Toolkit:

Energy efficient building design

Buildings: Session 3

#energyefficientworld

Buildings energy efficiency sessions in partnership with:

International Finance Corporation
WORLD BANK GROUP

Energy Efficiency Training Week: Buildings Program

1. **Where to start:** Understanding energy use in buildings
2. **Where to start:** Energy efficiency potential in buildings
3. **Toolkit:** Energy efficient building design
4. **Toolkit:** Energy efficient building technologies

   Where do I get help? IEA's Technology Collaboration Programmes
5. **Toolkit:** Enabling investment with energy efficiency policies
6. **What are the steps :** Building energy codes and standards

   Site Visit: Ministry of Public Works and Housing
7. **What are the steps:** Set targets and develop policies
8. **Did it work:** Evaluating the multiple benefits of energy efficiency
9. **Did it work:** Tracking progress with energy efficiency indicators

   Where do I get help? International and regional energy efficiency initiatives
10. **Energy Efficiency Quiz:** Understanding energy efficiency in buildings

3. Toolkit: Energy efficient building design

Trainers: Brian Dean and Autif Sayyed

Session: 1.5 hours

Purpose: To teach the fundamentals of how building design can reduce energy use in buildings. This course will also describe how an integrated design process and the use of simulation tools can achieve cost effective and energy efficient buildings.

Scenario: Builders are saying that construction timelines are short and it is not possible to design more efficient buildings because it is too complicated. *What changes in building design can enable more energy efficiency in buildings?*

Integrated design process

Sufficiency, efficiency, renewables

Tiered approach to integrated design

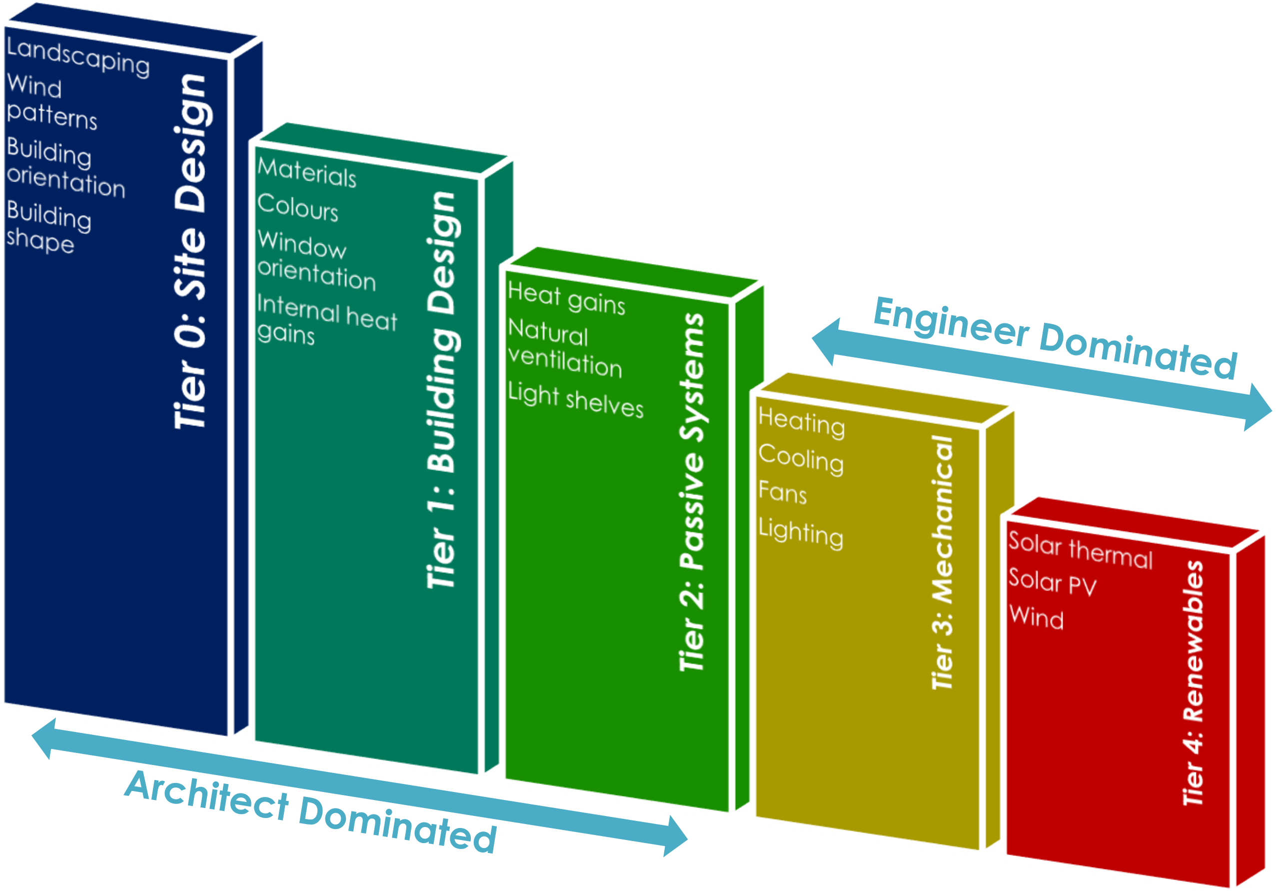
Design charrette

Path to zero emissions or net zero energy buildings

	1 Energy sufficiency	2 Energy efficiency	3 Renewable energy
Energy strategy	■ Reduce energy needs	■ Reduce energy consumption	■ Reduce CO_2 emissions by using renewable energy
Policy instrument	■ Land-use policies ■ Building energy codes	■ Building energy codes ■ S&L policies	■ Land-use policies ■ Building energy codes ■ S&L policies for equipment
Policy measure	■ Bioclimatic design principles ■ Use of passive solutions	■ Mandatory S&L for: ■ overall building energy performance ■ building elements and equipment	■ Mandatory share of supply from renewable energy sources ■ Mandatory S&L for equipment

