Framework of Continual Commissioning to Produce and Maintain Energy-efficient Buildings

- *definition and examples* -

Nobuo Nakahara

Prof. Emeritus, Nagoya University;

Chairman, Building Services Commissioning Association

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- Promoting commissioning activities in Japan
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- Definition of commissioning process
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- Simulation for OPR, design Cx and BOFD
- Discussion on Continual Commissioning (CC), concept and its new definition for LCCx
- Framework of CC and on-going PDCA
- Role of BOFD and BEMS (BACS), and BACS Cx.
- Principle of Environmental Circle
- Topics on GWG issue

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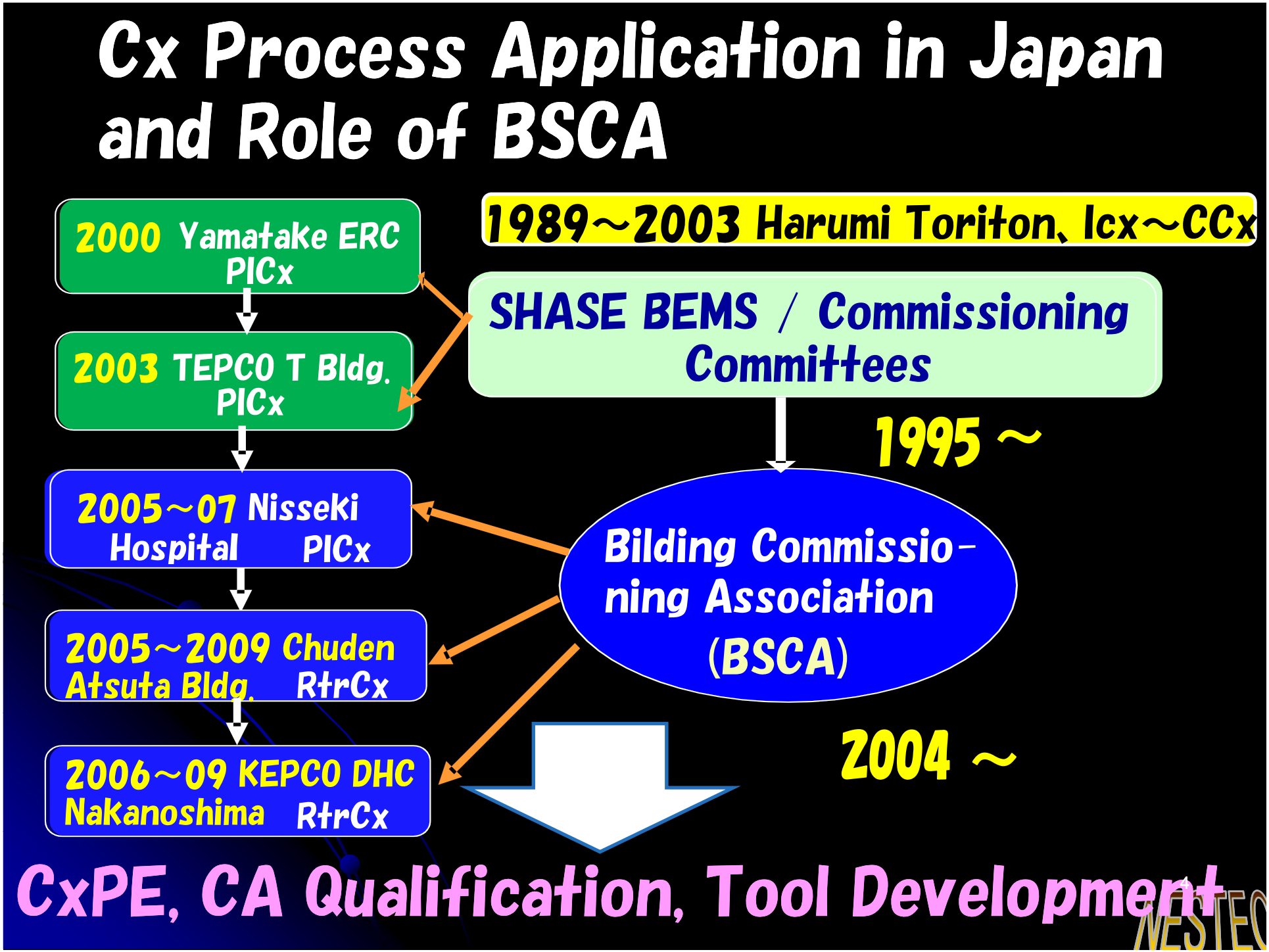
Cx Process Application in Japan and Role of BSCA



