
- clear glazing

3- light filtration and screening elements

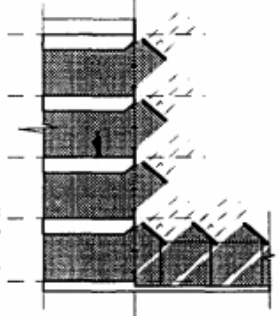
N. Hybrid PV Awning Systems

Characteristics:
- PVs independent of building skin
- New construction or retrofit
- Passive shading/daylight control benefits
- Moderate additional costs for structure
- Little danger of waterproofing complications
- Wiring must penetrate building skin



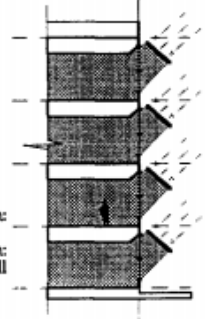
N.1 Perspective:

PV hybrid awning/wall system
Cna be extended into independent trellis/canopy at ground level



N.2 Wall Section:

PV hybrid awning/wall system with:
- opaque awnings attatched to vertical wall,
- awnings can be extended into independent trellis at ground level

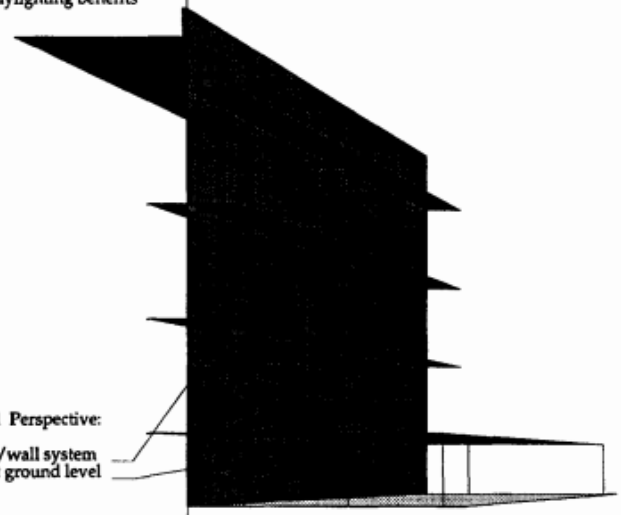


N.3 Wall Section:

PV hybrid awning/wall system with:
- opaque awnings attatched to vertical wall

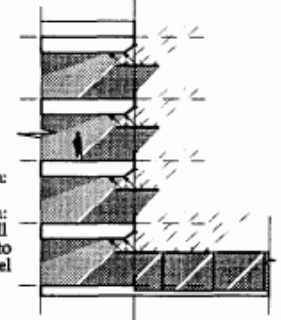
O. Hybrid PV Awning/Light Shelf Systems

Characteristics:
- PVs independent of building skin
- New construction or retrofit
- Passive shading/daylight control/daylighting benefits
- Potentially significant structural and weatherproofing costs



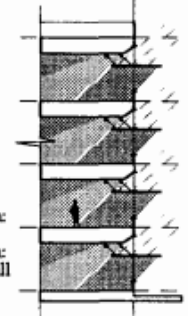
O.1 Perspective:

Hybrid PV light shelf/wall system
Can be extended into independent trellis at ground level



O.2 Wall Section:

Hybrid PV light shelf/wall system with:
- opaque PV light shelves attached to vertical wall
- horizontal PVs which can be extended into independent trellis at ground level



O.3 Wall Section:

Hybrid PV light shelf/wall system with:
- opaque PV light shelves attached to vertical wall

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