Source: www.iea.org/publications/policypathwaysseries/

The tiered approach for the integrated design process



Integration of:

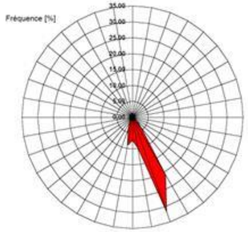
- Multiple design professionals
- Multiple aspects of building design and construction

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated Design Process: Tier 0 – Site Design

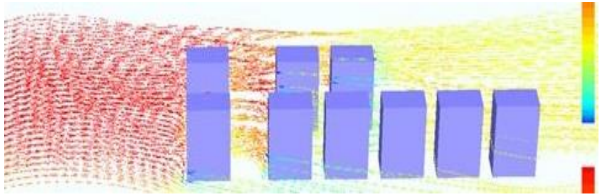
Landscaping

- Impact on solar gains on building
- Impact on airflow
- Seasonal variation



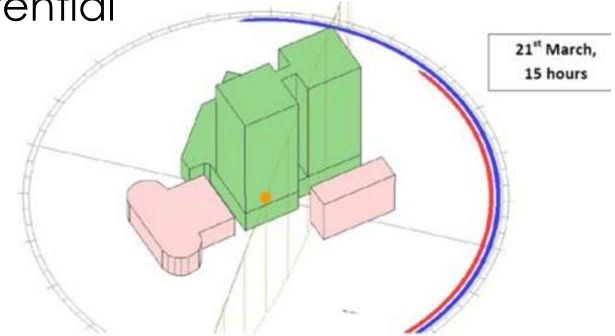
Wind patterns

- Dominant wind direction in hot summer
- Layout of buildings for natural ventilation potential



Building orientation & building shape

- Solar gains on facades
- Optimal orientation of facades



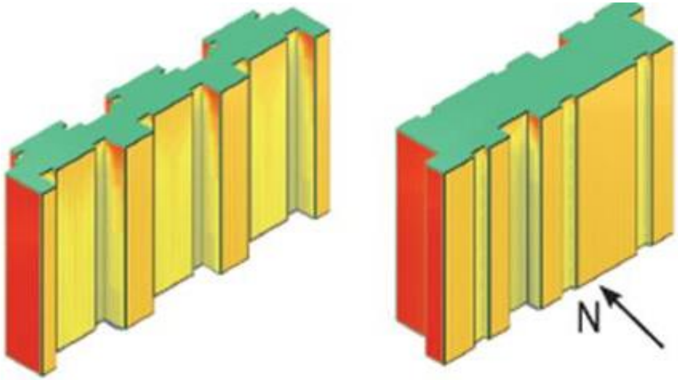
Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated Design Process: Tier 0 – Site Design

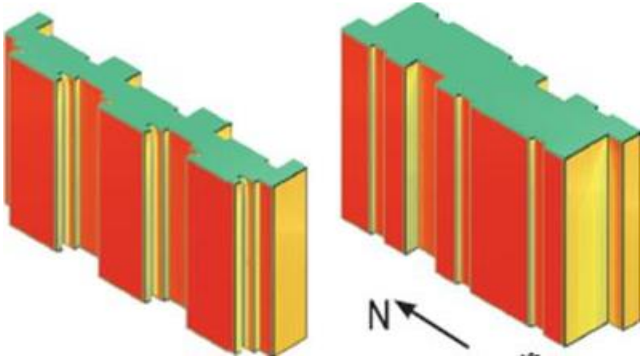
Facade orientation

- Crucial, especially for long buildings
- Account for annual solar gains by orientation

Isometric view from South West



Long facades facing South and North



Long facades facing East and West

Source: India BEEP and India BEE. Design Guidelines For Energy-Efficient Multi-Storey Residential Buildings (Composite and Hot-Dry

Integrated Design Process: Tier 0 – Site Design

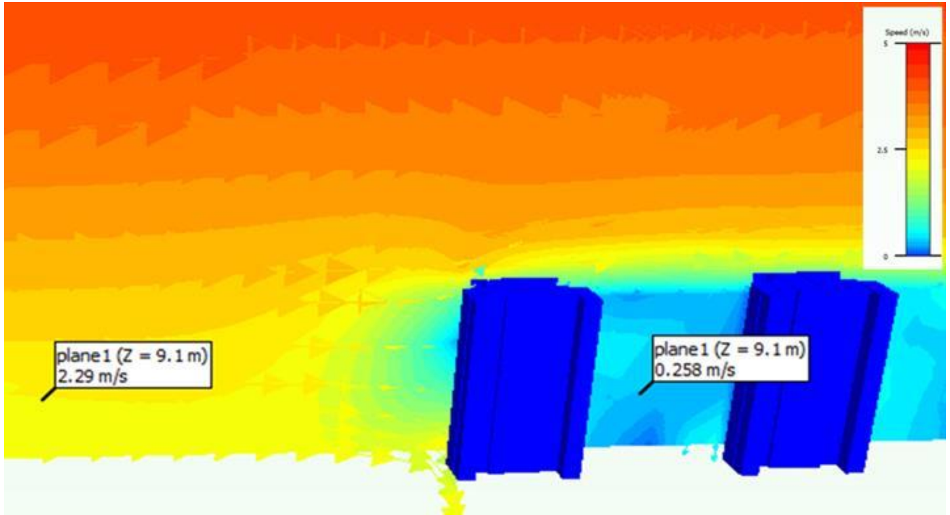
Landscaping
Wind patterns
Building orientation
Building shape

