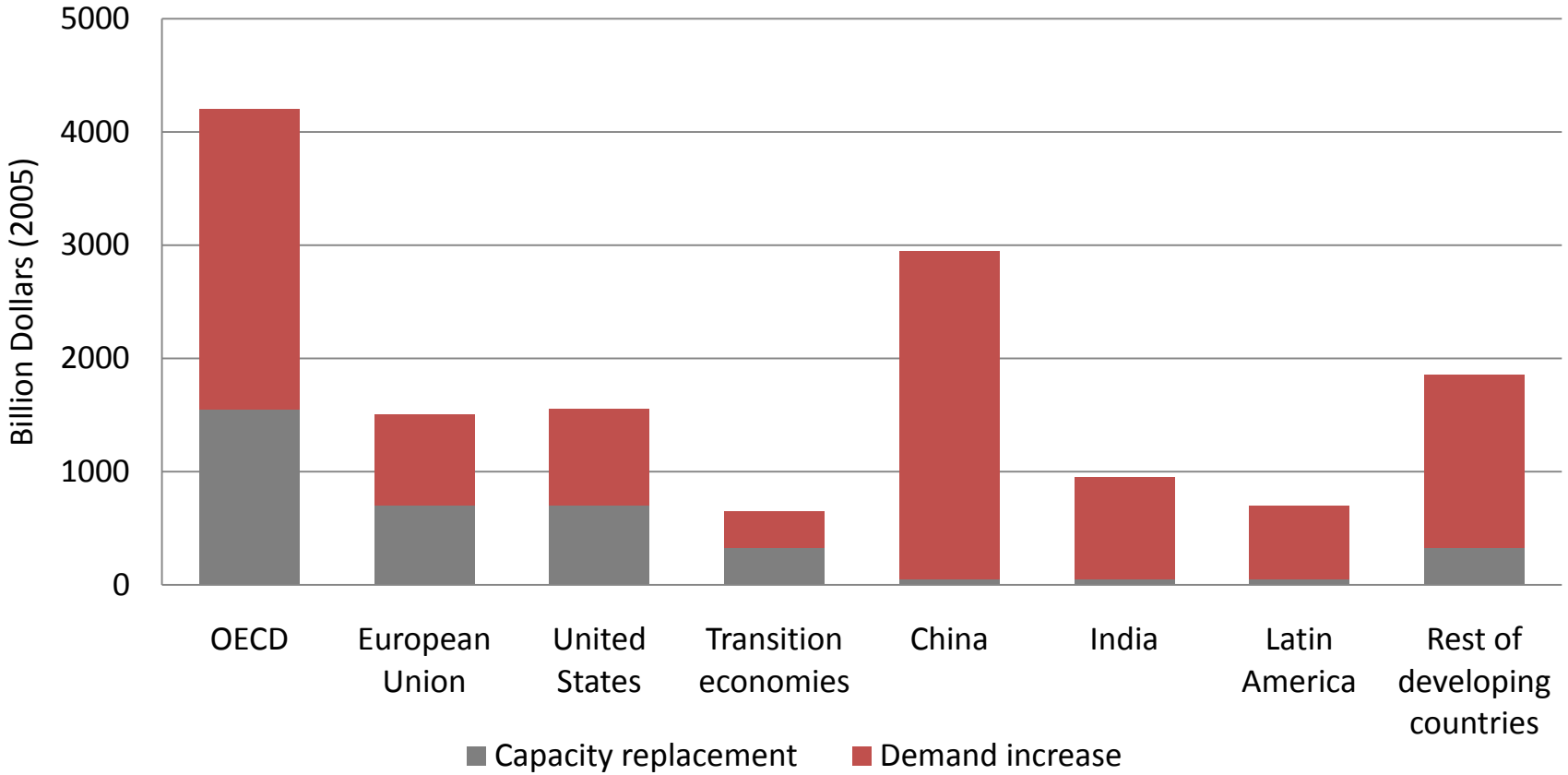
Energy Conservation Building Code

India Insulation Forum, May 15, 2014, Ahmedabad

WORLD Energy Scenario



Cumulative Power Sector Investment 2005-2030

The largest investments are needed in developing countries, especially countries like China and India, mostly to meet surging demand

- SOURCE: International Energy Agency, World Energy Outlook 2006

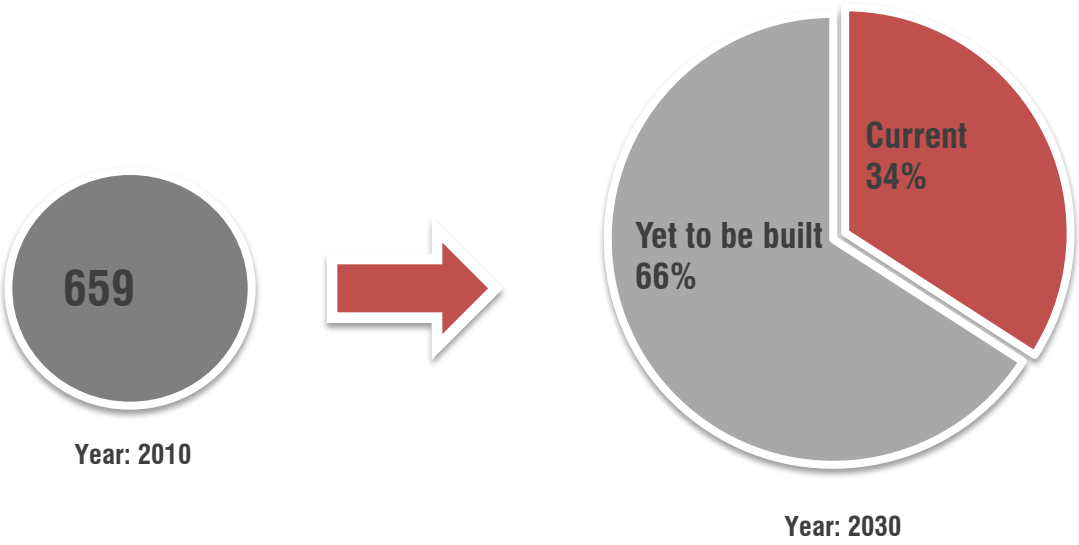
Energy Scenario in INDIA

- 16% of global population
- 4.5% Compound Annual Growth Rate (CAGR) in primary energy demand (1997-2007)
- Capital Investment needed on Supply Side - approx. $1 trillion
- Installed Capacity in India – approx. 160,000 MW
- Projected Capacity in 2030 – 800,000 MW
  - 600 MW capacity addition each week for the next 20 years
- Continued deficit supply in 2007-08 (MoP)
  - Peak power deficit of 16.6%
  - Energy Deficit of 9.9%
- Capacity Added by China in last two years – 180,000 MW
  - More than total installed capacity in India
- No other country in the history would have encountered the growth in the AC load that India is poised to experience

Commercial Buildings Growth Forecast

- Currently, ~ 659 million m^2 (USAID ECO-III Internal Estimate Using MOSPI, CEA and Benchmarked Energy Use data)

- In 2030,~ 1,900 million m^2 (estimated) *
  - 66% building stock is yet to be constructed



** Assuming 5-6% Annual Growth*

SOURCE: McKinsey & Company (2009), Environmental and Energy Sustainability: An Approach for India

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Powers and Functions of BEE

guidelines for ECBC under clause (p) of section 14 of EC Act 2001

Power of GoI to Facilitate and Enforce Efficient Use of Energy and its Conservation

- Prescribe ECBC for efficient use of energy

- **Amend the ECBC to suite the regional and local climatic conditions**

- Direct every owner of the building, being a designated consumer to comply with the provisions of ECBC

February 8, 2011 - 5/12

Significance of ECBC

- Regulates building thermal performance & energy use according to climate zone
  - Encourages climatic responsive building design
- Encourages use of daylighting, shading, natural ventilation, solar energy etc.
  - Energy efficiency strategies appropriate for India
- Focuses on energy performance of buildings rather than green building design
  - Material properties, water use, building site etc. not regulated
  - Green Building Design standards will refer to ECBC for energy performance

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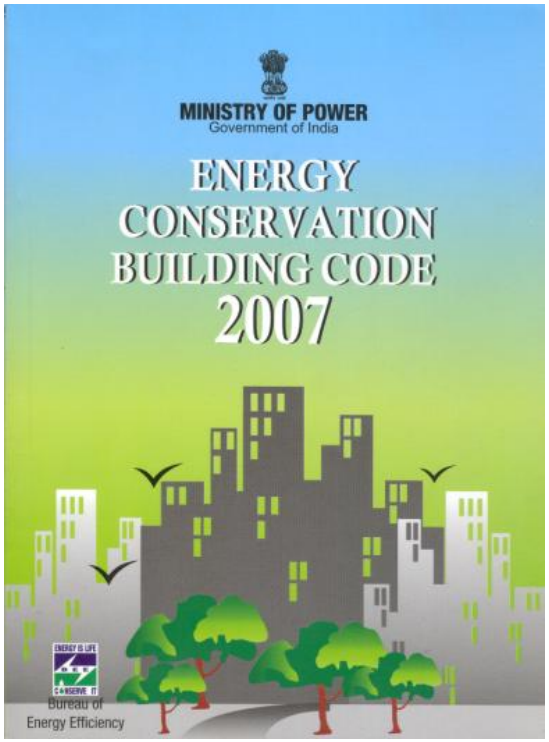


ECBC set minimum energy efficiency standards for design and construction

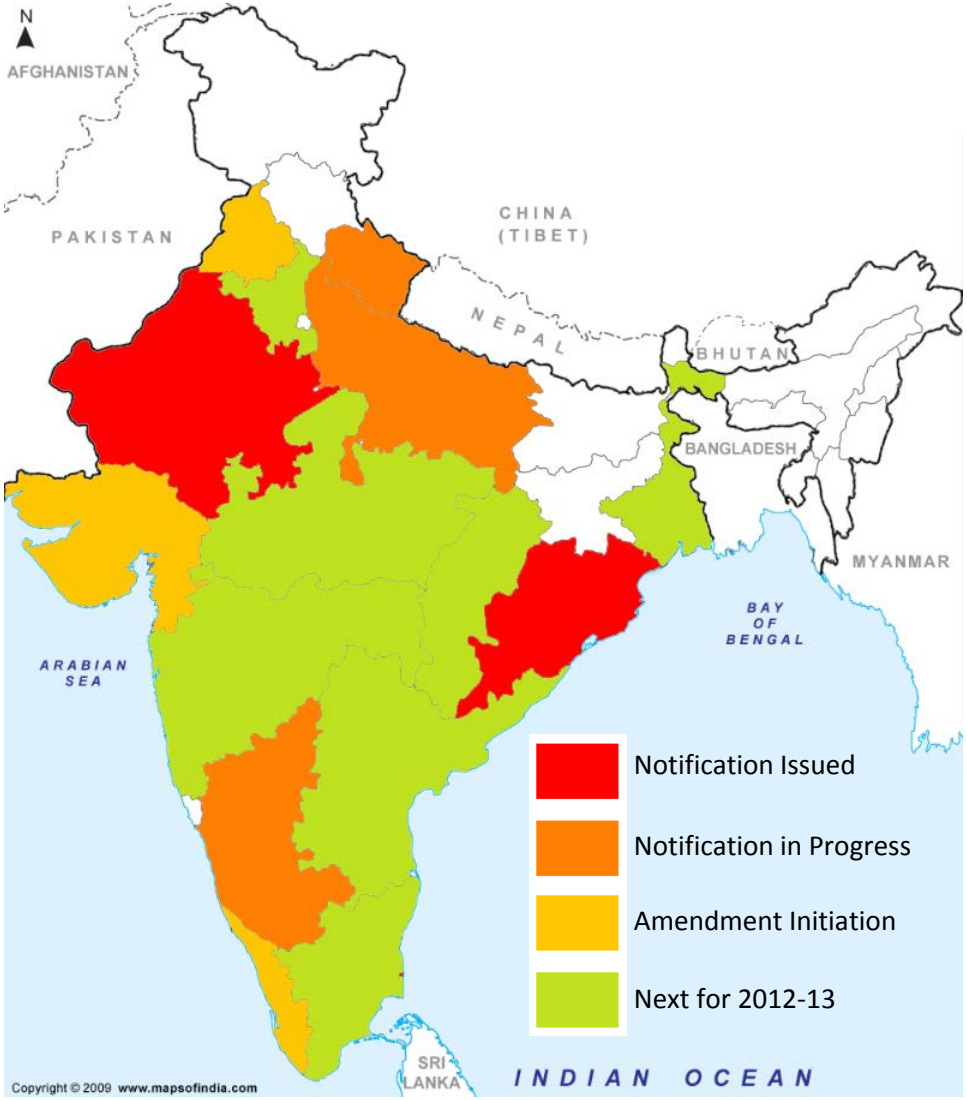
It encourage energy efficient design or retrofit of buildings

It does not constrain the building function, comfort, health, or the productivity of the occupants

Has appropriate regard for economic considerations

April 19, 2012

Status of ECBC at State Level



- Notification Issued
  - Rajasthan, Odisha, & Puducherry
- Notification in progress
  - UP, Karnataka and Uttarakhand,
- Amendment Initiation
  - Punjab, Kerala, Gujarat
- Next identified for 2012-2013
  - MP, Haryana, Chhattisgarh, AP, Tamil Nadu, West Bengal, Maharashtra

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Adoption

– Mandatory requirement is to be adopted at SDA or by the ULB or by an agency such as the state PWD. ECBC compliance is included in building bye-laws.