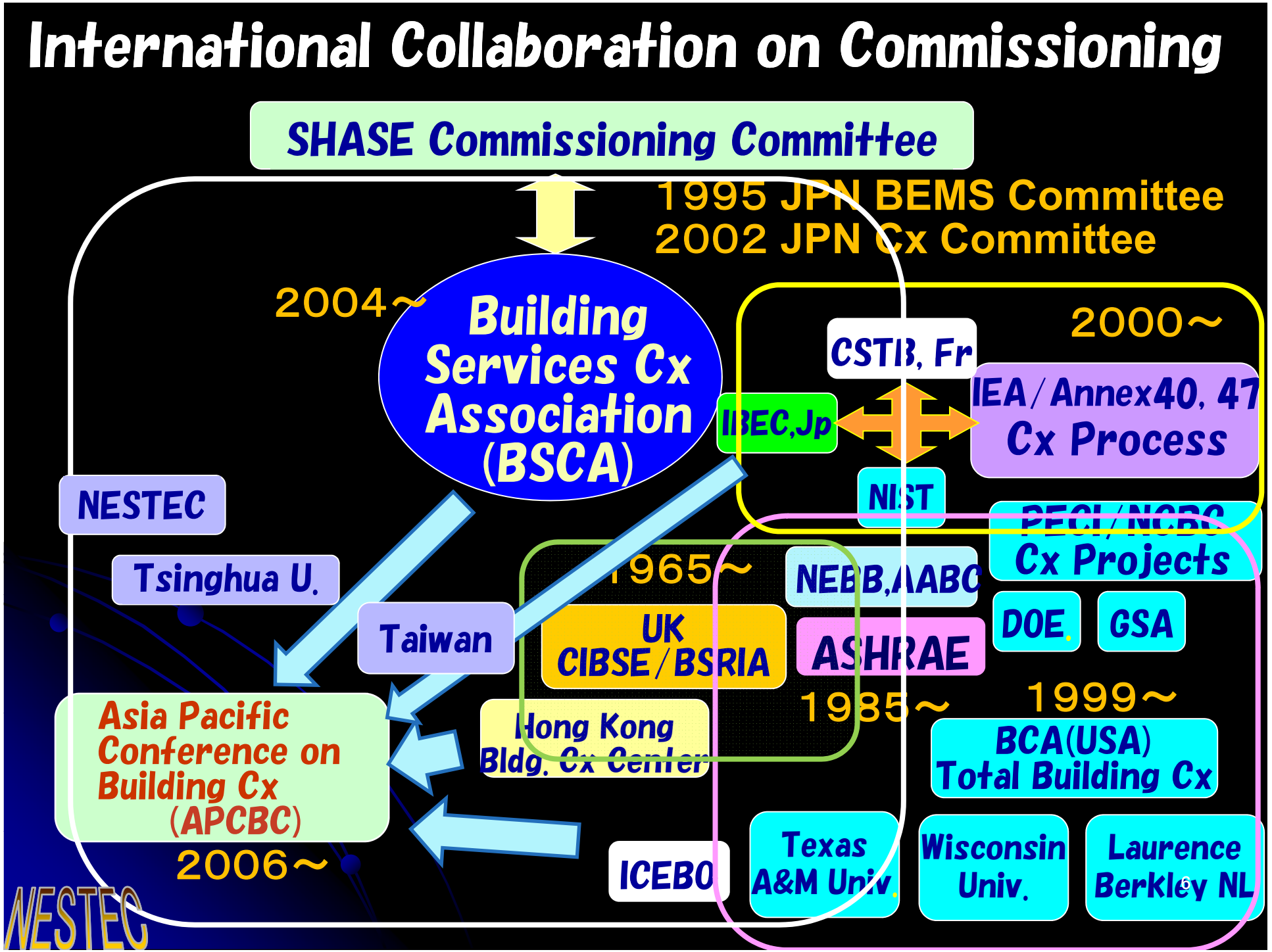
Author's Experience as CA on HVAC

- **Harumi DHC, Initial Cx, for System selection**
  - Total floor area: 670,000m2
  - Land area: 8ha
  - From Program phase to Post-acceptance phase
- **Y Office/Laboratory**, Initial (partial) Cx.
  - Approx. 1,700m²
  - After Construction phase to Operation phase

- **A Office Building**, (full for retrofit stage)RetroCx.
  - Approx. 9,400m²
  - From Pre-design phase but After FDD to Operation phase

- **N Hospital Facility**, Initial (partial) Cx.
  - Approx. 82,000m² and Annexes
  - After Schematic design step to Elaboration phase