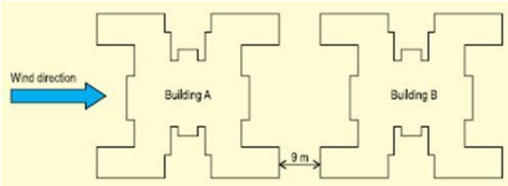
Tier 0: Site Design

Influence of buildings on wind velocity

- Building shape, size and layout all influence wind speeds

Air velocity when wind is perpendicular to building facade orientation



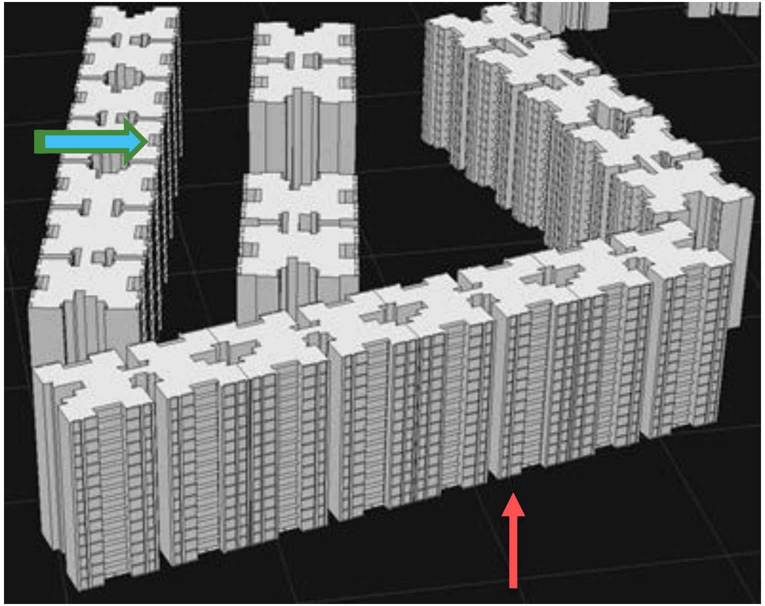


Source: India BEEP and India BEE. Design Guidelines For Energy-Efficient Multi-Storey Residential Buildings (Composite and Hot-Dry

Example wind distribution for a project in Indore (DB Pride)

Tier 0: Site Design

- Landscaping
- Wind patterns
- Building orientation
- Building shape



View from the South / Main wind from the West

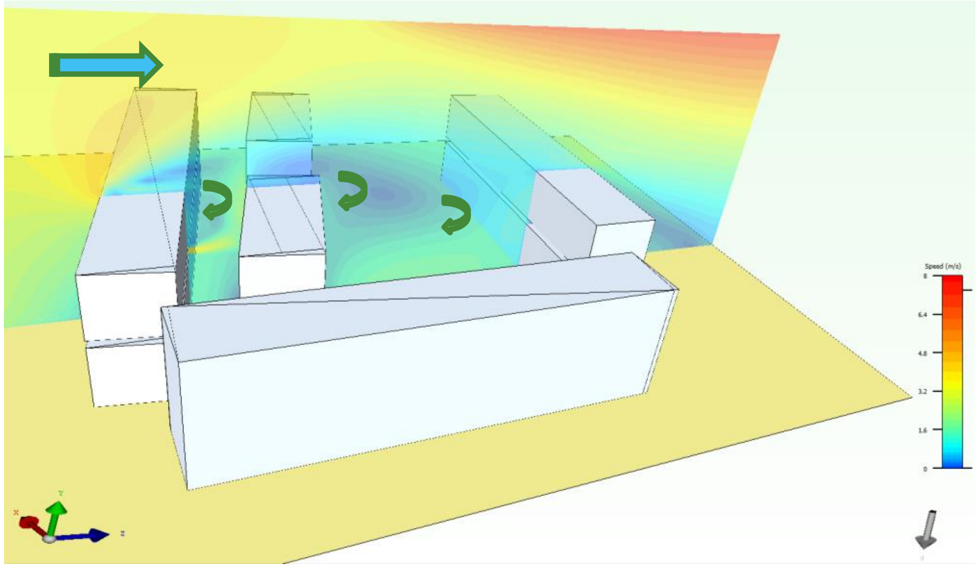
Source: India BEEP

Integrated Design Process: Tier 0 – Site Design

Landscaping
Wind patterns
Building orientation
Building shape

Tier 0: Site Design

Example wind distribution for a project in Indore (DB Pride)



Using wind speed for natural ventilation

- **Low-density projects:** influence cross (horizontal) and stack (vertical) ventilation
- **High density projects:** there is low wind speed between buildings, but you can use wind speed on the roof to increase suction on vertical shafts for increased stack ventilation.

Source: India BEEP and India BEE. Design Guidelines For Energy-Efficient Multi-Storey Residential Buildings (Composite and Hot-Dry

Integrated Design Process: Tier 1 – Building Design

Walls, windows, shading and solar gains

- Wall should be designed to have insulation
- Window area should be limited to 10-30% of the wall area
- Windows should be highly efficient, particularly if more than 25% of the wall area (both thermal protection and solar protection)
- Shading with overhangs should be designed based on solar angles (i.e. typically overhangs are more effective on North and South walls)
- Shading with movable external shades can be highly effective for optimized daylighting and controlling solar gains.
    - Shutters
    - Movable blinds

(technologies are described in more detail in the next session)

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated Design Process: Tier 1 – Building Design

Building envelope is often the main source of heat gain/loss

- Walls, windows, roof, uncontrolled air infiltration
- There is a wide variation in the quality of building envelopes:

U ~ 3.5 W/m^2.K
Monolithic concrete wall

35% Windows with inadequate shading

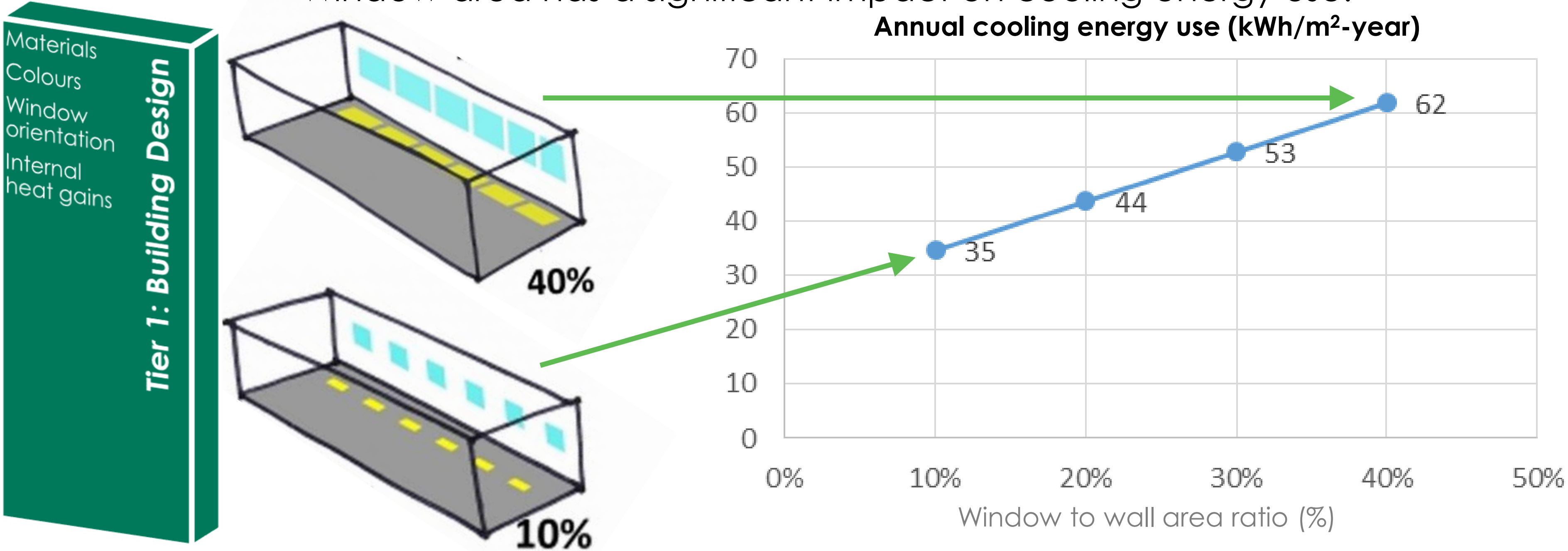
U ~ 0.5 W/m^2.K

10% Windows with shading

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Building envelope is often the main source of heat gain/loss

- Window area has a significant impact on cooling energy use:



Source: BEEP India

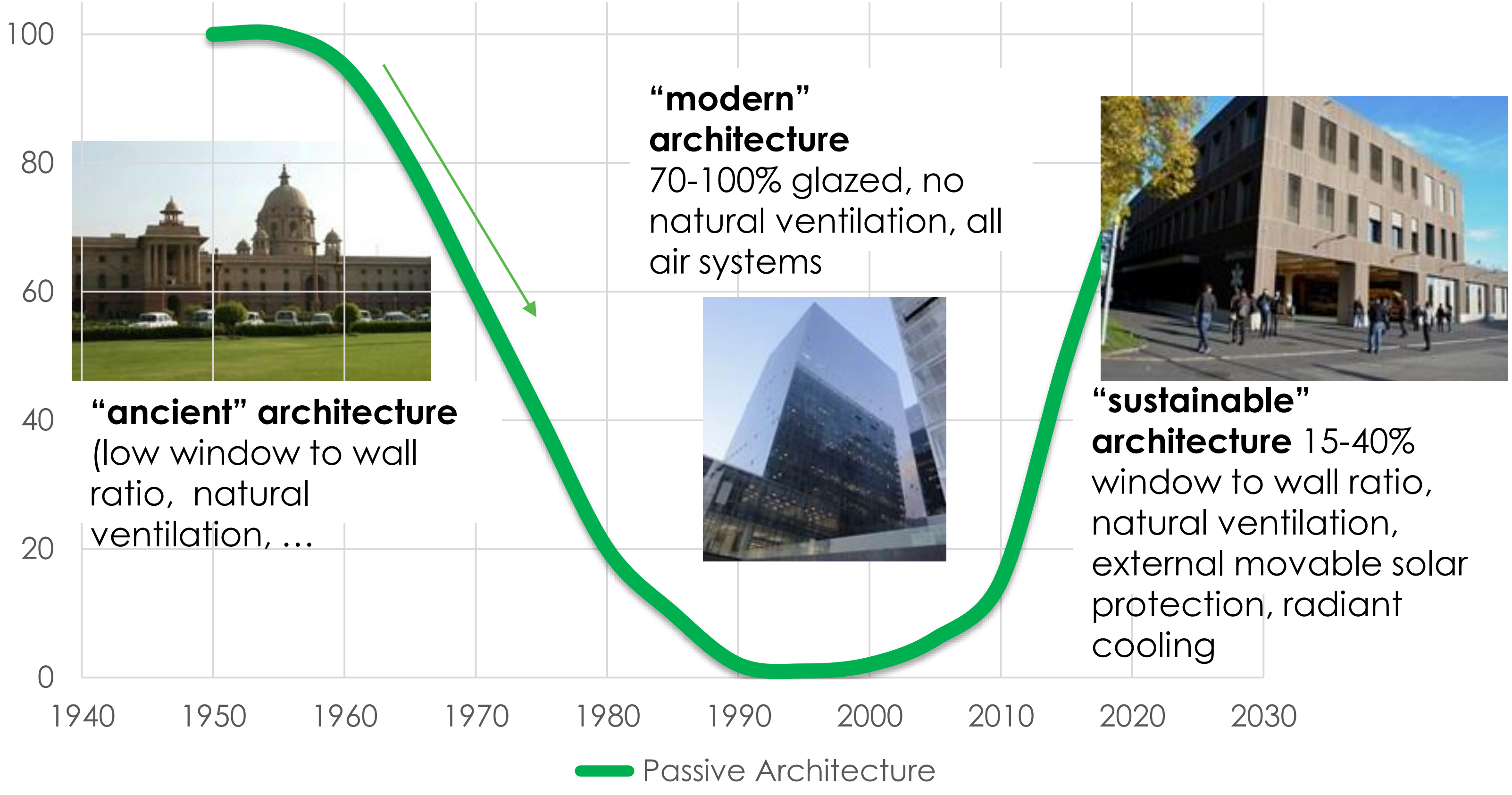
Integrated Design Process: Tier 2 – Passive Systems