Implementation

– Architects and engineers design the building to meet ECBC requirements
– Contractors construct and commission the building to meet ECBC Requirements

Enforcement

– The process of checking ECBC requirements in a building
– Happens at design stage to get construction permit, and after construction to get occupancy certificate

Challenges to ECBC Compliance

- **Adoption**
  - Each local government has to modify bye-laws
- **Implementation**
  - Lack of expertise amongst architects, engineers and contractors
  - Lack of availability of equipment with prescribed efficiency levels
  - Lack of third party objective testing facilities that measure product efficiency with standard test procedures.
- **Enforcement**
  - Enforcement at urban local bodies
  - Lack of expertise and human resources
  - Occupancy approval does not include all building systems

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Code Enforcement Overview

Step 1 must be a compliance check before construction that gives a permit to construct based on drawings and Documentation

Step 2 must be a compliance check with on-site inspection that ensures that the building as an asset is code compliant

Step 3 may be an optional ongoing check for compliance based on building Energy Performance Index

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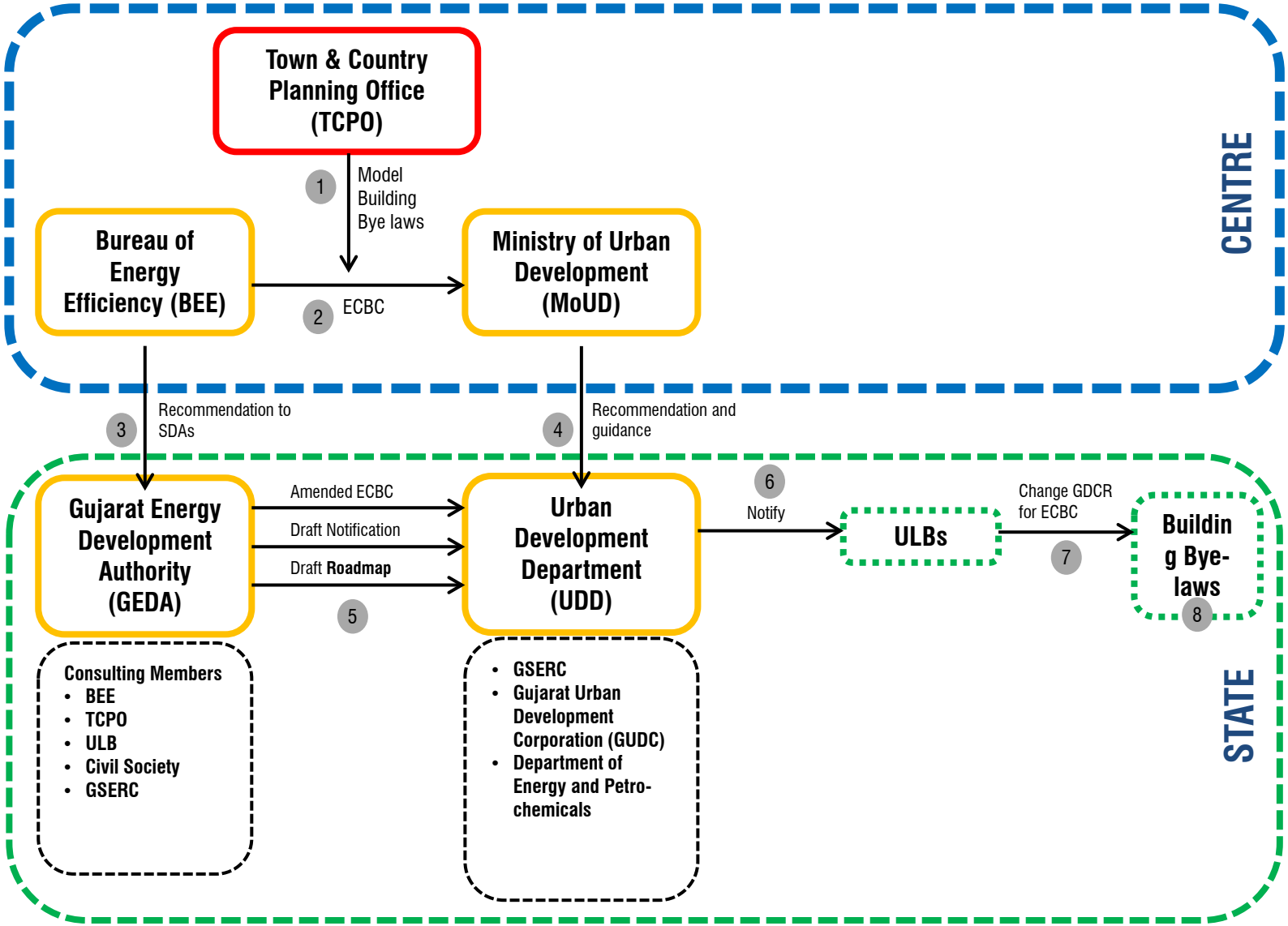
Models of Enforcement

- Through local government and agencies that provide building construction permits
- Through the local utility company
- Through 3rd party certification agencies

ECBC Draft Notification Process



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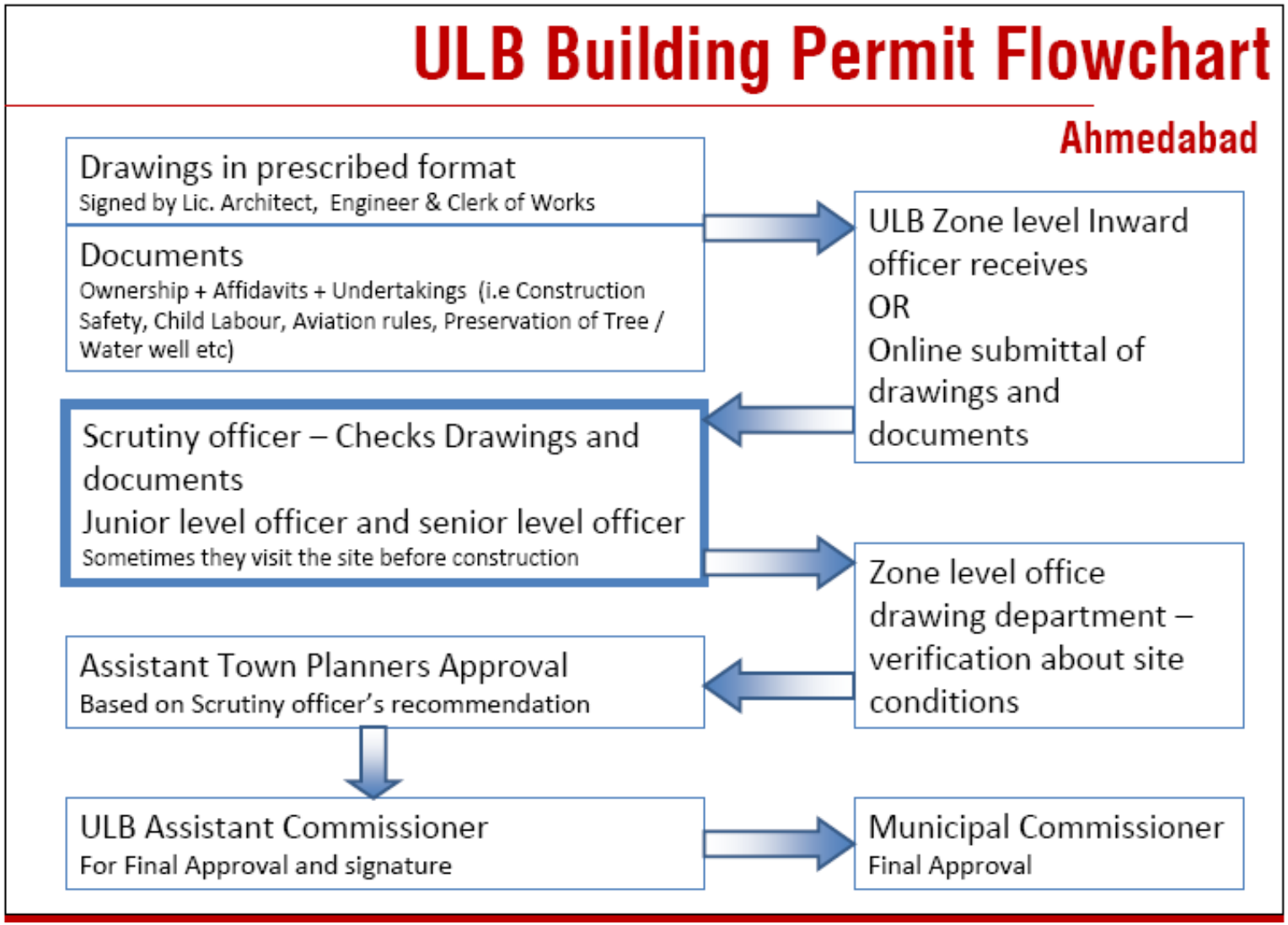

What is
Energy Conservation Building Code ?

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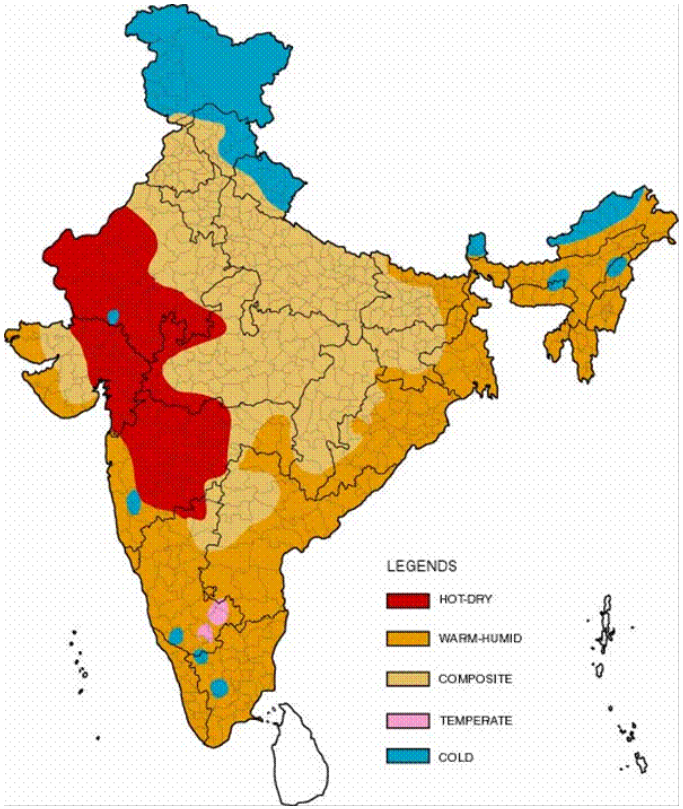

Five Climate Zones in India

ECBC refers to these and suggest different compliance for different zones

- Hot – Dry
- Warm – Humid
- Composite
- Temperate
- Cold

U value Specified for wall for Hot-Dry is different than composite

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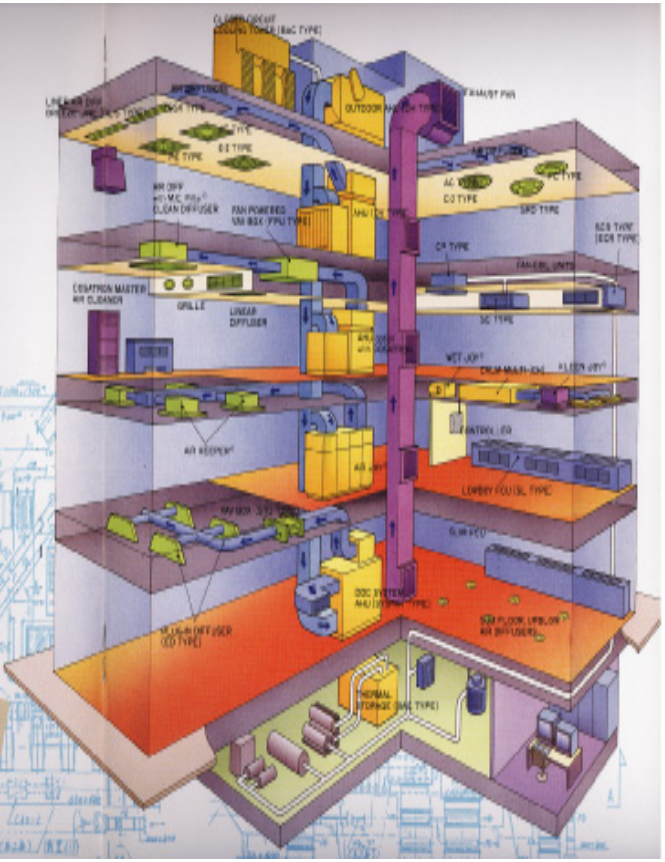

The provisions of this code apply to:

- Building envelopes (except for unconditioned storage spaces)
- Mechanical systems
- Interior and exterior lighting
- Electrical power and motors

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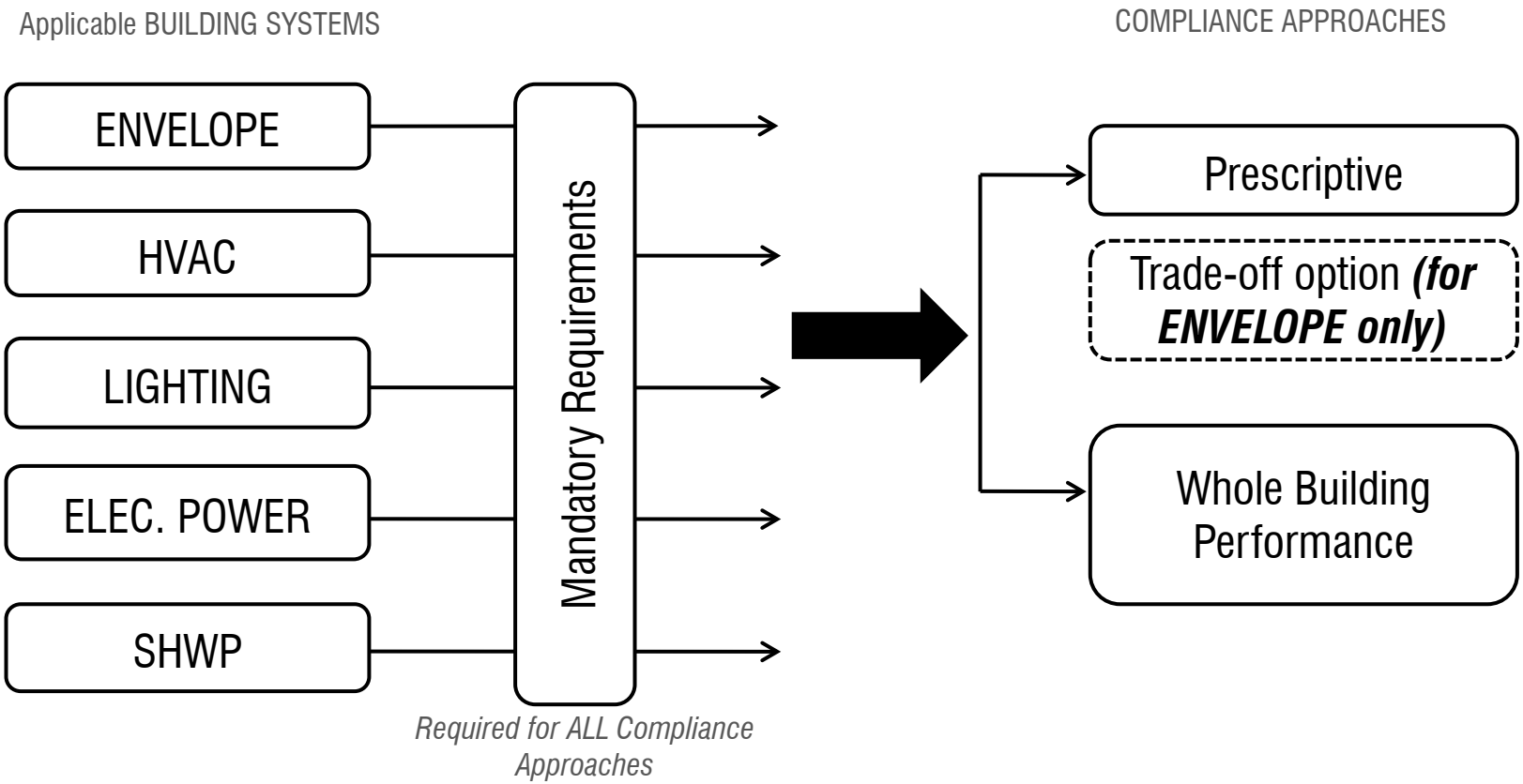
Compliance Approaches