International Collaboration on Commissioning



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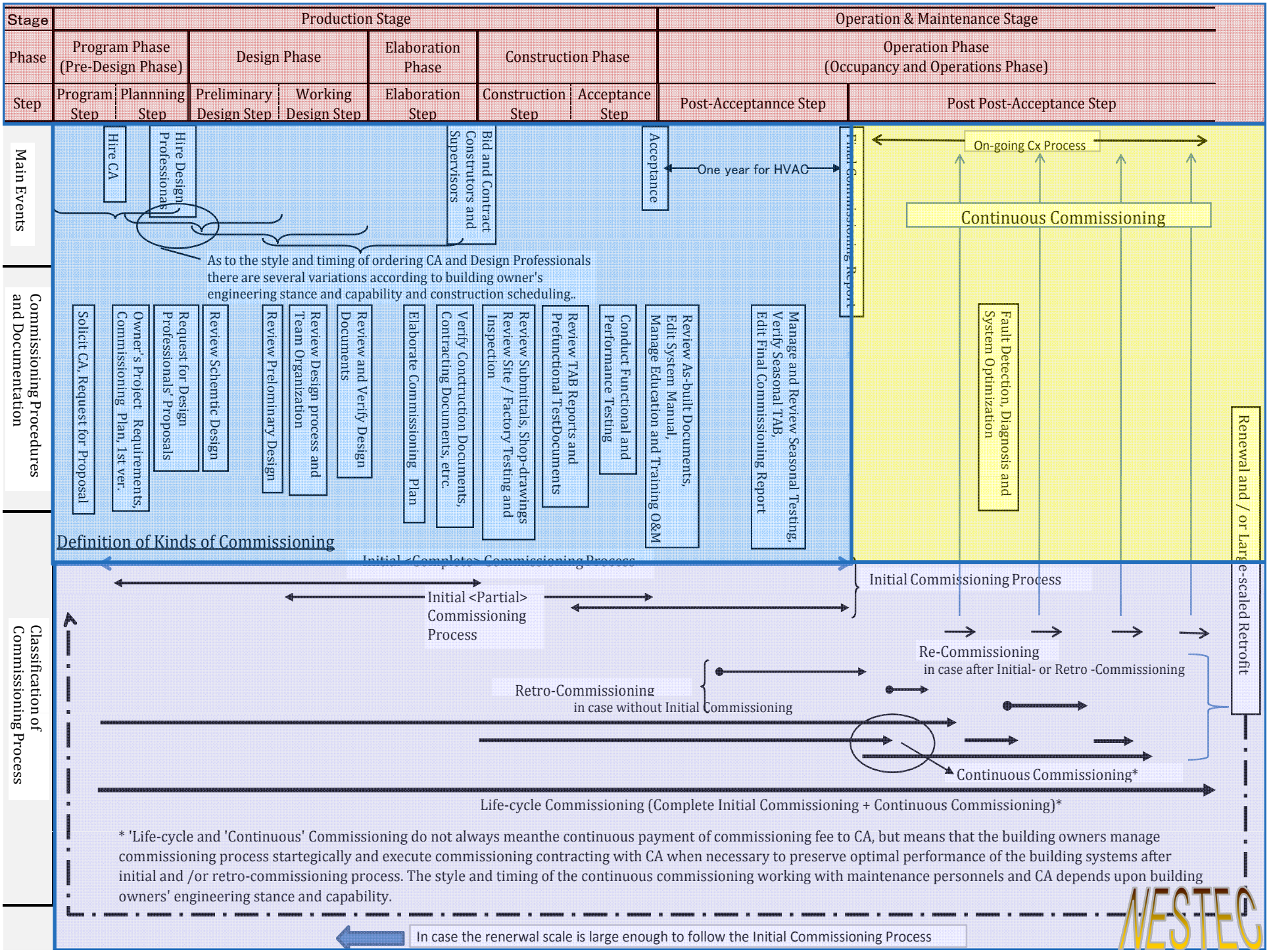
Stage
Production Stage
Operation & Maintenance Stage
Phase
Program Phase (Pre-Design Phase)
Design Phase
Elaboration Phase
Construction Phase
Operation Phase (Occupancy and Operations Phase)
Step
Program Step
Plannning Step
Preliminary Design Step
Working Design Step
Elaboration Step
Construction Step
Acceptance Step
Post-Acceptannce Step
Post Post-Acceptance Step
Main Events
Hire CA
Hire Design Professionals
Bid and Contract Constructors and Supervisors
Acceptance
One year for HVAC
Final Commissioning Report
On-going Cx Process
Continuous Commissioning
As to the style and timing of ordering CA and Design Professionals there are several variations according to building owner's engineering stance and capability and construction scheduling..
Commissioning Procedures and Documentation
Solicit CA, Request for Proposal
Owner's Project Requirements, Commissioning Plan, 1st ver.
Request for Design Professionals' Proposals
Review Schemtic Design
Review Prelominary Design
Review Design process and Team Organization
Review and Verify Design Documents
Elaborate Commissioning Plan
Verify Conctruction Documents, Contracting Documents, etrc.
Review Submittals, Shop-drawings Review Site / Factory Testing and Inspection
Review TAB Reports and Prefunctional TestDocuments
Conduct Functional and Performance Testing
Review As-built Documents, Edit System Manual, Manage Education and Training O&M
Manage and Review Seasonal Testing, Verify Seasonal TAB, Edit Final Commissioning Report
Fault Detection, Diagnosis and System Optimization
Renewal and / or Large-scaled Retrofit
Definition of Kinds of Commissioning
Classification of Commissioning Process
Initial <Complete> Commissioning Process
Initial Commissioning Process
Initial <Partial> Commissioning Process
Re-Commissioning in case after Initial- or Retro -Commissioning
Retro-Commissioning in case without Initial Commissioning
Continuous Commissioning*
Life-cycle Commissioning (Complete Initial Commissioning + Continuous Commissioning)*
* 'Life-cycle and 'Continuous' Commissioning do not always meanthe continuous payment of commissioning fee to CA, but means that the building owners manage commissioning process startegically and execute commissioning contracting with CA when necessary to preserve optimal performance of the building systems after initial and /or retro-commissioning process. The style and timing of the continuous commissioning working with maintenance personnels and CA depends upon building owners' engineering stance and capability.
In case the renerwal scale is large enough to follow the Initial Commissioning Process
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Stage	Production Stage					Oper
Phase	Program Phase (Pre-Design Phase)		Design Phase		Elaboration Phase	Construction Phase		(Occup
Step	Program Step	Plannning Step	Preliminary Design Step	Working Design Step	Elaboration Step	Construction Step	Acceptance Step	Post-Acceptannce Step

Main Events

- Hire CA
- Hire Design Professionals
- Bid and Contract Construtors and Supervisors
- Acceptance
- One year for HVAC
- Final Commissioning Report

As to the style and timing of ordering CA and Design Professionals there are several variations according to building owner's engineering stance and capability and construction scheduling..

Commissioning Procedures and Documentation

- Solicit CA, Request for Proposal
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- Review Submittals, Shop-drawings Review Site / Factory Testing and Inspection
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- Conduct Functional and Performance Testing
- Review As-built Documents, Edit System Manual, Manage Education and Training O&M
- Manage and Review Seasonal Testing, Verify Seasonal TAB, Edit Final Commissioning Report

Definition of Kinds of Commissioning

- Initial <Complete> Commissioning Process
- Initial <Partial> Commissioning Process