Passive systems are reliant on Tier 0 (site design) and Tier 1 (building design), and include:

- Passive cooling
    - Evaporative cooling (airflow and water)
    - Ventilative cooling (natural ventilation)
    - Earth tunnel (underground)
- Passive heating (trombe wall and greenhouse effect)
- Passive lighting (daylighting)

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated Design Process: Tier 2 – Passive Systems



Source: BEEP India

Integrated Design Process: Tier 3 – Mechanical Systems

After all of the passive options are used, mechanical systems can deliver the designed comfort:

- Active heating systems
- Active cooling systems
- Fans
- Active lighting

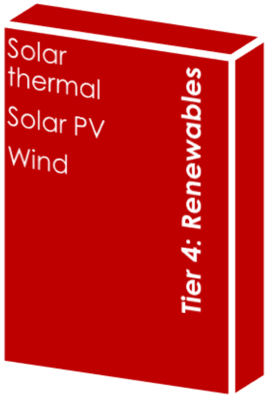
(technologies are described in more detail in the next session)

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated Design Process: Tier 4 – Renewable Energy

To deliver net zero energy or emissions, renewable energy can be used to provide all on-site energy needs

- Solar thermal
  - Typically for hot water or heating
- Renewable electricity
  - Solar photovoltaic
  - Wind
  - Purchased renewable energy

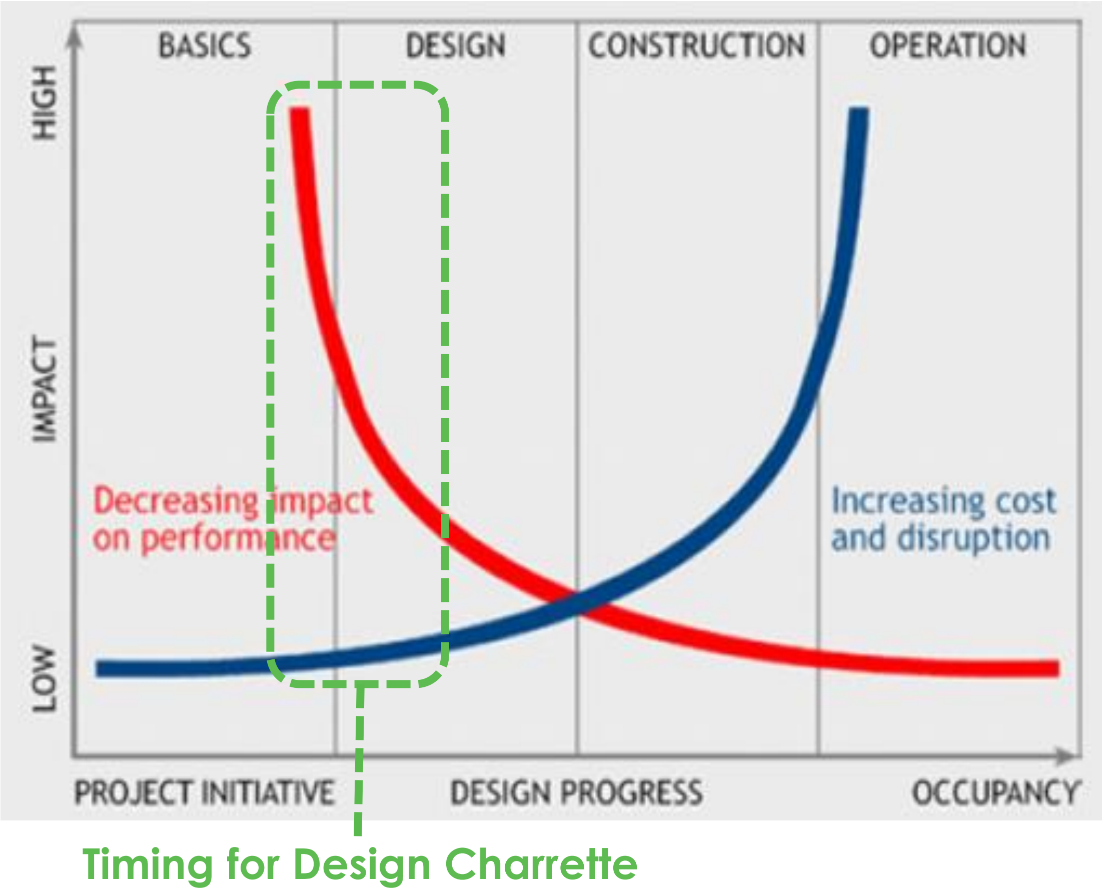


Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for

Integrated design process: Design Charrette

Experience shows:

- Cost-effective and energy efficient design (25-40% energy savings at no/ marginal cost increase) is possible if the **architect, engineer and client** work together in a Design Charrette/Workshop during the early design phase.
- More savings are achieved when the **architects and engineers** continued to work together in the design phase.