Compliance Approaches

- **PRESCRIPTIVE**
  - Each building/system component should have specific performance value
- **TRADE-OFF**
  - Applies to Building Envelope ONLY
  - Component performance value can be less BUT Overall performance of the envelope complies with ECBC
- **WHOLE BUILDING PERFORMANCE**
  - Allows flexibility in meeting or exceeding energy efficiency requirements by optimizing system interactions
  - Component and Systems Modeling: Envelope, Lighting, HVAC
  - Physical Processes: Day lighting, Heat-flow, Airflow

Compliance Approaches

Approaches	Mandatory Provisions of ECBC	Flexibility	Expert Knowledge	Linear Approach	Use of Energy Simulation
PRESCRIPTIVE	Required	Low	Low	Yes	No
TRADE-OFF	Required	Medium	Medium	No	May be
WHOLE BUILDING PERFORMANCE	Required	High	High	No	Yes

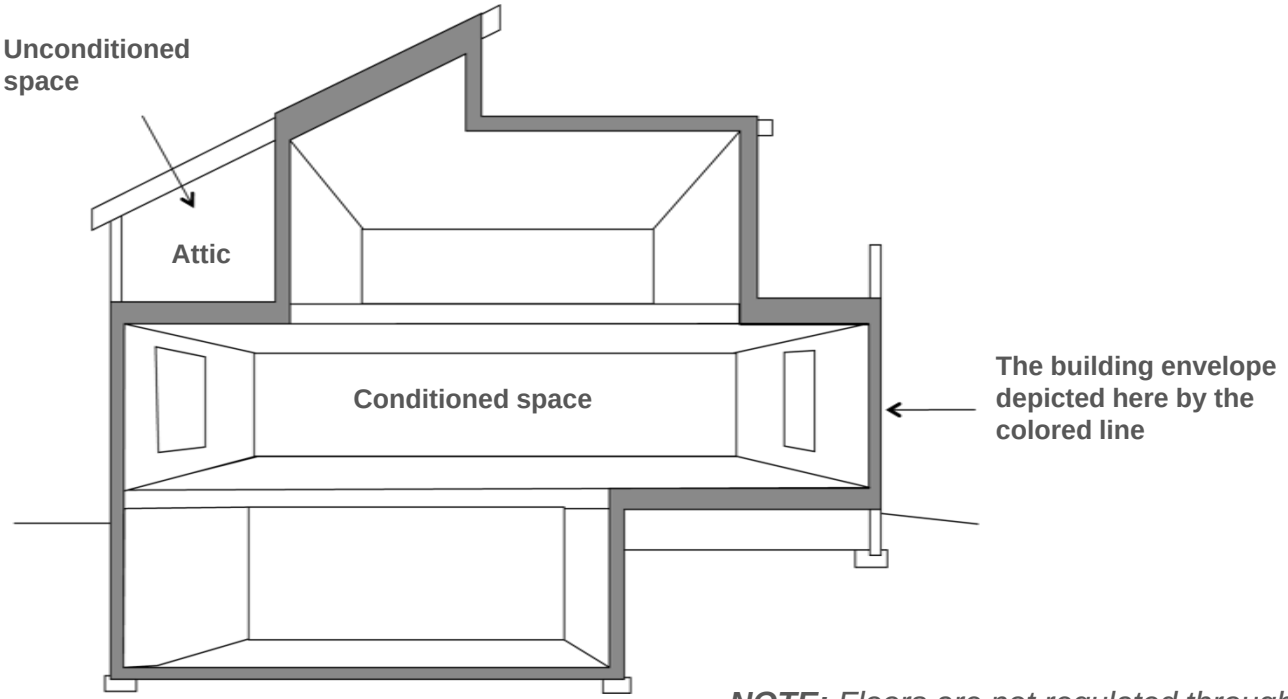
Building Envelope

- Building Envelope
- Opaque Construction
  - **Heat Transfer**
  - **ECBC Requirements**
- Cool Roofs
  - **ECBC Prescriptive Requirements**
- Fenestration
  - **Heat Transfer**
  - **ECBC Requirements**
- Air Leakage
  - **ECBC Mandatory Requirements**
- ECBC Compliance Forms

Building Envelope

Surface that separates external environment from the interior (occupied) Space

- *Opaque Construction:* Roof, Walls and Floors
- *Fenestration:* Windows, Doors and Skylights



NOTE: *Floors are not regulated through the ECBC*

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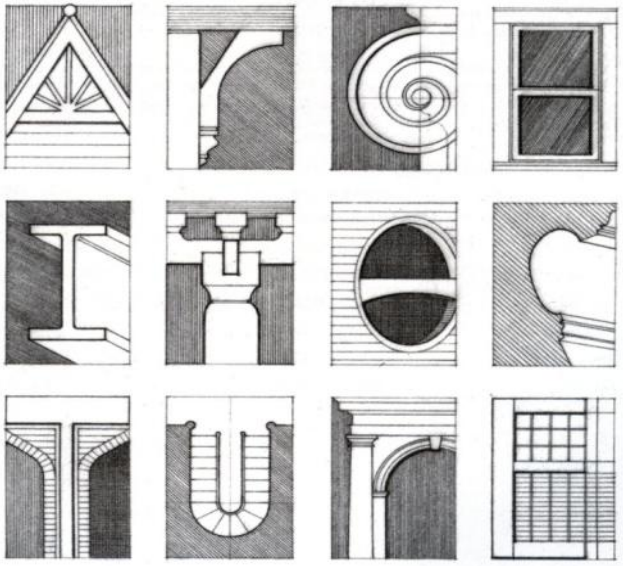


Prescriptive Approach

Each building element should have specific performance value

U- factor of Building Element
For **Hot & Dry Climate Zone**

Roof Assembly: 0.261 W/M^2-C
Opaque Walls: 0.440 W/M^2-C
Sky Lights: 11.24 max with curb W/M^2-C
Vertical fenestration: 3.30 W/M^2-C

Building Envelope Design Considerations

- *Climate & microclimate*
  - Temperature, humidity, solar radiation, wind speed/direction, landform, vegetation, water bodies, open spaces, etc.
- *Building Orientation & Form*
  - Orientation of the building, surface-to-volume ratio and exposed surface area

COMPOSITE CLIMATE

MODERATE CLIMATE

HOT-DRY CLIMATE

COLD CLIMATE

Building Envelope Design Considerations

- *Building Envelope Component Design*
  - Area, orientation and tilt of the building envelope components
  - Roof form design, choice of shading devices, fenestration size, placement of windows, construction specifications etc.
- *Building Material Specification*
  - Insulating Properties (U-values, SHGC), emissivity & color/texture

NOTE:

- *ECBC requirements affect envelope component design & material selection*
- *ECBC requirements impact heat transfer through buildings by regulating building insulation, area of fenestration and air leakage through buildings*

Opaque Construction

- Heat Transfer
  - R-value (Insulation)
  - U-value
- ECBC Requirements
  - Mandatory Requirements
  - Prescriptive Requirements

Heat Transfer

Mode of Heat Transfer	Affected By	ECBC's role in regulating Heat Transfer
CONDUCTION	Thermal Properties of Materials & Effectiveness of Insulation	U-factors/ R-values of roofs & walls
CONVECTION	Air movement at the surface	Building Envelope Sealing Requirements
RADIATION	Indirect and direct solar radiation	• R-values of roofs & walls • Cool Roofs

Heat Transfer

Thermal Property	Units	Effect of Thickness	Relationship
CONDUCTIVITY [k]	W/m·K	For unit thickness (m)	
RESISTIVITY [r]	m·K/W	For unit thickness (m)	1/k
RESISTANCE [R-value]	m^2·K/W	For thickness of construction (d)	d/k
CONDUCTANCE (Single Layer) [U-value]	W/m^2·K	For thickness of construction (d)	1/R-value
CONDUCTANCE (Multiple Layers) [U-factor]	W/m^2·K	For thickness of construction (d)	1/R-$value_{(Total)}$

R-value

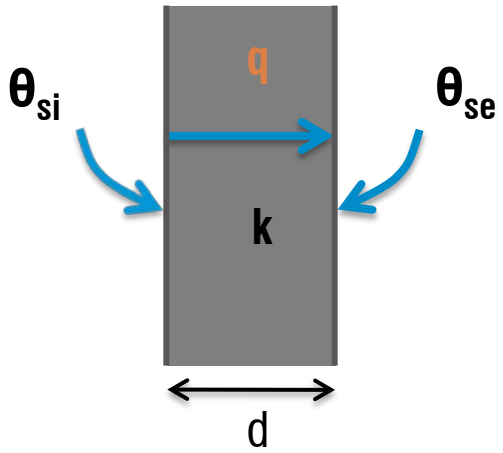
- Thermal resistance : R-value

$$R = \frac{\text{Thickness of the material (d)}}{\text{Thermal conductivity of the material (k)}}$$

Thermal resistances of multi-layered components

$$R_T = \frac{d_1}{k_1} + \frac{d_2}{k_2} + ... + \frac{d_n}{k_n} = \sum_{n}^{1} \frac{d_n}{k_n}$$

k	: Conductivity
d	: Thickness in m
θ_{si}	: Indoor surface temperature
θ_{se}	: Outdoor surface temperature



- Effectiveness of thermal insulation to retard the heat flow
- Higher R-value indicates higher insulating properties
  - (Units = $m^2 \cdot K/W$)

U-value

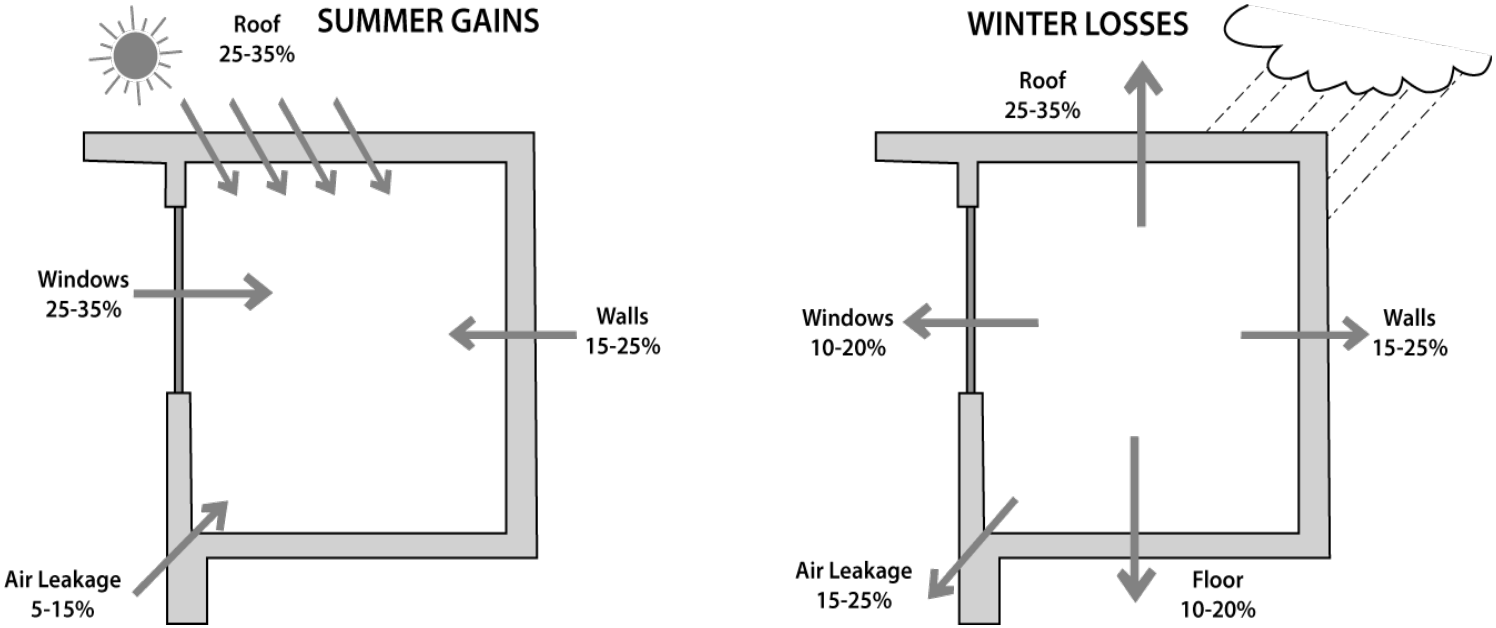
- Thermal Conductance (Heat Transfer Coefficient): U-value

$$U = \frac{1}{R}$$

- Measures heat transfer through the envelope due to a temperature difference between the indoors and outdoors (Unit = $W/m^2 \cdot K$)
- U-factor of composite wall/roof assembly as $1/R_T$
- Rate of the heat flow, therefore, lower numbers are better

Building Insulation

- One of the ways to improve energy efficiency, especially in air conditioned buildings
- Has high R-value
- Increases thermal comfort in cooling & heating mode
- Helps in reducing heating and cooling costs



ECBC Requirements: Mandatory

- U-factors shall be determined from the default tables in Appendix C §11 or determined from data or procedures contained in the ASHRAE Fundamentals, 2005.

Description	Density kg/m^3	Conductivity[b] (K), W/(m·K)	Conductance (C), W/(m^2·K)	Resistance[c] (R) 1/k, K·m^2/W	Resistance[c] (R) For Thickness Listed (1/C), K·m^2/W	Specific Heat kJ/(kg·K)
BUILDING BOARD						
Asbestos cement board.....	1900	0.58	—	1.73	—	1.00
Asbestos-cement board....3.2 mm	1900	—	187.4	—	0.05	—
Asbestos-cement board....6.4 mm	1900	—	93.7	—	0.011	—
Gypsum or plaster board. 9.5 mm	800	—	17.6	—	0.056	1.09

ECBC Requirements: Prescriptive

- For opaque construction, individual building envelope components must comply with:
  - **Maximum U-factor or Minimum R-value** (Exterior roofs , ceilings and opaque walls)
  - **Solar Reflectance & Emittance** (Cool Roofs)
- Compliance requirements vary according to:
  - The climate zone of the building location
  - Occupancy of the building (24 hour use or daytime use)

ECBC Requirements: Prescriptive
(Opaque Walls)

- Maximum U-factor is prescribed for the complete wall assembly
- Minimum R-value is prescribed for insulation alone (excluding air films)

Table 4.2: Opaque Wall Assembly U-factor and Insulation R-value Requirements

Climate Zone	Hospitals, Hotels, Call Centers (24-Hour)		Other Building Types (Daytime)	
	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)
Composite	U-0.440	R-2.10	U-0.440	R-2.10
Hot and Dry	U-0.440	R-2.10	U-0.440	R-2.10
Warm and Humid	U-0.440	R-2.10	U-0.440	R-2.10
Moderate	U-0.440	R-2.10	U-0.440	R-2.10
Cold	U-0.369	R-2.20	U-0.352	R-2.35

ECBC Requirements: Prescriptive

(Roofs)

- Maximum U-factor is prescribed for the complete roof assembly
- Minimum R-value is prescribed for insulation alone (excluding air films)

Climate Zone	24-Hour use buildings Hospitals, Hotels, Call Centers etc.		Daytime use buildings Other Building Types	
	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)
Composite	U-0.261	R-3.5	U-0.409	R-2.1
Hot and Dry	U-0.261	R-3.5	U-0.409	R-2.1
Warm and Humid	U-0.261	R-3.5	U-0.409	R-2.1
Moderate	U-0.409	R-2.1	U-0.409	R-2.1
Cold	U-0.261	R-3.5	U-0.409	R-2.1

- Recommendations made for proper placement, installation and protection of insulation

ECBC Requirements: Prescriptive

For roofs with slope less than 20 degree

- Initial solar reflectance of no less than 0.70
- Initial emittance no less than 0.75

Initial reflectance/emittance may decrease over time, depending on the product, due to aging, dirt, and microbial accumulation.