Cla
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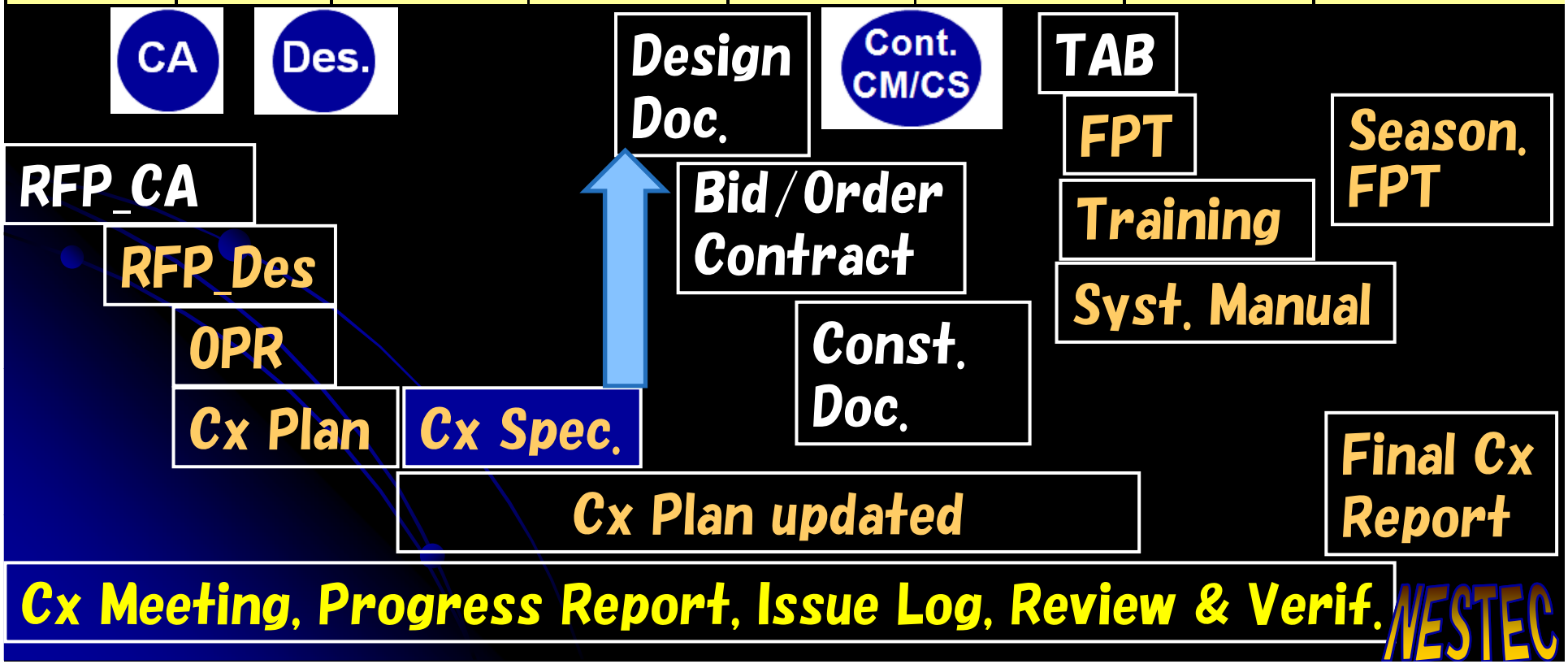
Operation & Maintenance Stage
Operation Phase
(Occupancy and Operations Phase)
ce
Post-Acceptannce Step
Post Post-Acceptance Step
Acceptance
One year for HVAC
Final Commissioning Report
On-going Cx Process
Continuous Commissioning
Review As-built Documents,
Edit System Manual,
Manage Education and Training O&M
Manage and Review Seasonal Testing,
Verify Seasonal TAB,
Edit Final Commissioning Report
Fault Detection, Diagnosis and
System Optimization
Renewal and / or Large-scale
Initial Commissioning Process
Re-Commissioning

Commissioning Process for New Construction

Production Stage							Operation Stage
Program Phase (Pre-Design Phase)		Design Phase		Elabolation Phase	Construction Phase		(Occupancy & Operation Phase)
Program Step	Planning Step	Preliminary Design Step	Working Design Step	Elabolation Step	Construction Step	Acceptance Step	Post-Acceptance Step



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Why HVAC Simulations as Cx?

- **Pre-design Phase**
  - To establish Project Plan and/or OPR for owner's decision-making
- **Design Phase**
  - Degraded quality of Design Documents, due to
    - less time
    - less fee
    - less skill, less training
  - Electronic standard documents easily sum up enormous volume of apparently beautiful docs
  - Prevailed distributed packaged system
  - Order BACS design outside without sufficient spec. with narratives and flowcharts.

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Why Simulation and Design Cx? cont.

- **Design Phase** cont.
  - Calculation/Simulation Tools developed too further for designers to handle in short worktime.
  - And yet, design professionals are erroneously too much expected to do perfect work even with insufficient fee due to excessive competition.
  - Building owners should recognize they must anyhow pay for a good job
  - Commissioning process during design phase should make sure of successful achievement, and that owners hire well qualified commissioning authority from the third party.

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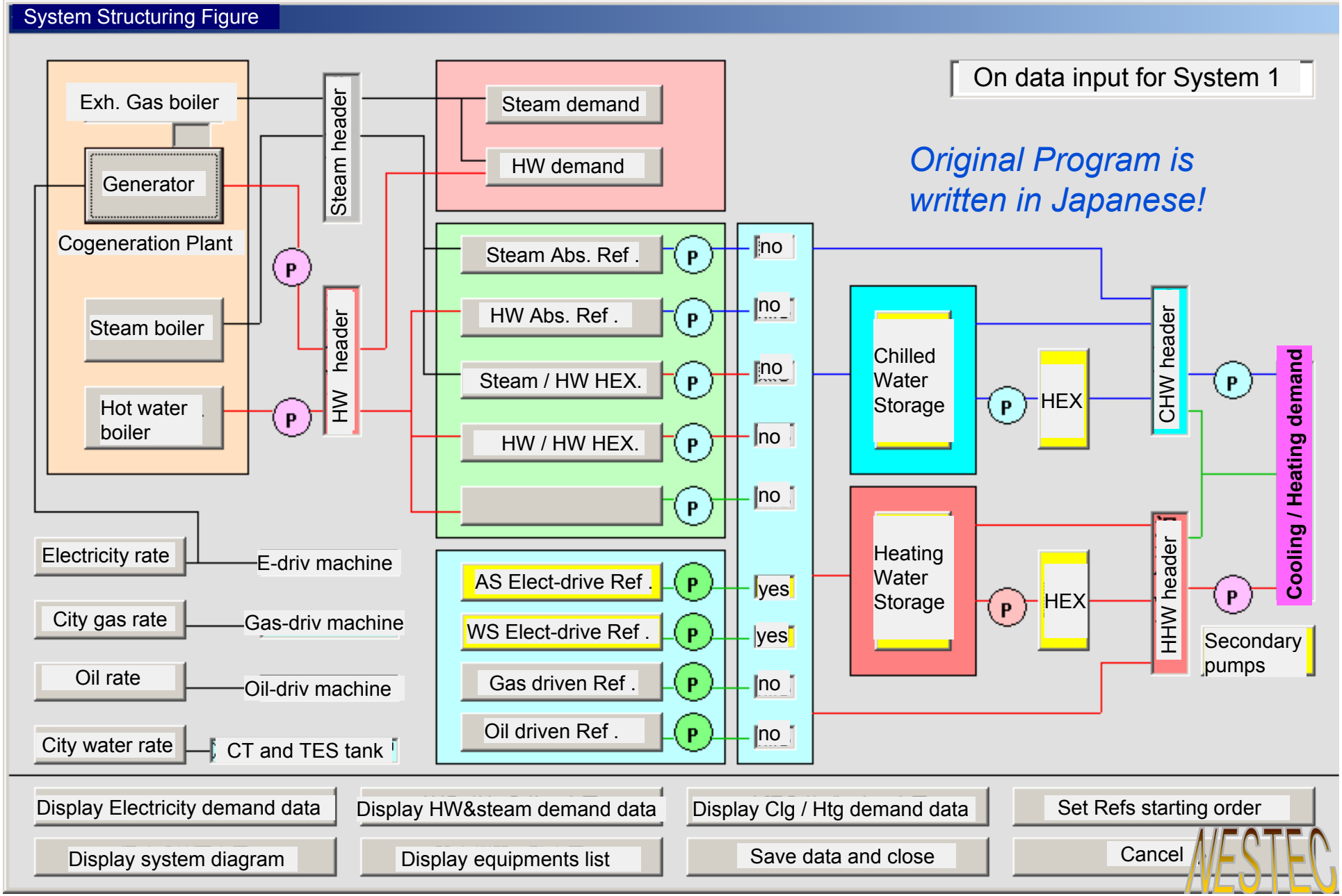
Energy Plant Menu of TES_ECO