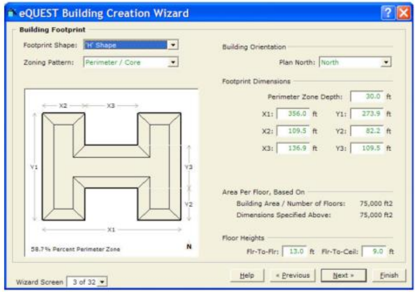


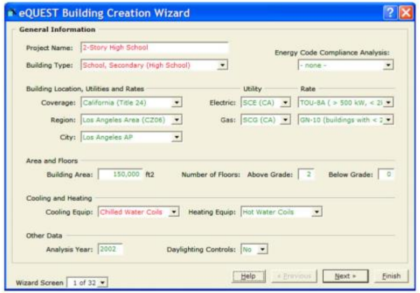
Source: BEEP India and IEA Task 23 Optimization of Solar Energy Use in Large Buildings, 2003

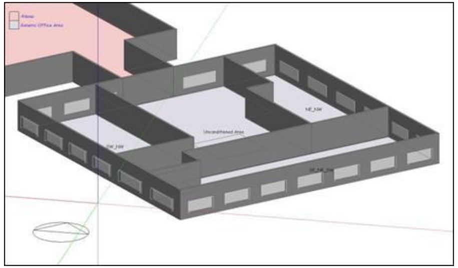
Building energy modelling

- Should be used throughout the design process from schematic design (early) to construction (end of design) to understand the impact of design decisions
- At the early design stage, use *simplified models* or *simplified modelling*:
  - **Simplified model**: such as using “wizard mode” in eQUEST that pre-fills information so that you do not have to enter in all data.
  - **Simplified modelling**: such as modelling one zone of the building

eQUEST ... the QUick Energy Simulation Tool





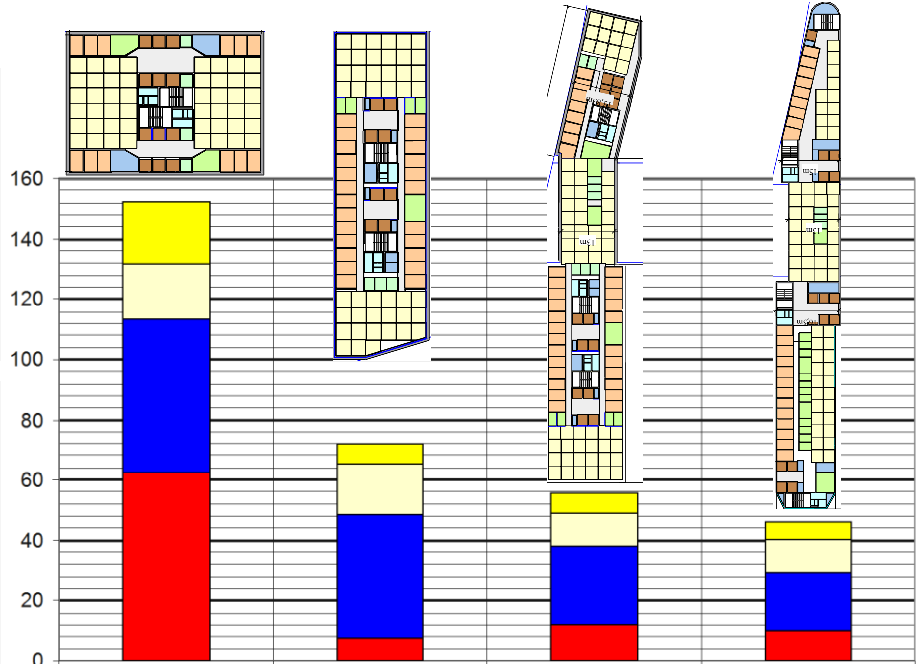


Source: BEEP India and DOE2.com

Example: high rise office building for France Ministry of Ecology

Option 1 (reference case): Square deep floor plate, poor envelope, no dynamic solar shading, mechanical ventilation without heat recovery

Option 2 (high performance): Square shallow floor plate, good quality envelope, dynamic solar shading (SHGC=15%), mechanical ventilation with heat recovery, natural ventilation on the peripheral zones



	Option 1	Option 2	Option 3	Option 4
Specific electricity for mechanical ventilation	20.9	6.7	6.7	5.5
Specific electricity for lighting	18.1	16.7	11.1	11.1
Specific cooling requirements	51.1	40.6	25.9	19.1
Specific heating energy	62.3	7.9	12.2	10.1

Option 3 ("bioclimatic" design): shallow floor plate (15.4 m depth), good quality envelope, dynamic solar shading (SHGC=15%), mechanical ventilation with heat recovery, natural ventilation on the peripheral zones