Efficiency Recommendation for Cool Roofing Products (U.S. DOE)

Efficiency Recommendation[a]				
Roof slope	Recommended Solar Reflectance		Best Available Solar Reflectance [b]	
	Initial	3 Years after Installation	Initial	3 Years after Installation
Low-slope (<2:12)	65% or greater	50% or greater	87%	85%
High-slope[c] (<2:12)	25% or greater	15% or greater	77%	60%

a) Following this recommendation will provide the greatest benefit where cooling energy costs exceed heating costs
b) Roof products must be tested when new and after three years of exposure, according to ASTM E-903
c) For products that can be installed on both low- and high-slope roofs, "Low-slope" guidelines should be followed.

Fenestration: Outline

- Heat Transfer
  - Solar Heat Gain Coefficient (SHGC)
  - Shading Coefficient (SC) and SHGC
  - Visual Light Transmittance (VLT)
- ECBC Requirements
  - ECBC Mandatory Requirements
  - ECBC Prescriptive Requirements

ECBC Requirements: Overview

- ECBC regulates heat gain through fenestration through
- Size and Orientation
  - ECBC regulates maximum glazing area (Window-to-Wall Ratio)
- Shading Devices
  - ECBC takes into account reduction in heat gain through use of shading devices
- Glazing Properties
  - ECBC regulates Solar Heat Gain Factor (SHGC), U-value and Visual Light Transmittance (VLT)

ECBC Requirements: Mandatory

- U-factors AND SHGC (Appendix C of the ECBC)
- In accordance with ISO-15099 AND labeled and certified by the manufacturer
- U-Factors and SHGC must be certified by an accredited independent testing laboratory

Table 11.1: Defaults for Unrated Vertical Fenestration (Overall Assembly including the Sash and Frame)

		Clear Glass			Tinted Glass		
Frame Type	**Glazing Type**	**U-Factor (W/m²-°C)**	**SHGC**	**VLT**	**U-Factor (W/m²-°C)**	**SHGC**	**VLT**
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, vinyl, or fiberglass frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40

ECBC Requirements: Mandatory

- **Air Leakage through doors and fenestration**
  - for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m^2.
  - Other fenestration and doors shall not exceed 2.0 l/s-m^2.

- **Building Envelope Sealing**
  - The following areas of the enclosed building envelope shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:
    - Joints around fenestration and door frames
    - Openings between walls and foundations and between walls and roof and wall panels
    - Openings at penetrations of utility services through, roofs, walls, and floors
    - Site-built fenestration and doors

Energy Conservation Building Code, India

Development of Base case model for Each Buildings/Projects and then Its percentage comparison with proposed project / building

Whole Building Performance Approach

Energy flows on an hourly basis for all 8,760 hours in the year,

Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays,

Thermal mass effects,

Part-load and temperature dependent performance of heating and coolingequipment,

Air-side and water-side economizers with integrated control, and

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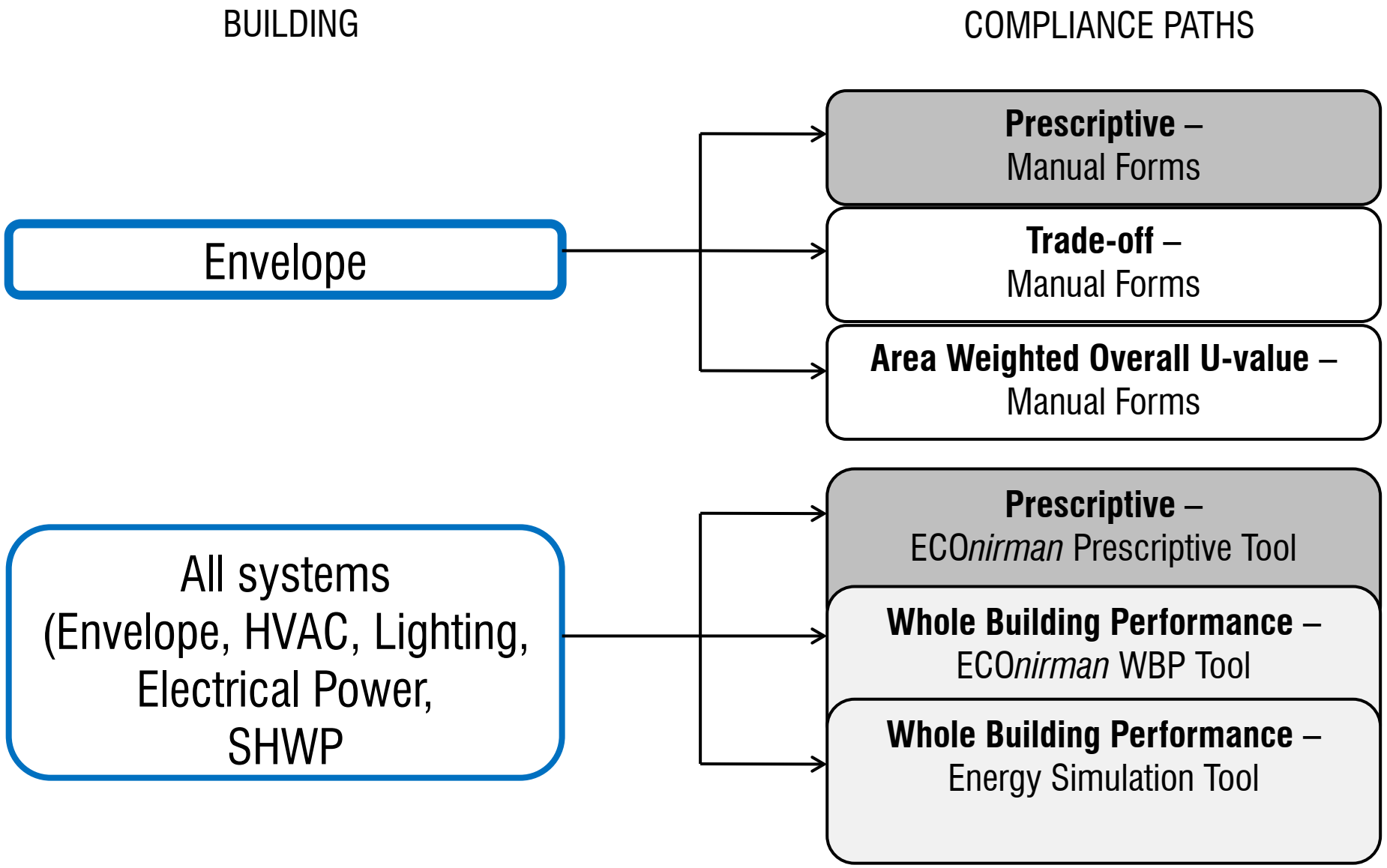
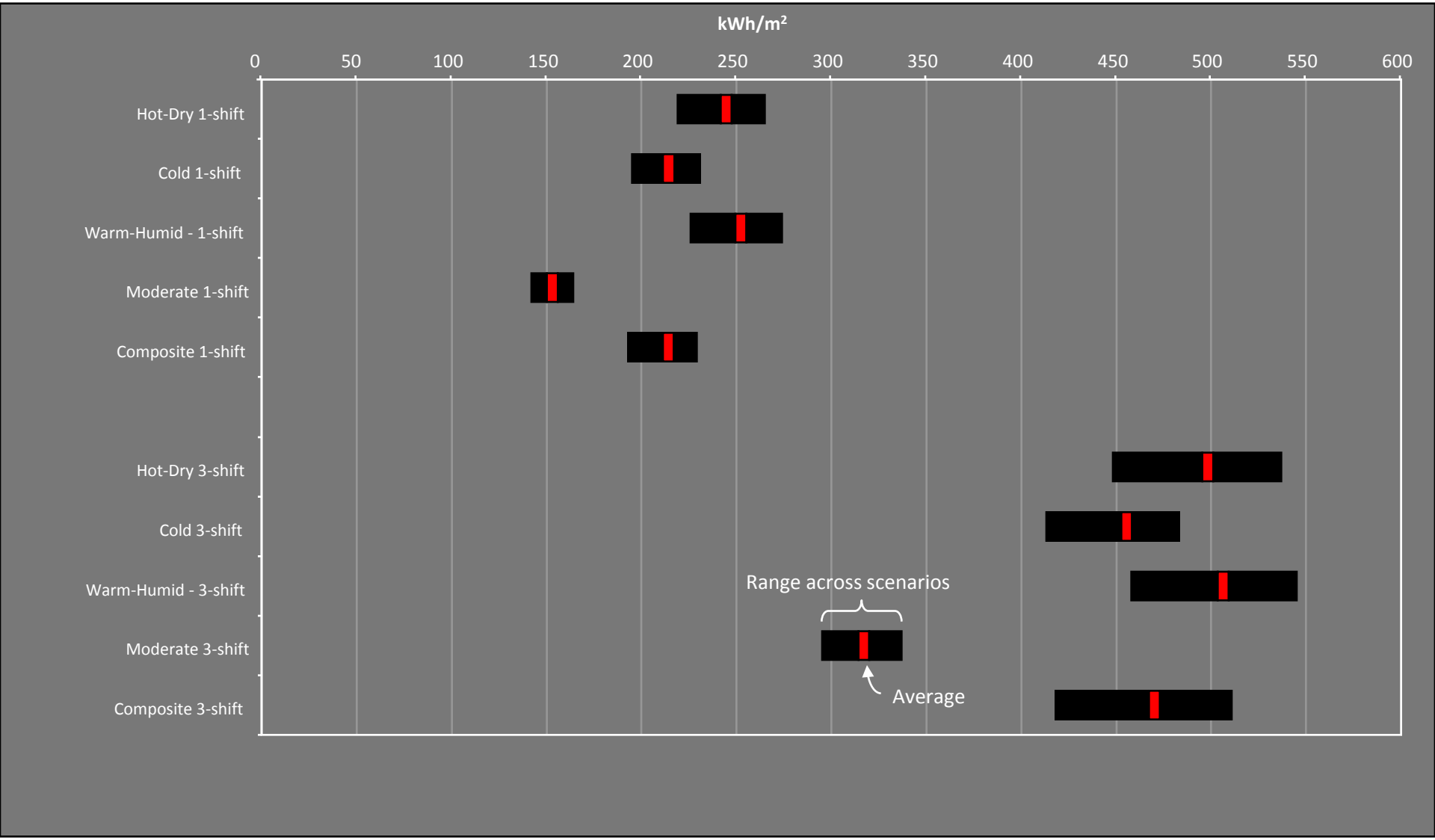
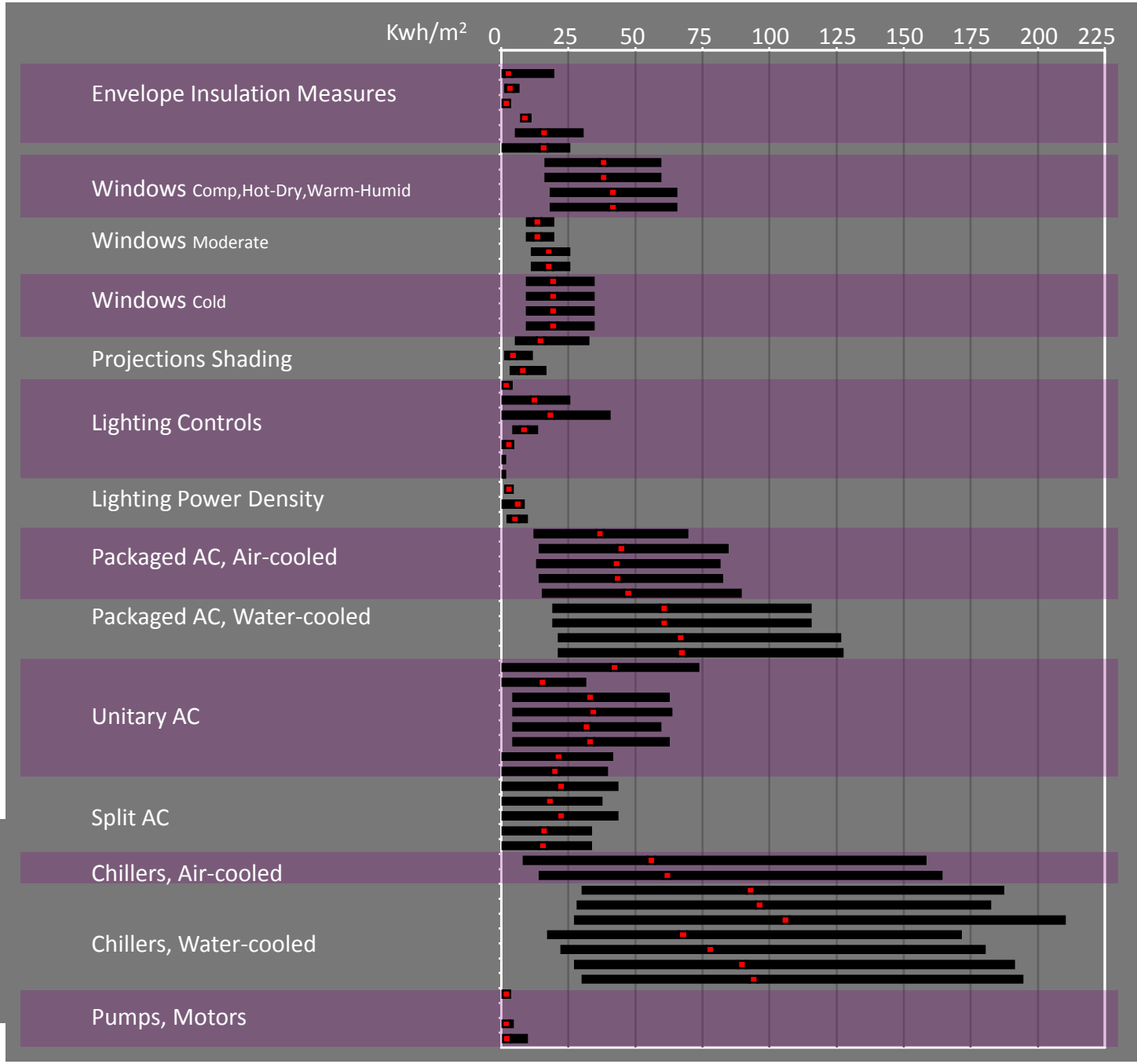
Compliance Options