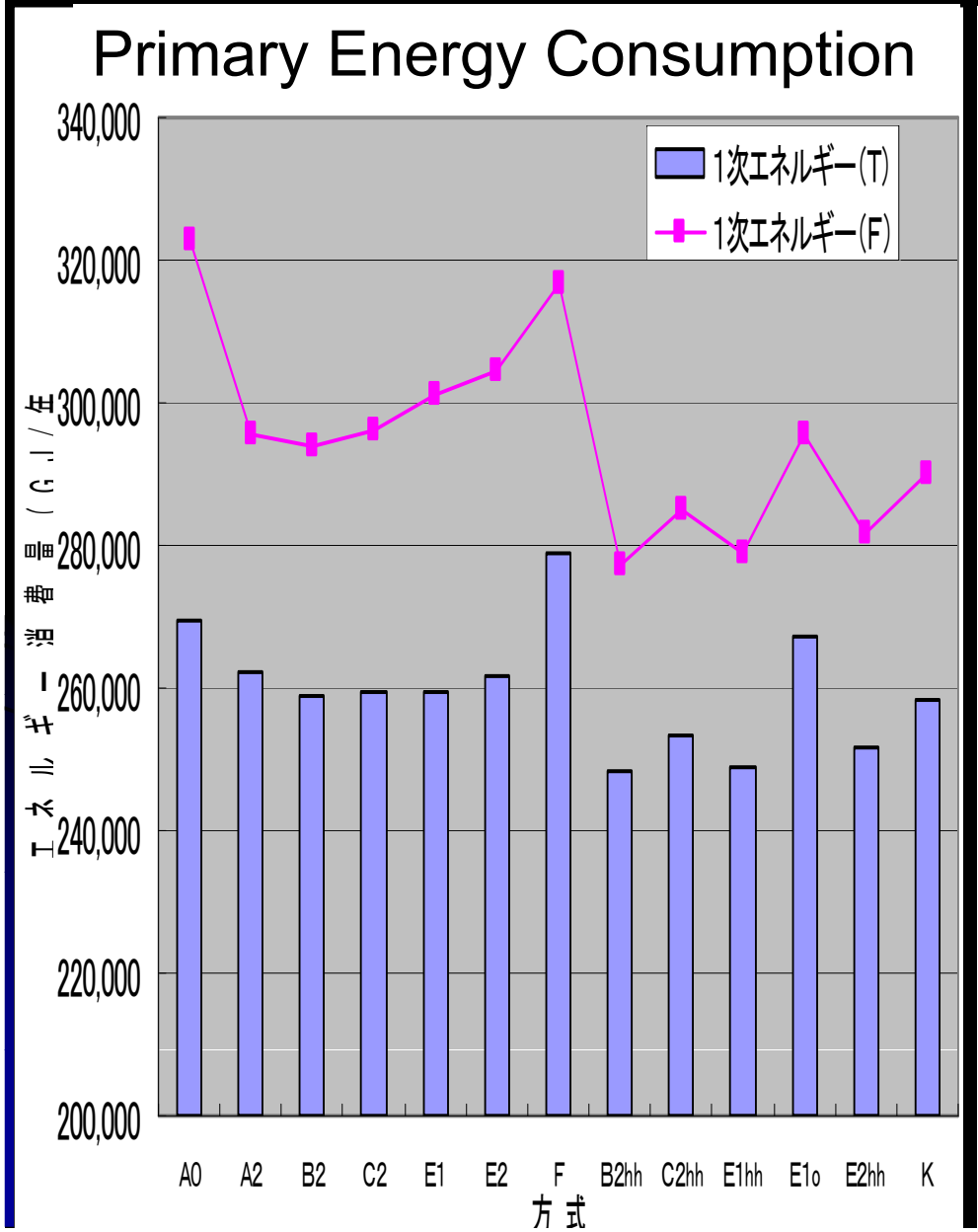
Energy System Options

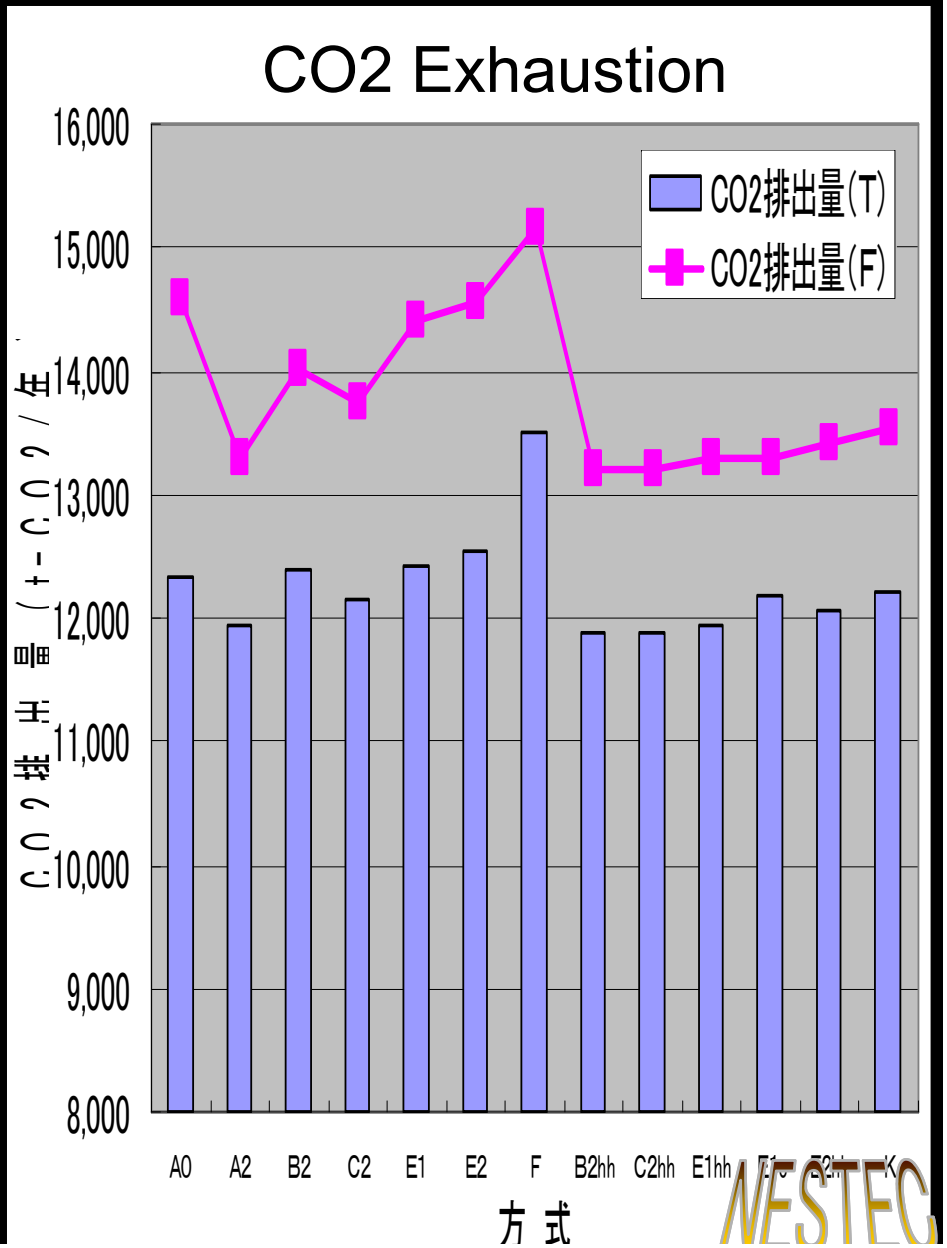
	System feature	Combination
A0	Non-Storage Centrifugal	INV-driven Centrifugal Ref.(695RT × 4) +Boiler(5t/h × 2)
A2	Thermal Stotage Centrifugal＋HRHP	Centrifugal (920RT × 2)+HRHP(527/664kW) +Boiler(5t/h × 2)
B2	Thermal Storage w/CGS600kW Centrifugal ＋HRHP	CGS(600kW) × 2+ExAR(210RT) +Centrifugal(650RT × 2)+HRHP(527/664kW) +Boiler(4t/h × 3)
C2	Thermal Storage w/CGS300kW Centrifugal＋HRHP	CGS(300kW) × 2+ExAR(100RT) +Centrifugal (700RT × 2)+HRHP(527/664kW) +Boiler(4t/h × 3)
E1	Thermal Storage E/G=2/1 Complex w/CGS600	CGS(600kW) × 2+ExAR(210RT) +Centrifugal (920RT)+HRHP(527/664kW) +AR(300RT)+Boiler(4t/h × 3)
E2	Thermal Storage E/G=1/1 Complex w/CGS600	CGS(600kW) × 2台+ExAR(210RT) +HRHP(527/664kW) +AR(630RT)+Boiler(5t/h × 3)
F	Non-Storage w/CGS600 AR E/G=0/100	CGS(600kW) × 2+ExAR(210RT) +AR(630RT × 4)+Boiler(5t/h × 5)

Note: HRHP: Heat Recovery Heat Pump, water sourse
CGS: Co-generation system w/Exhaust gas
ExAR: Exhausted heat driven Absorption machine

Annual primary energy

Annual CO2





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Continuous Commissioning Process (ASHRAE 0-2005)

- Continuous Commissioning Process: A continuation of the Commissioning Process well into the Occupancy and Operations Phase to verify that a project continues to meet current and evolving Owner's Project Requirements. Continuous Commissioning Process activities are on-going for the life of the facility

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On-Going Commissioning Process (ASHRAE 0-2005)

- On-Going Commissioning Process: A continuation of the Commissioning Process well into the Occupancy and Operations Phase to verify that a project continues to meet current and evolving Owner's Project Requirements. On-Going Commissioning Process activities occur throughout the life of the facility; some of these will be close to continuous in implementation, and others will be either scheduled or un-scheduled (as needed)

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Re-Commissioning
(ASHRAE 0-2005)

- Re-Commissioning: An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process. This may be a scheduled re-commissioning developed as part of an On-Going Commissioning Process, or it may be triggered by use change, operations problems, or other needs.