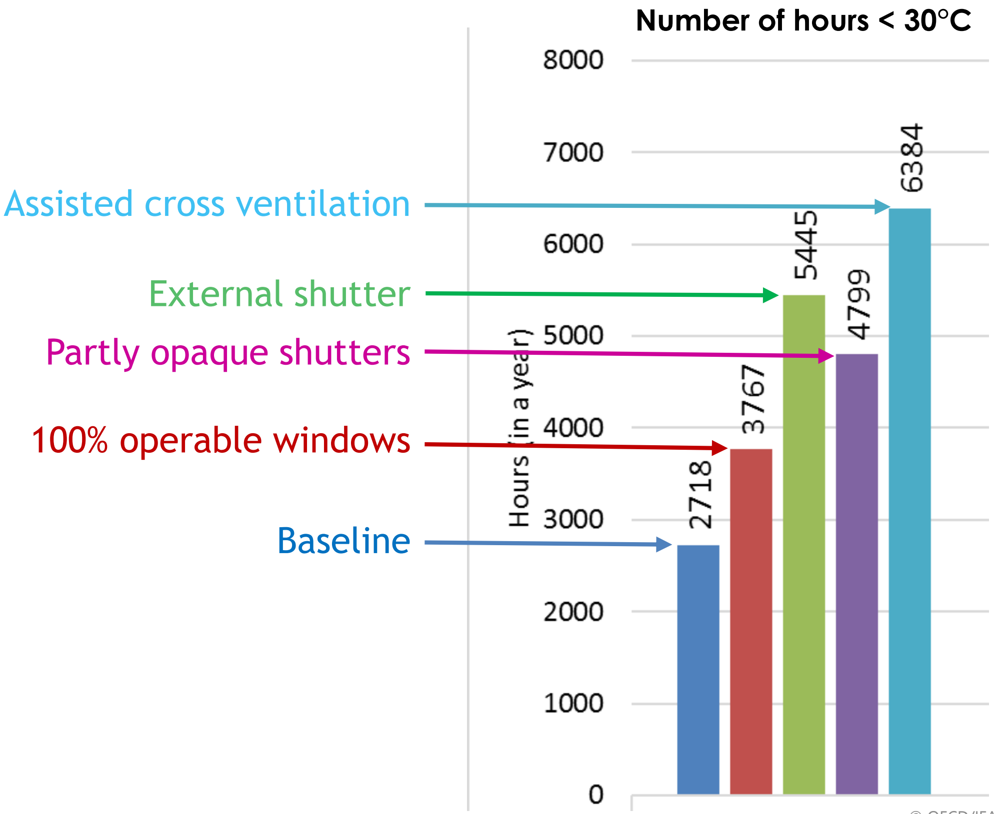
Option 4 ("bioclimatic" design with cross ventilation): shallow floor plate (15.4 m depth), good quality envelope, dynamic solar shading (SHGC=15%), mechanical ventilation with heat recovery, natural ventilation between peripheral and central zones

Source: BEEP India

Integrated design process: Design Charrette

Example: thermal comfort without active cooling

Low cost housing project Smart Ghar



Source: BEEP India

Design, Construction and Commissioning:

- **Simplified:** typically for small residential and other small projects in developing economies.
- **Detailed:** typically for large projects (both residential and commercial)

The design process and investment decision processes are different depending on the total effort by designers and developers.

- The larger the project, the *larger the opportunity for energy efficiency*
- The larger the project, the *better opportunity for integrated design*

Design, construction and measurement standardisation

Capital gap and performance gap

Investment Ready Energy Efficiency

The energy efficiency capital gap

Projects

- Untapped market opportunity
- Healthy returns
- Established industry
- Excess capacity

Investors

- Search for yield
- Risk/return
- Growing emphasis on impact investing
- Growing interest in EE

Source: Investor Confidence Project

The performance gap

Why Don't Green Buildings Live Up to Hype on Energy Efficiency?

Analysts call it the "energy performance gap" – the difference between promised energy savings in green buildings and the actual savings delivered. The problem, researchers say, is inept modeling systems that fail to capture how buildings really work.

BY RICHARD CONNIFF · MAY 25, 2017

Not long ago in the southwest of England, a local community set out to replace a 1960s-vintage school with a new building using triple-pane windows and super-insulated walls to achieve the highest possible energy efficiency. The new school proudly opened on the same site as the old one, with the same number of students, and the same head person—and was soon burning more energy in a month than the old building had in a year.

Lack of standardisation results in:

Greater performance risk

Uncertainty limiting demand

Higher transaction costs

Difficult to build capacity

Difficult to aggregate

Source: Investor Confidence Project

What owners and investors want

- Clear and transparent construction or renovation project plan based on industry best practices
- Evidence of the qualification of professionals
- Third-party measurement and verification
- Consistent documentation
- A project label that represents these components and can live with the project

Source: Investor Confidence Project

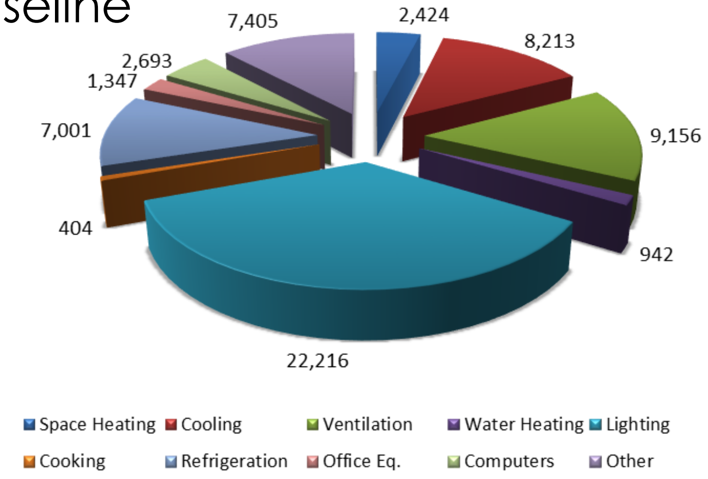
What does a standardised approach looks like?

Source: Investor Confidence Project

What does a standardised approach looks like?

Baselines provide a reference regarding energy use, allowing for prediction of energy consumption in different scenarios, and for energy savings calculations.

- Develop 12 month energy consumption baseline
- Determine energy use by end-use
- Building performance
- Weather data
- Occupancy data



Source: adapted from Investor Confidence Project

What does a standardised approach looks like?

Baselining → **Savings Projections** → Design, Construction, Verification → Operations, Maintenance, Monitoring → Measurement & Verification (M&V)

Savings calculations provide important information for project valuation and for the determination of the energy efficiency measures to be implemented.

- Energy modeling software
- Modeler credentials
- Supporting model files and model calibration
- Key metric benchmarks
- Energy efficiency measures model variables
- Individual and packaged energy savings results

Source: adapted from Investor Confidence Project

What does a standardised approach looks like?