Energy Performance Index of Buildings



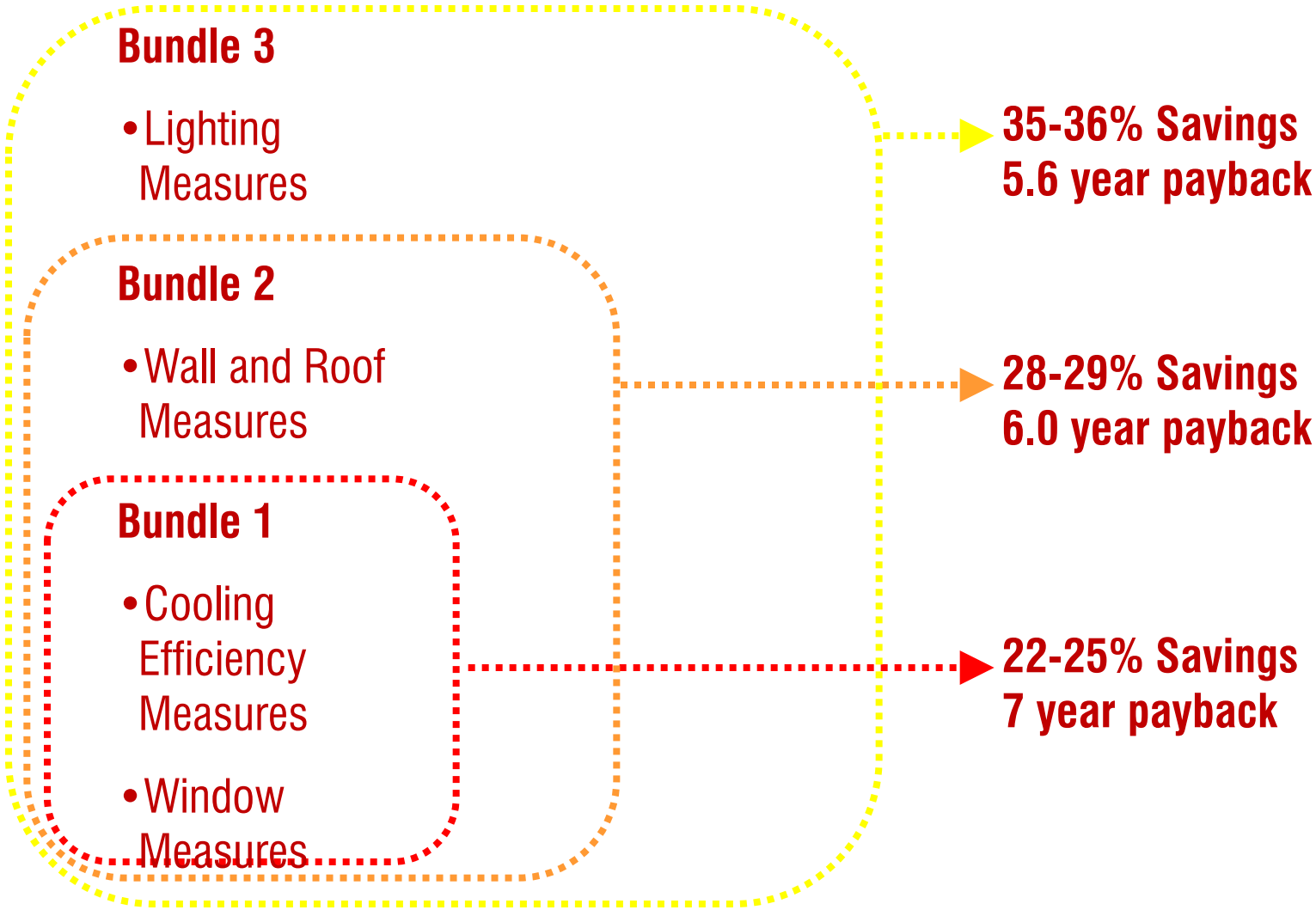
Savings Summary Of Various Energy Conservation Measures



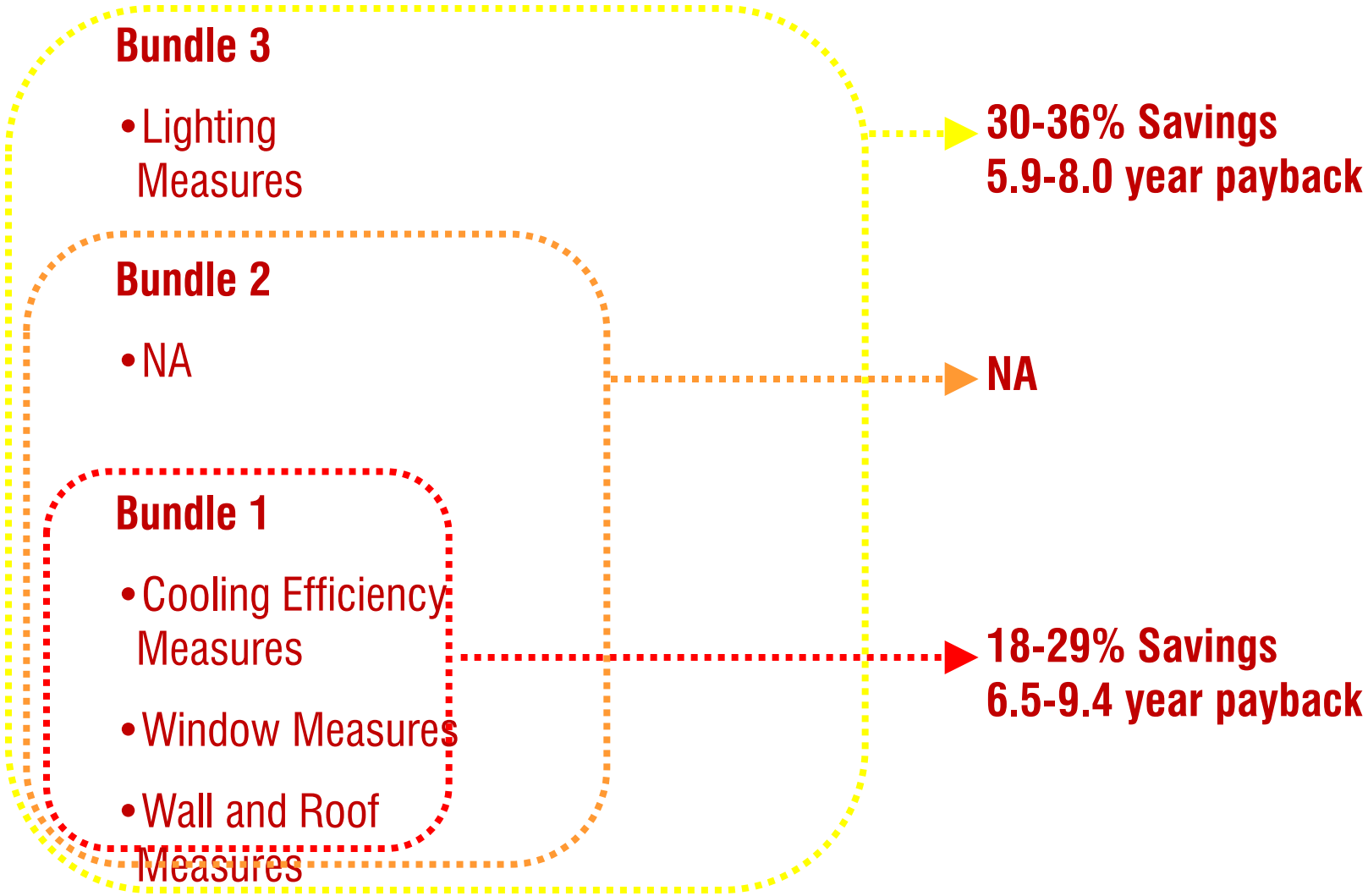
Implementation and Enforcement Approach 1

- The most promising measures for each climate zone in terms of annual energy savings are included in the first Bundle.
- Thus, ECMs with high energy savings are in Bundle 1, followed by moderate energy savings in Bundle 2 and those with lower energy savings in Bundle 3.
- This ensures that high energy savings are realized even when the first step- Stepped Bundle 1 is implemented.

Approach 1 Hot-Dry and Warm-Humid Climates

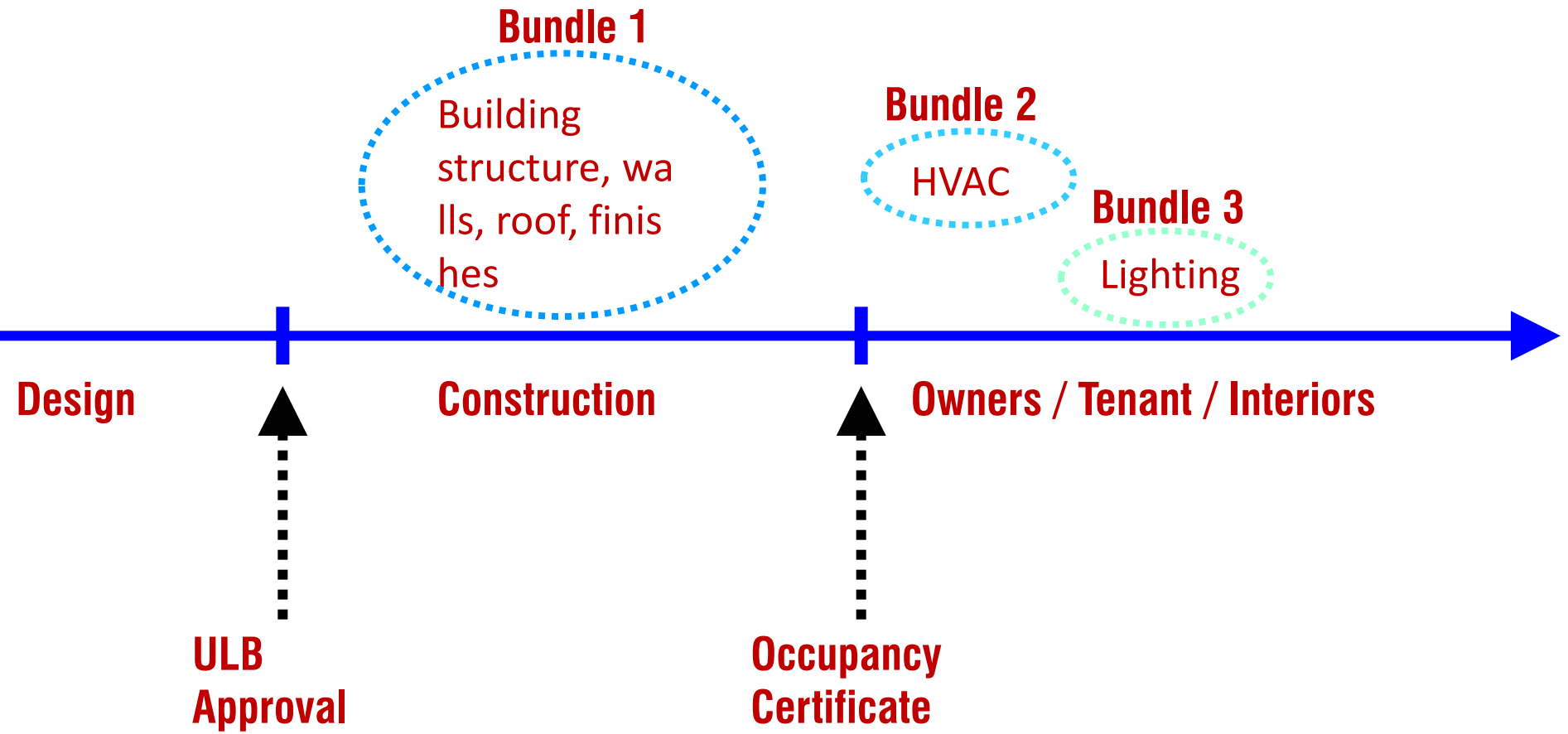


Approach 1 Cold, Moderate and Composite Climates



Construction and Permitting Process

For majority developer projects

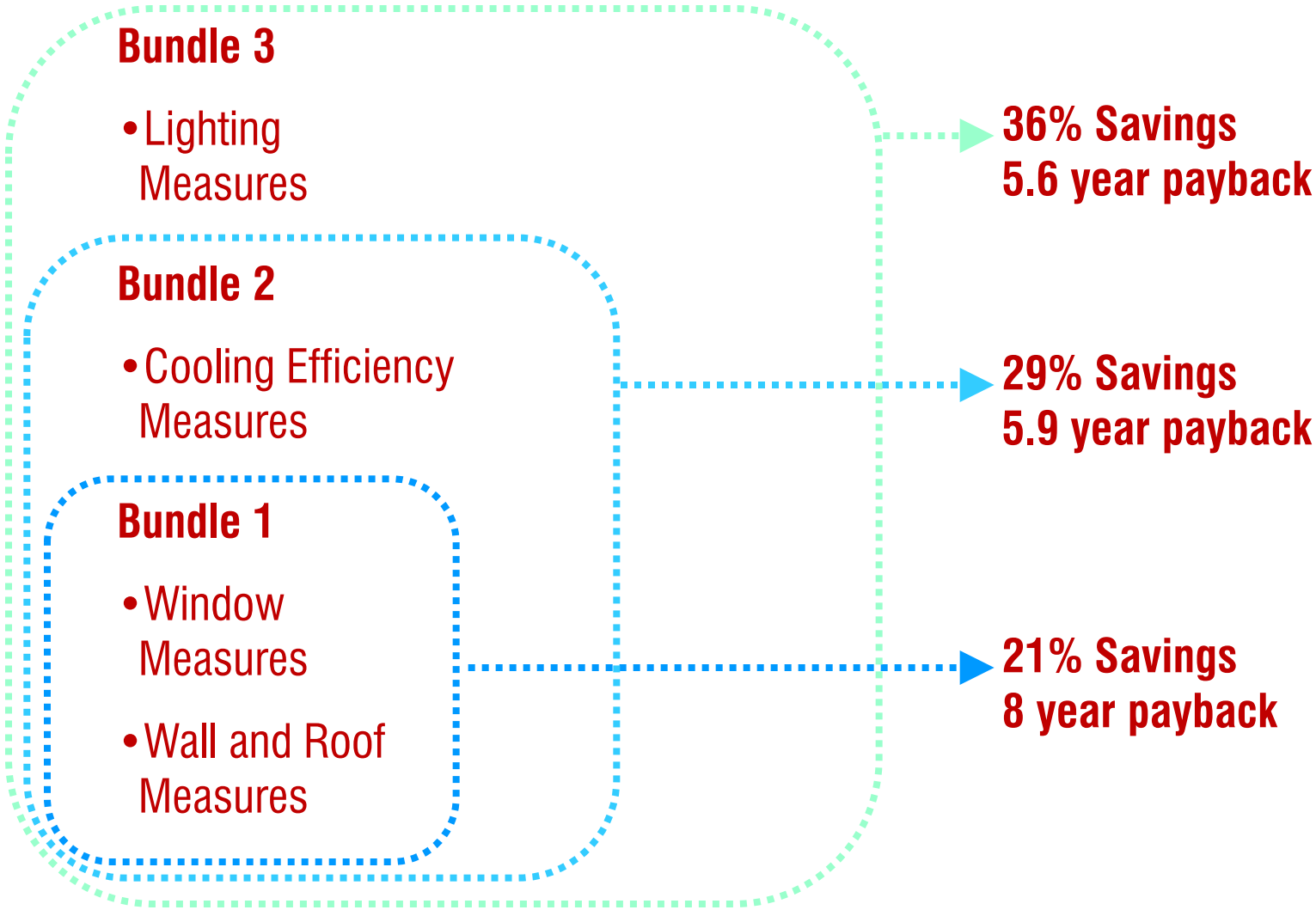


Implementation and Enforcement Approach 2

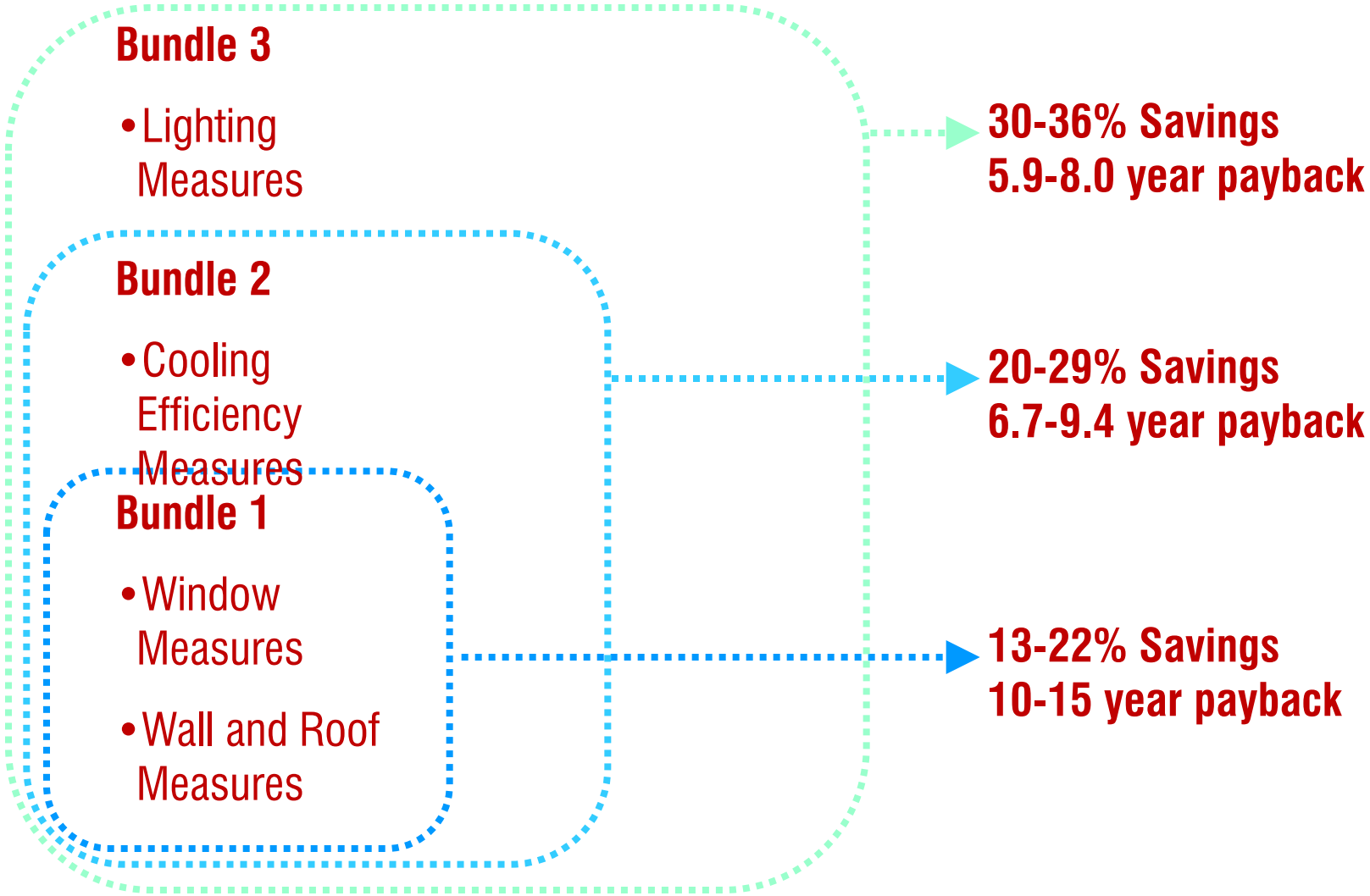
Bundles area arranged with ECBC requirements that align with the current building permitting process

- Bundle 1 contains measures that can be checked when the building shell is completed and ready for approval given the current construction approval process of most ULBs.
- Bundle 2 contains measures that could be implemented by the developer/owner with labeling programs as the mode of enforcement.
- Bundle 3 contains measures that are difficult to enforce with labeling programs or with the current ULB approval process, and may require an independent Third Party Agency.

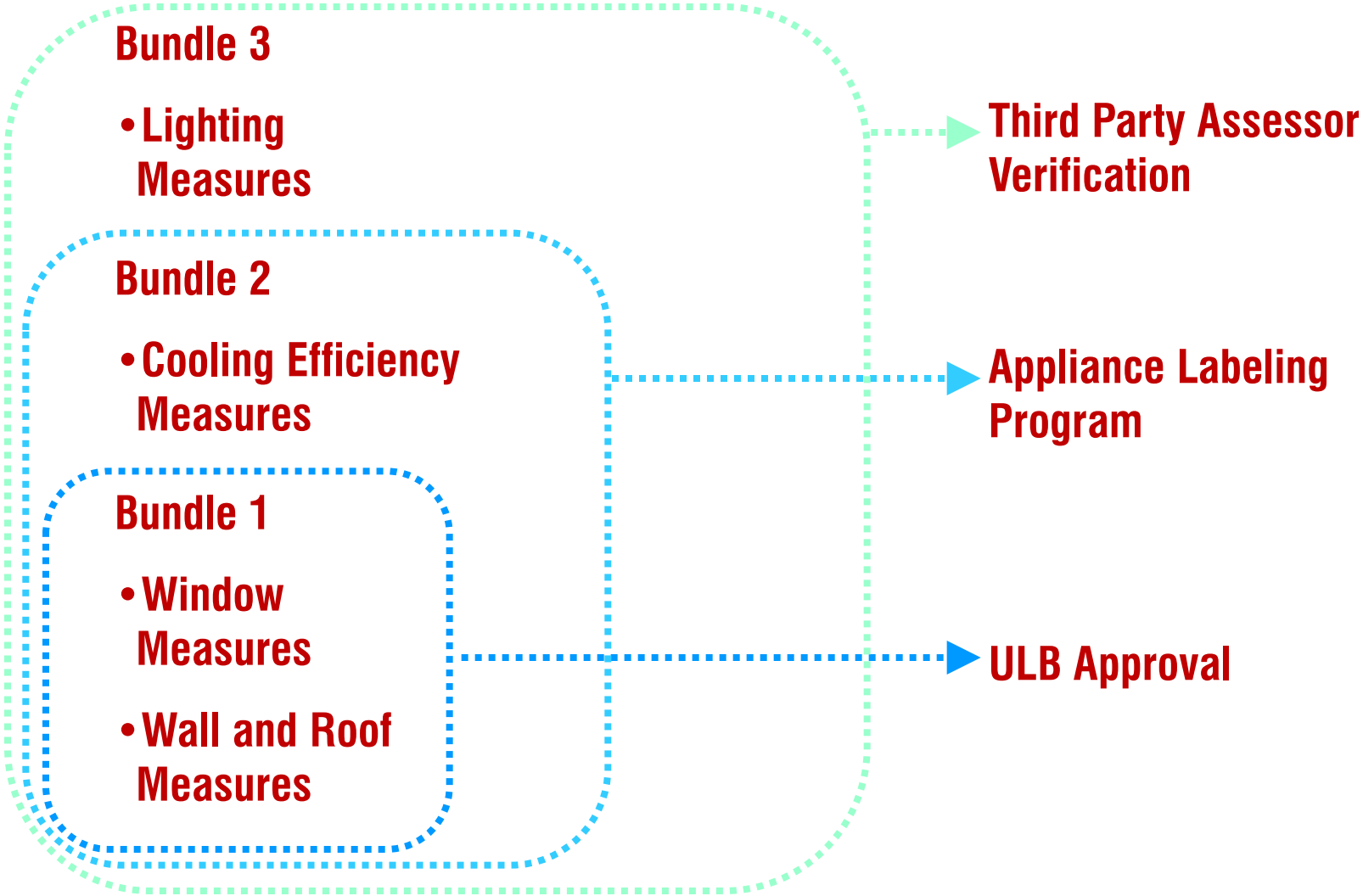
Approach 2 Hot-Dry and Warm-Humid Climates



Approach 2 Cold, Composite and Moderate Climate

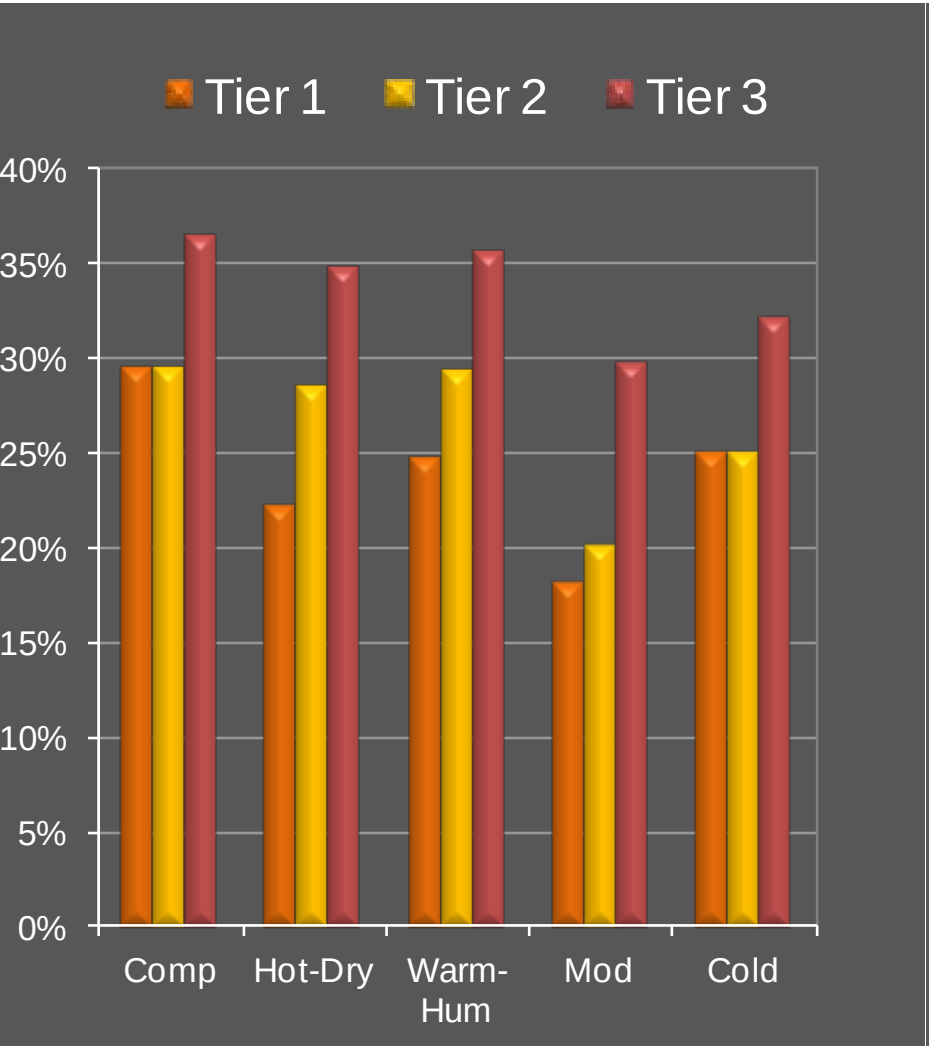


Approach 2

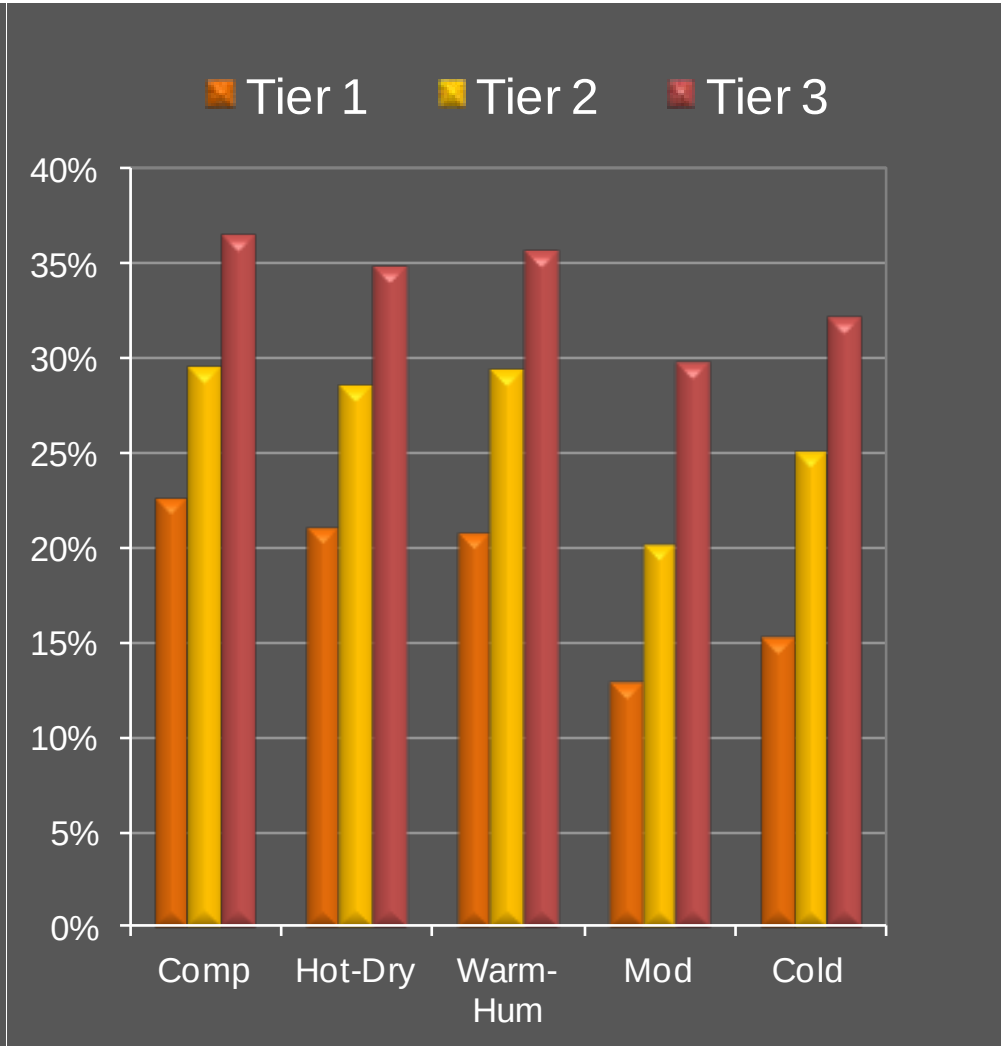

Bundle 3
• Lighting Measures
Bundle 2
• Cooling Efficiency Measures
Bundle 1
• Window Measures
• Wall and Roof Measures
Third Party Assessor Verification
Appliance Labeling Program
ULB Approval