Design, construction and verification are all crucial phases. Procedures and documentation of these processes is key to investor confidence.

- Operational performance verification plan
- Commissioning
- Inspection and spot measurements
- Data logging
- Training
- Systems manual

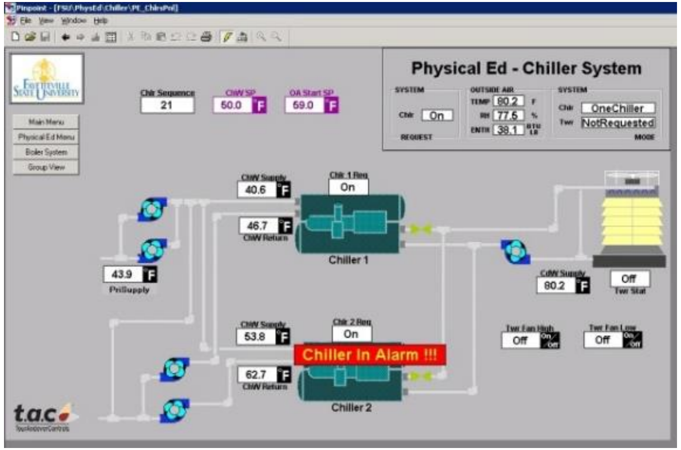
Source: adapted from Investor Confidence Project

What does a standardised approach looks like?

Baselining → Savings Projections → Design, Construction, Verification → **Operations, Maintenance, Monitoring** → Measurement & Verification (M&V)

The way that buildings are operated and maintained impact their energy performance, and monitoring this information is key to performance guarantees.

- OM&M plan and management framework
- OM&M process
  - Inspections
  - Retro commissioning
  - Ongoing commissioning
  - Monitoring-based commissioning
- Operator's manual and training

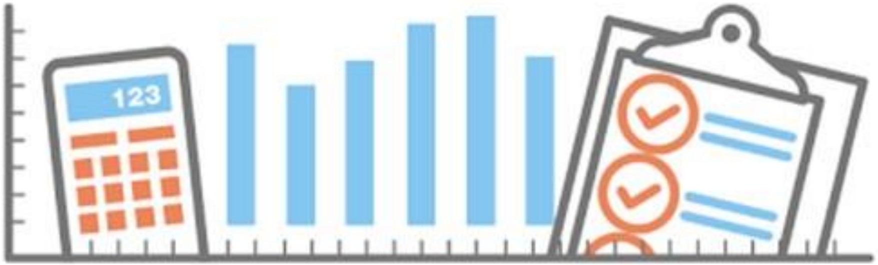


Source: adapted from Investor Confidence Project

What does a standardised approach looks like?

Proper measurement and verification procedures validate the reliability and effectiveness of predicted energy savings.

- M&V provider credentials
- Options A and B: retrofit isolation
- Option C: utility bill analysis
- M&V report



Source: adapted from Investor Confidence Project

Standardised approach

Does NOT:

- Invent new standards
- Attempt to impose national standards in another country
- Restrict engineering solutions
- Define a set level of energy savings

Does:

- Increase deal-flow in the near-term
  - Increase confidence in savings
  - Reduce transaction costs

- Reduce risk and costs in the long-term
  - Attract project finance investors
  - Reduce cost of capital

Source: Investor Confidence Project

Investor Ready Energy Efficiency (IREE)

An international framework for reducing owner and investor risk, lowering due diligence costs, increasing certainty of savings achievement and enabling aggregation.

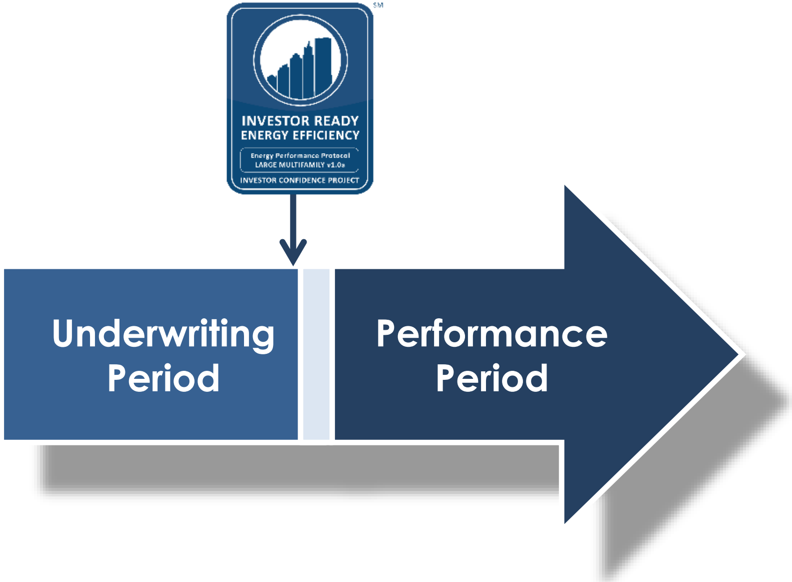
SM
INVESTOR READY
ENERGY EFFICIENCY
Energy Performance Protocol
LARGE MULTIFAMILY v1.0a
INVESTOR CONFIDENCE PROJECT

The IREE™ Certification ensures transparency, consistency and trust-worthiness through **best practice and independent verification.**

Source: Investor Confidence Project

Investor Ready Energy Efficiency (IREE)

An international framework for reducing owner and investor risk, lowering due diligence costs, increasing certainty of savings achievement and enabling aggregation.



The IREE™ Certification is **delivered prior to investment decision**

Source: Investor Confidence Project

Scenario:

Builders are saying that construction timelines are short and it is not possible to design more efficient buildings because it is too complicated.

What changes in building design can enable more energy efficiency in buildings?

www.iea.org

#energyefficientworld