% Annual Energy Savings

Annual Savings Approach

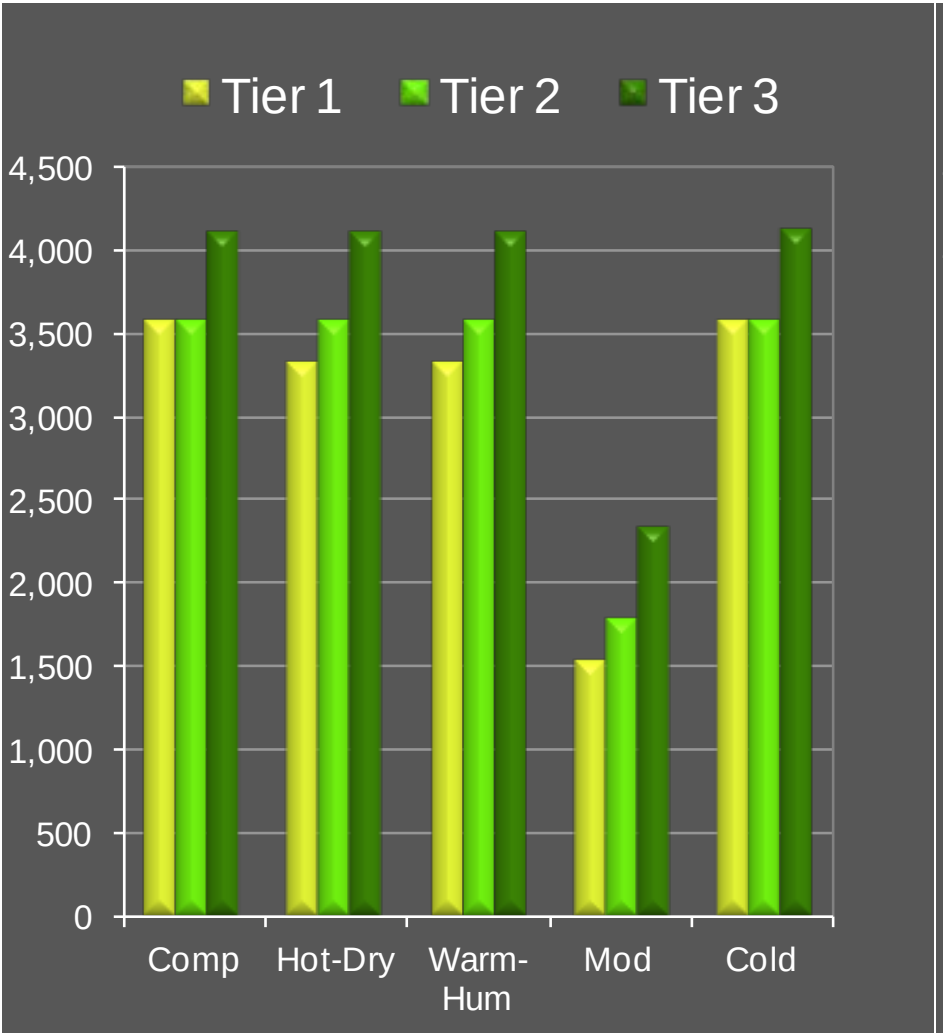


Easy Enforcement Approach

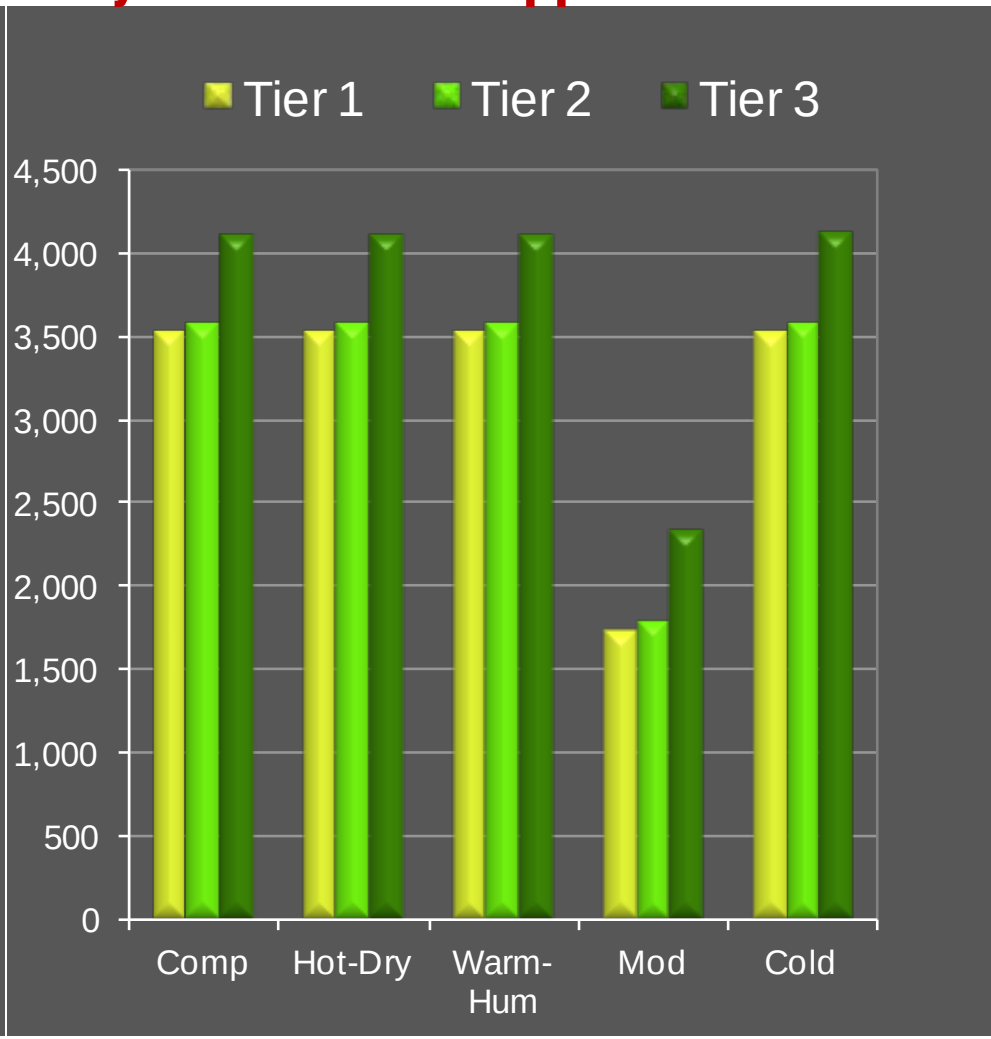


Incremental Cost INR/Sqmts

Annual Savings Approach

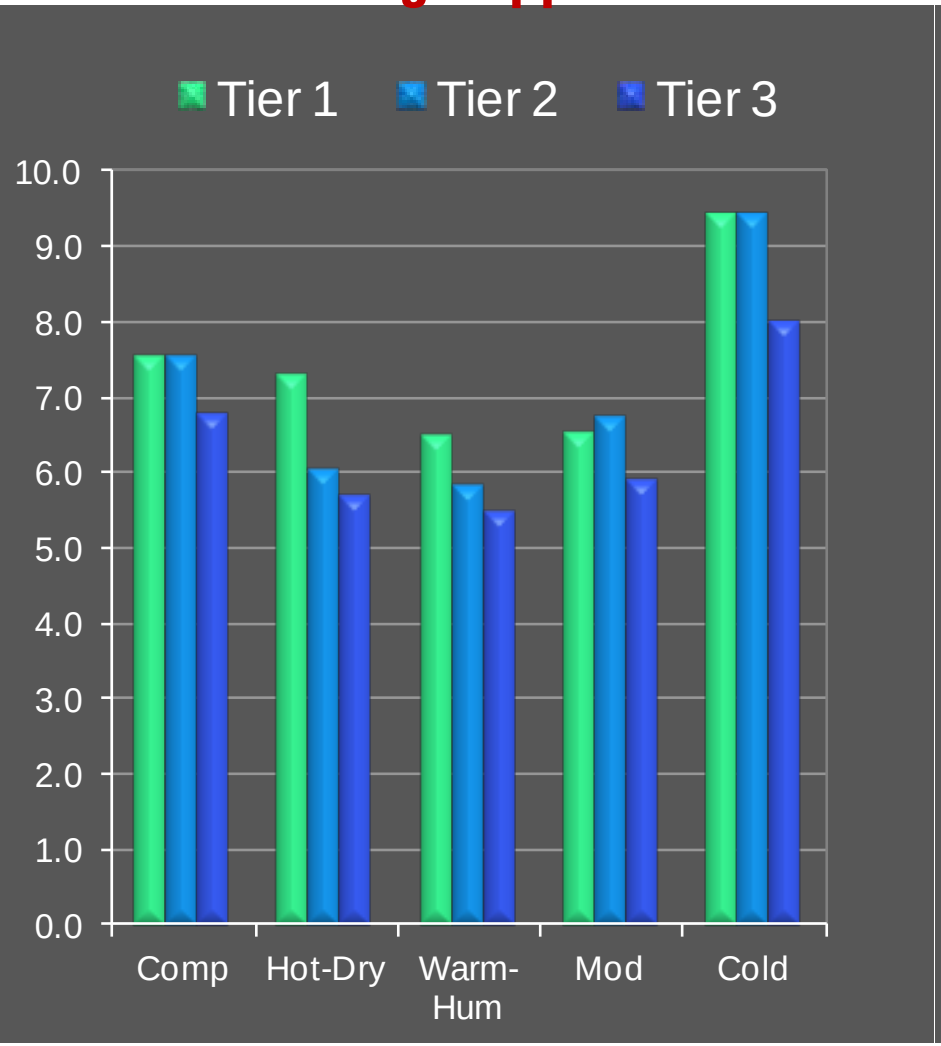


Easy Enforcement Approach

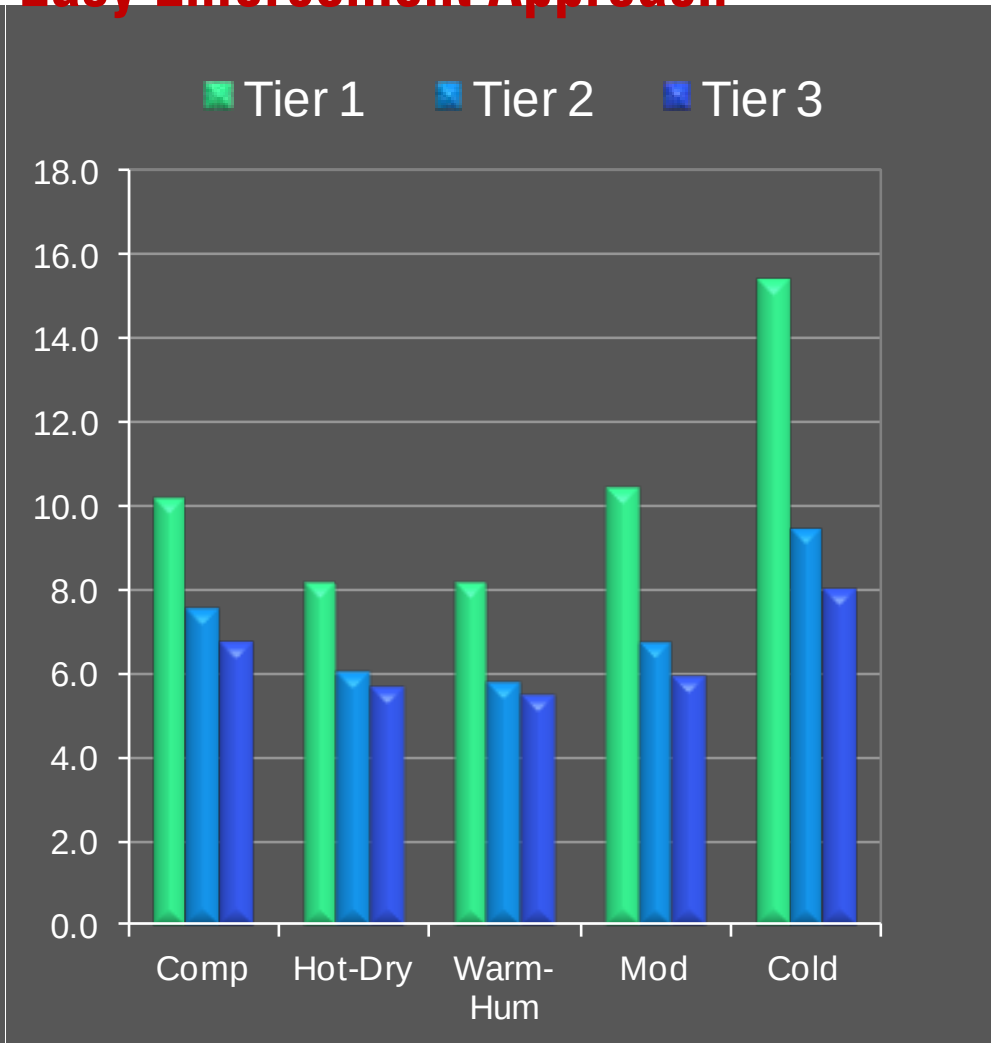


Simple Payback

Annual Savings Approach



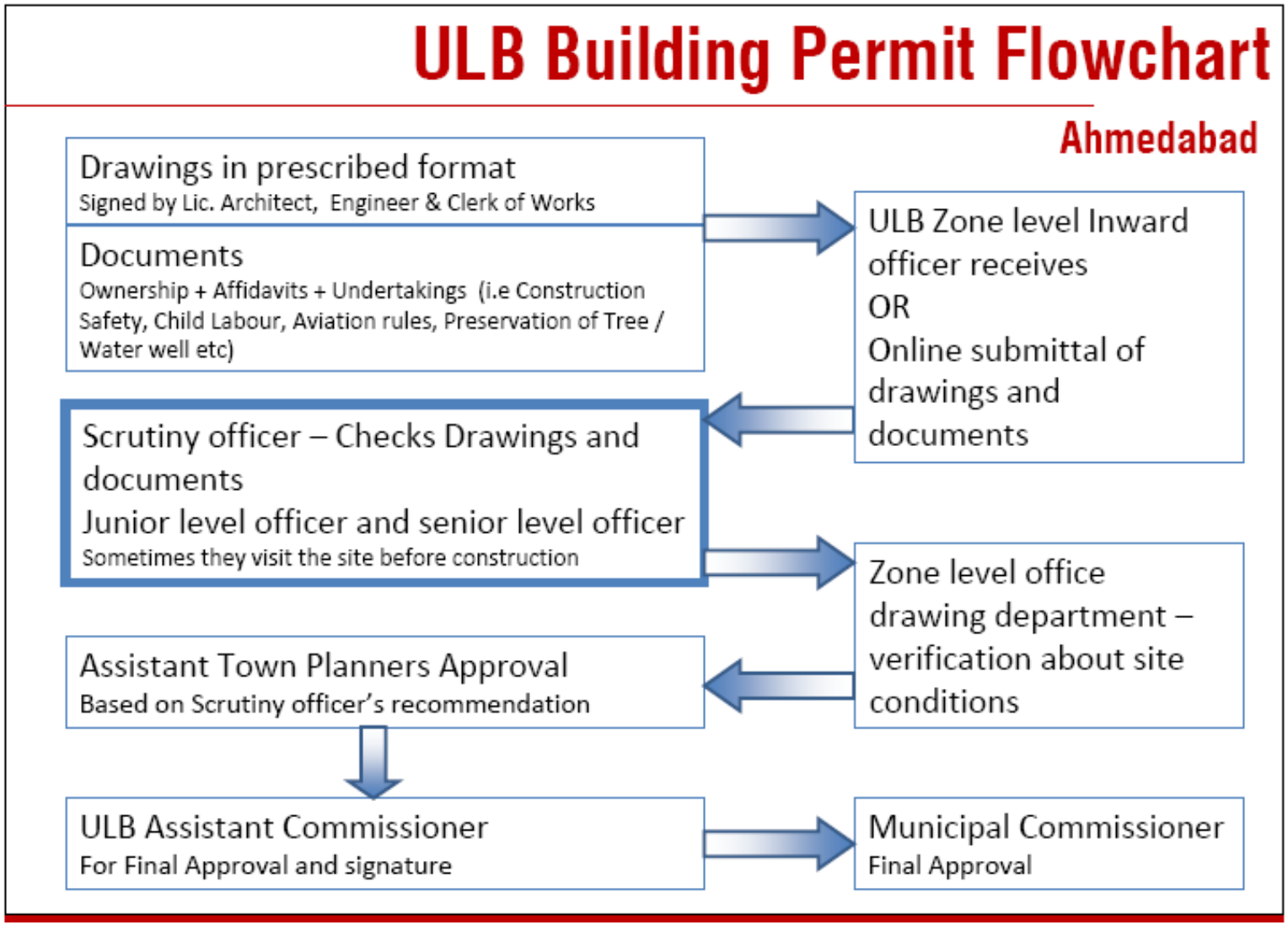
Easy Enforcement Approach



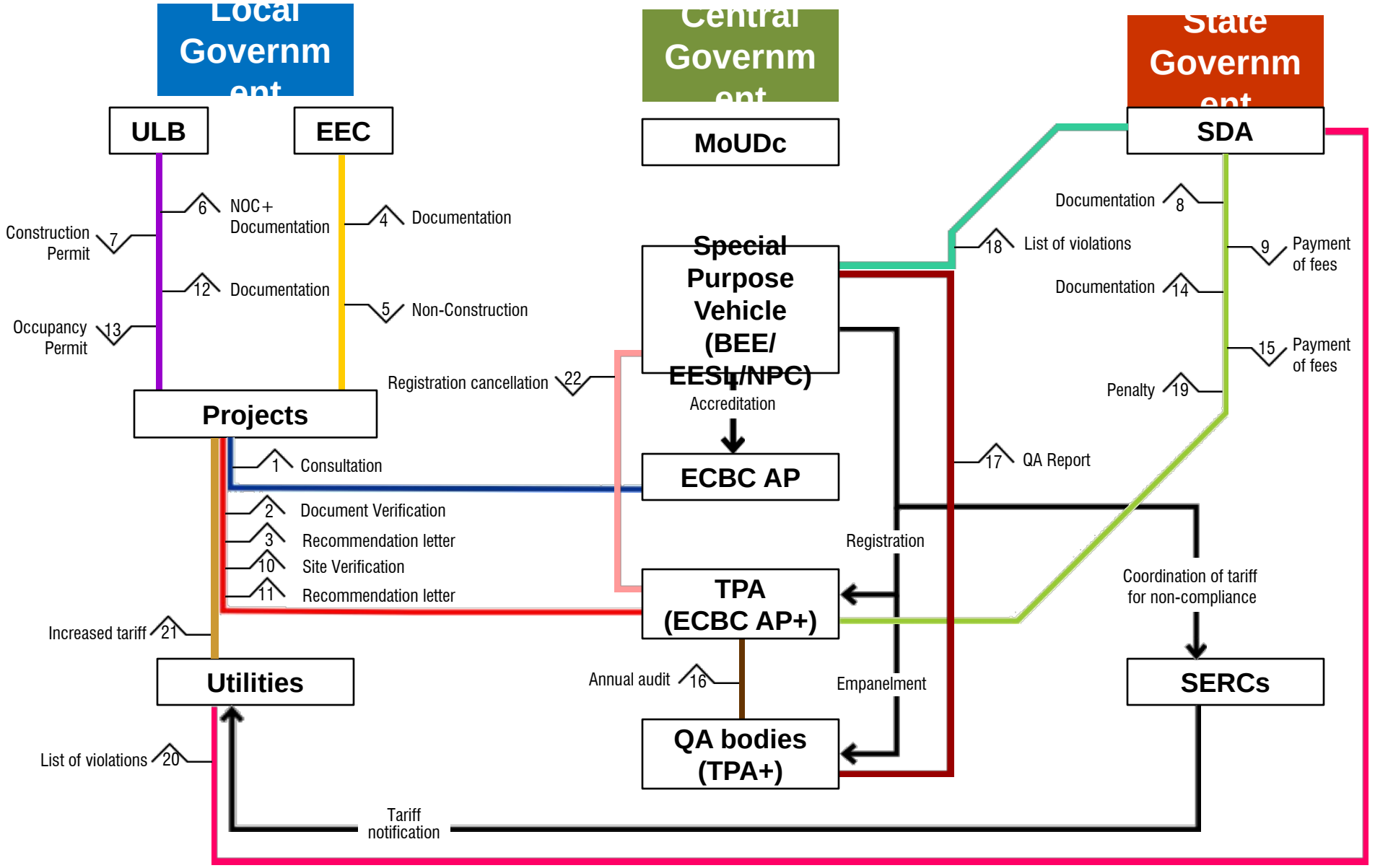
Enforcement Models

- Urban Local Body (ULB) Model
- Third Party Assessment (TPA) Model
- ECBC Expert Committee (EEC) model

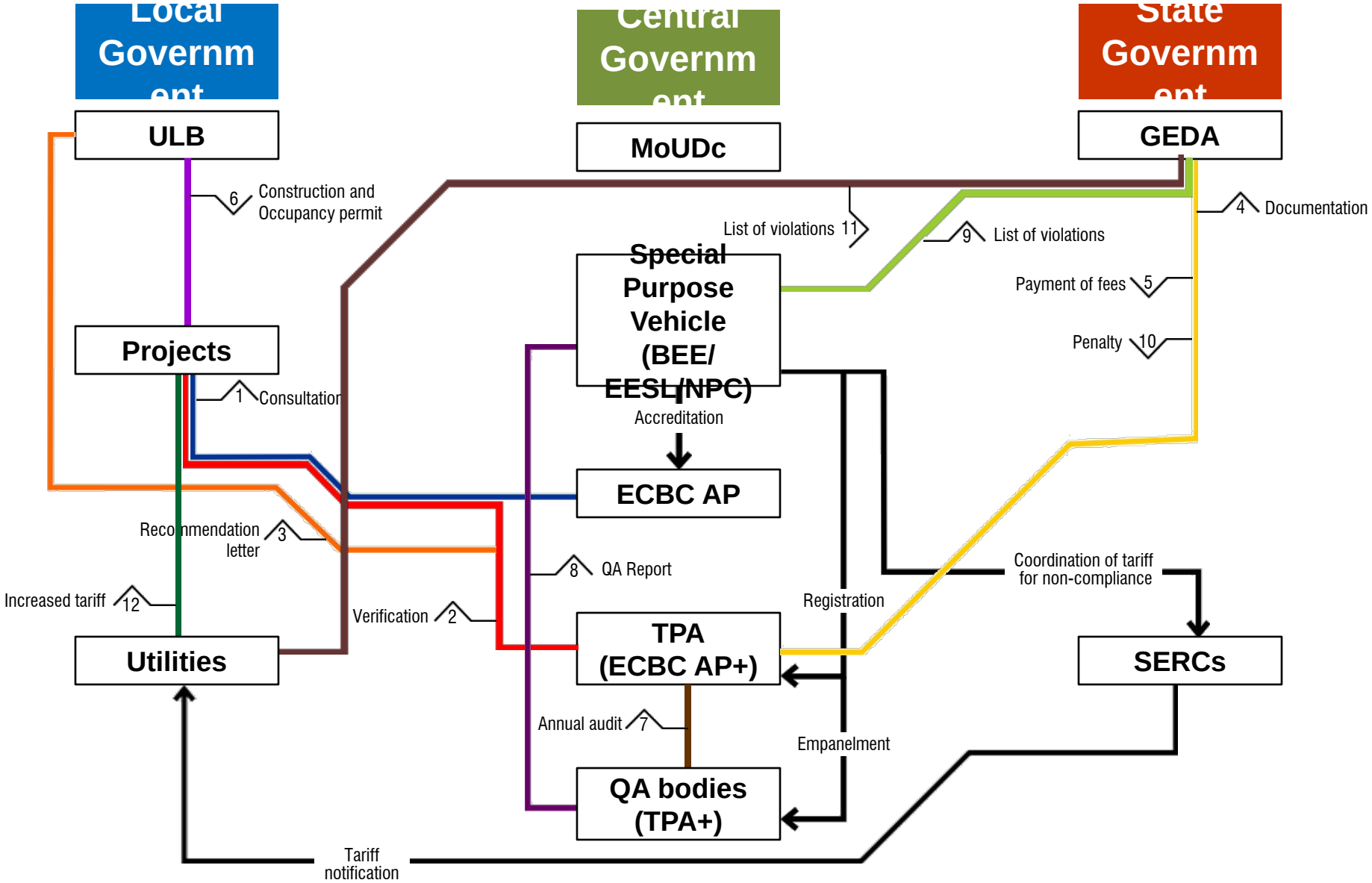
Energy Conservation Building Code, India



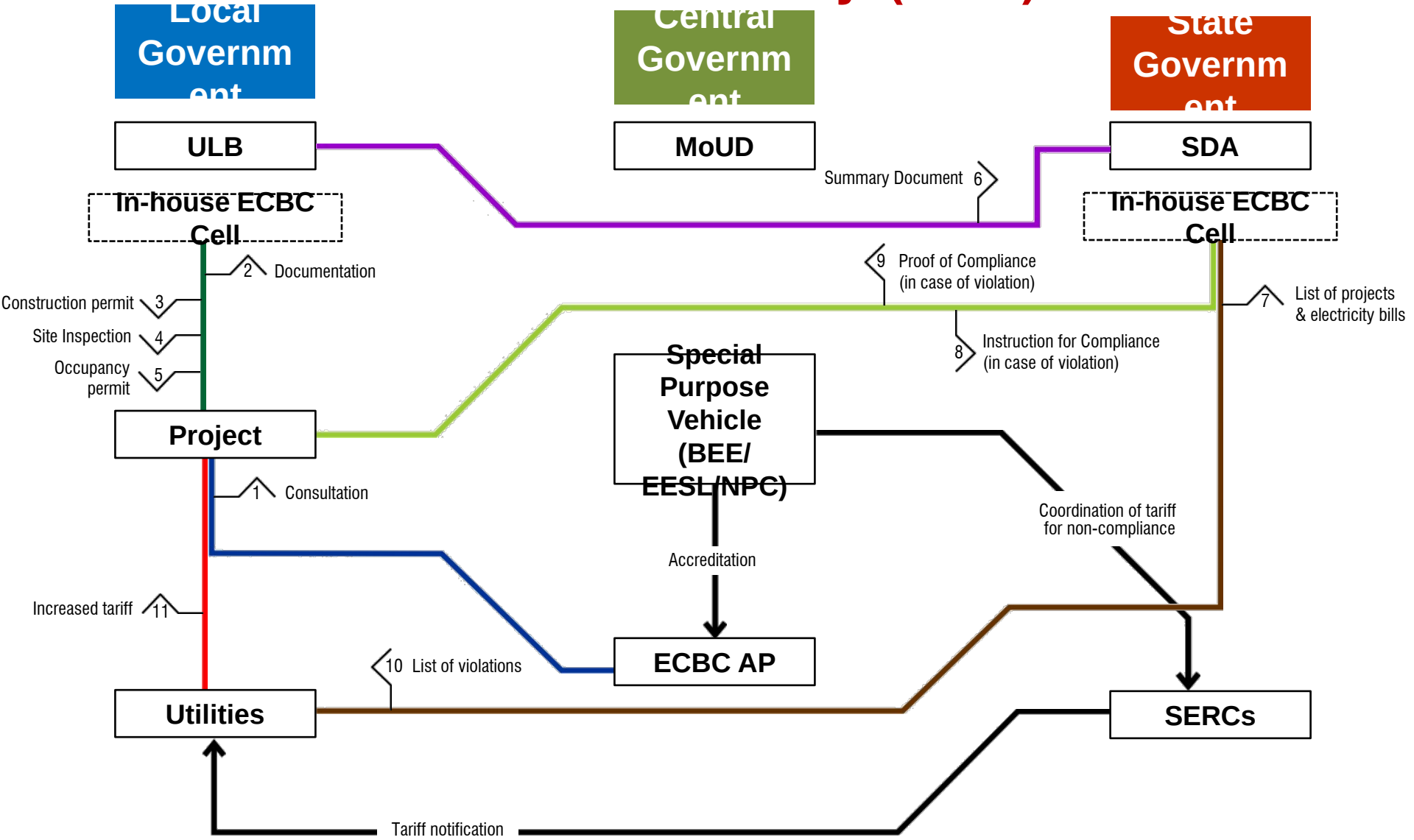
ECBC Expert Committee (EEC)



Third Party Assessors (TPA)



Urban Local Body (ULB)



Energy Conservation Building Code

Local Government Agency

Commonly used enforcement model

- Mixed success
- Requires staff and training at local government level

Challenges

- Energy code enforcement is a fairly complex activity with expertise of electrical-lighting, HVAC, and architectural systems.
- Agency staff can find it challenging to keep up with the pace of new construction
- Most government officers at ULBs have multiple roles - Sufficient Funding
- Consistency of quality of enforcement

Experience

- Code compliance in the USA is less that 50%, France 45%, China 65%, UK 85% with some having much higher enforcement, and others, lower.

Energy Conservation Building Code

Utility Company

Not a very common model

- Utility enforces at connection application
- Opportunity to monitor leaks and theft, better estimate peak loads
- Utilities staff may be more adept at electrical systems than the average local government agency official. Utilities have good Civil Eng department too.
- For Step 3, utility can share information about requested connected load information to third party – after one year occupation: utility bills?
- Utility may incorporate education, training and implementation (enabler to enforcement).

Energy Conservation Building Code

Third Party Agencies (TPA)

Increasingly popular mode of code enforcement.

- Allows easier scale up and scale down of capacity to handle growth
- Once instituted, it can include Rating Authorities

Challenges

– Requires a certification and qualification for TPAs

– This can be in the form of education, experience requirements and certification exams.

- **Examples of Success**

– Adopted in China with good success, 80% compliance reported.

– In response to issues about municipal-led regulatory enforcement, governments in Canada have used TPAs.

– Over 90% of the US State of Pennsylvania's 2,562 municipalities have enforced the code locally, using employees or via Certified TPAs

– Rating systems with TPAs used in Australia (NABERS), USA (HERS)

THANK YOU

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