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Continual (*or continuous*) Commissioning - new definition -

- **Continual (*or continuous*) commissioning (Cx) consists of on-going Cx carried out by O&M staff and re-Cx by commissioning professionals outside the O&M organization.**
- **The performance goal, or the kind of OPR, for a new cycle of on-going Cx is given in the report of foregoing commissioning process, i.e., either initial-Cx, retro-Cx or re-Cx process.**
- **However, the term 'continual' is just tentatively used in order not to be mistaken for the conventional meaning.**

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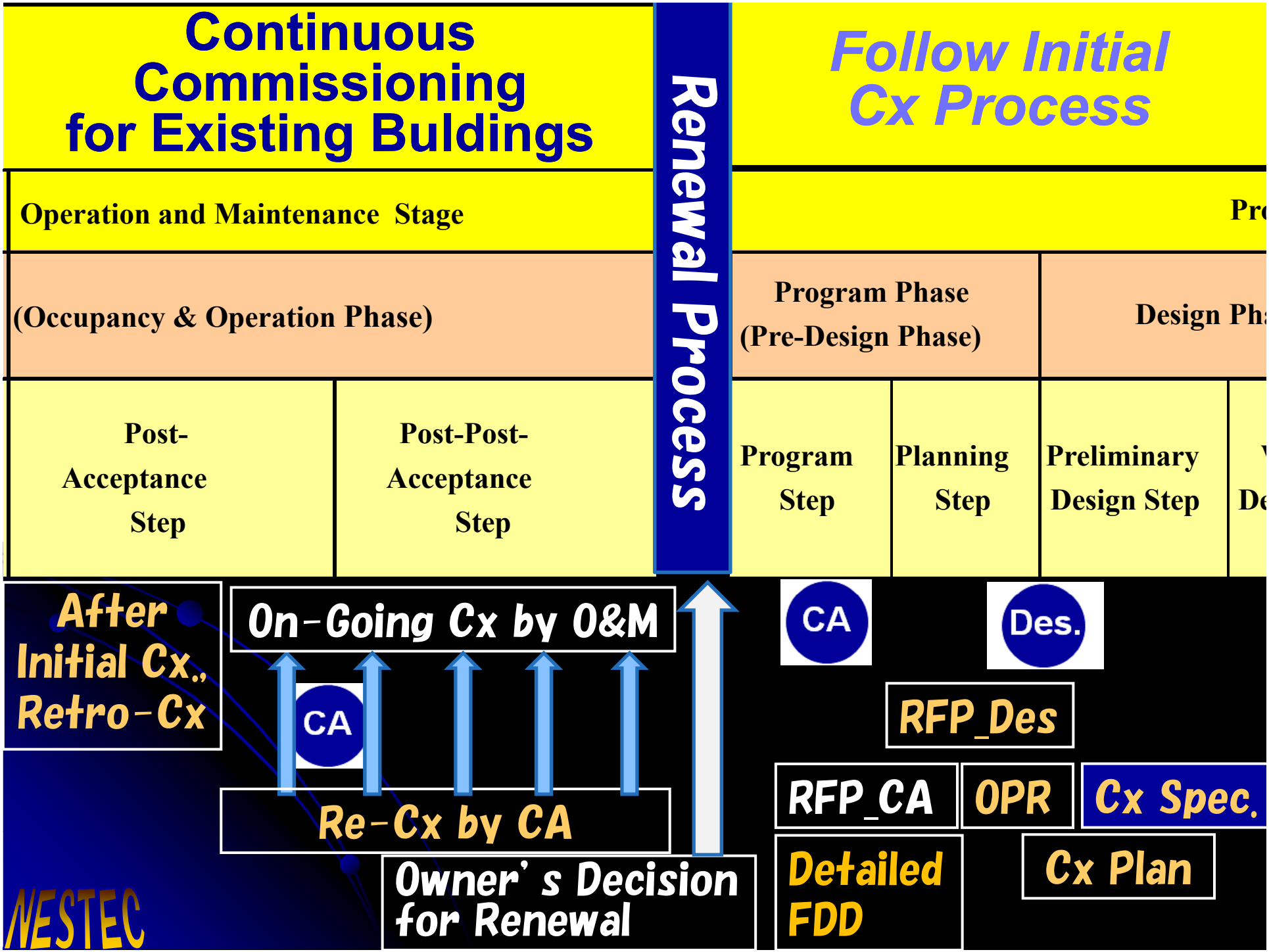
Continuous Commissioning for Existing Buldings
Renewal Process
Follow Initial Cx Process
Operation and Maintenance Stage
Pre
(Occupancy & Operation Phase)
Program Phase (Pre-Design Phase)
Design Pha
Post-Acceptance Step
Post-Post-Acceptance Step
Program Step
Planning Step
Preliminary Design Step
De
After Initial Cx., Retro-Cx
On-Going Cx by O&M
CA
Re-Cx by CA
Owner's Decision for Renewal
CA
Des.
RFP_Des
RFP_CA
OPR
Cx Spec.
Detailed FDD
Cx Plan
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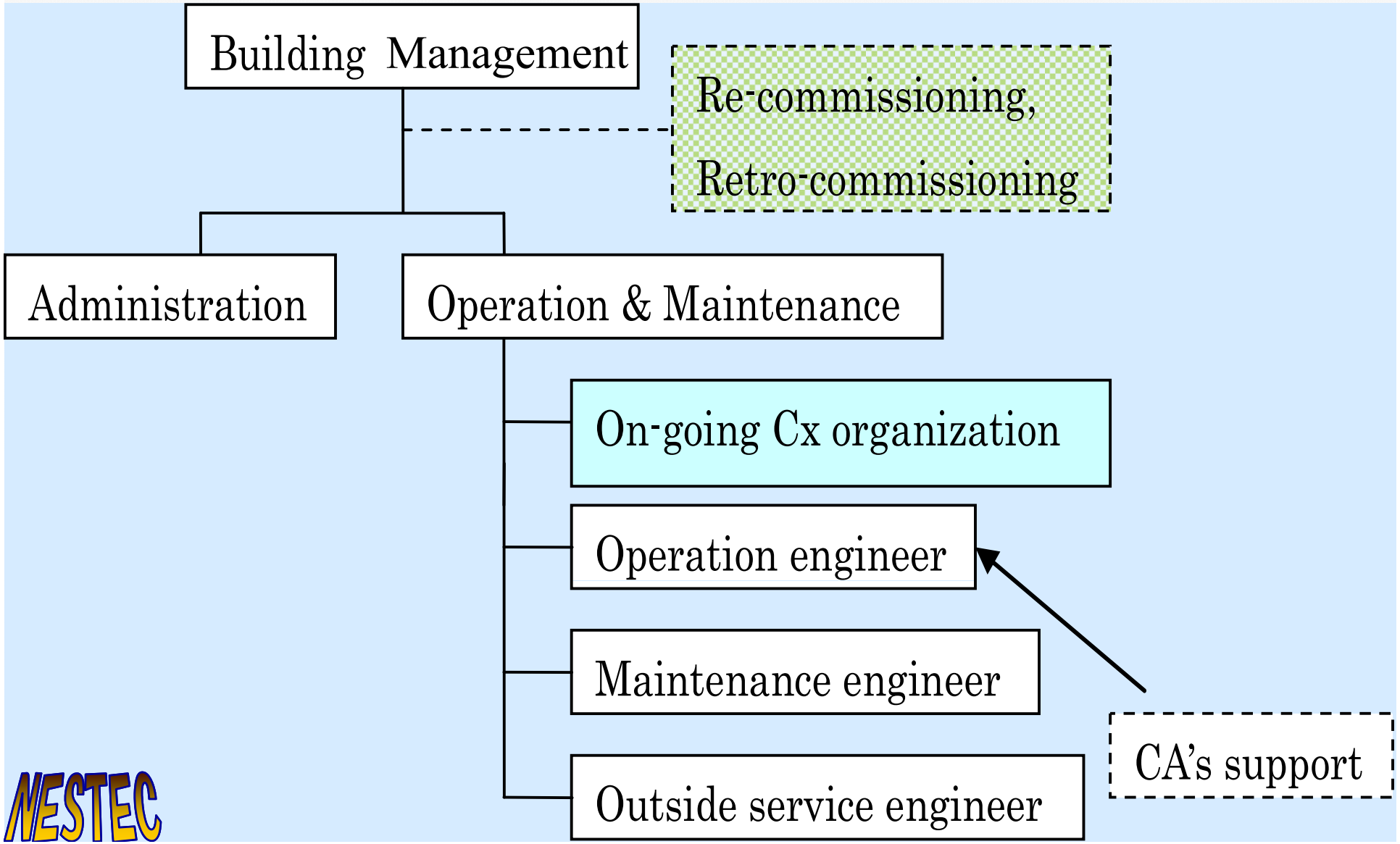
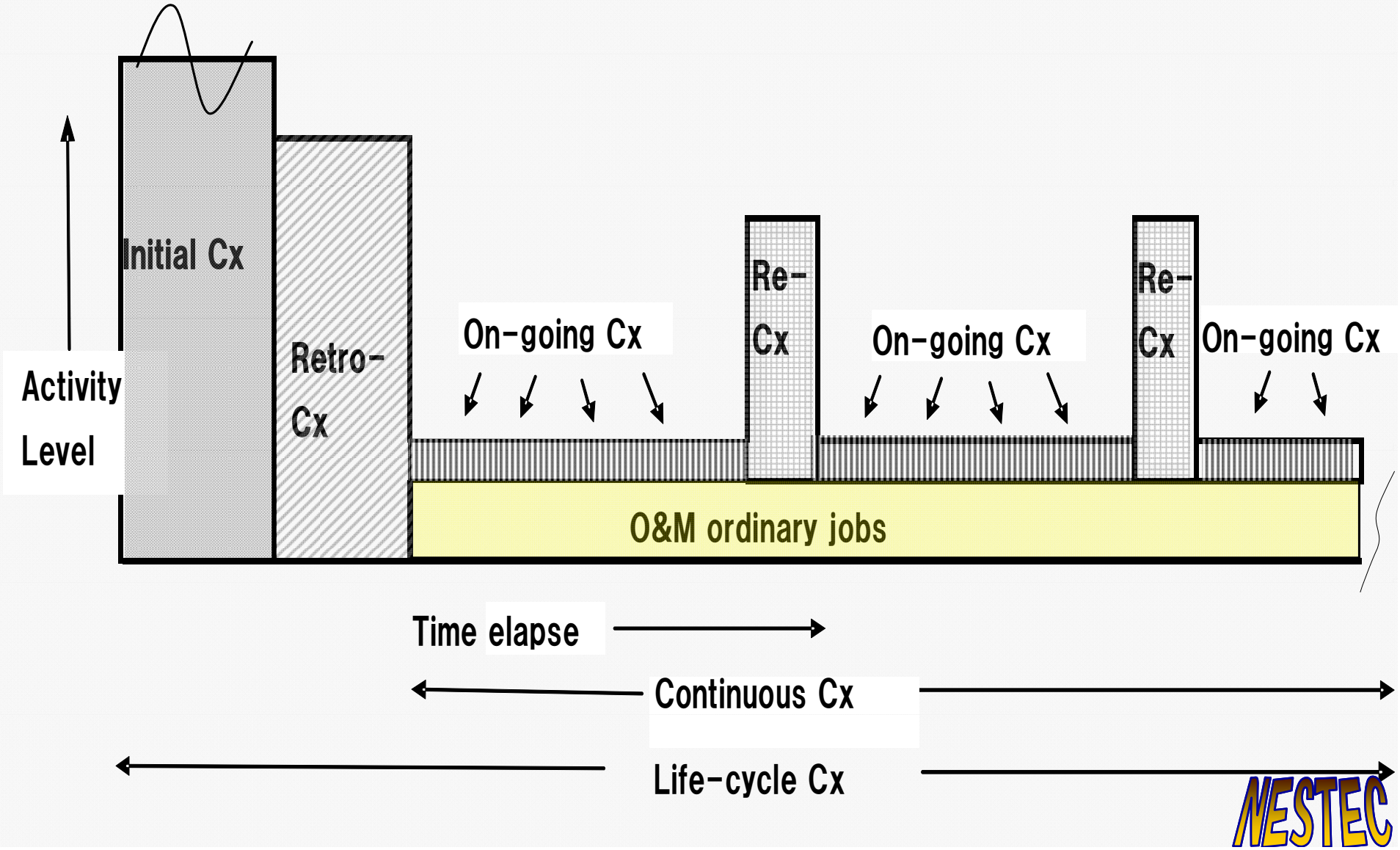
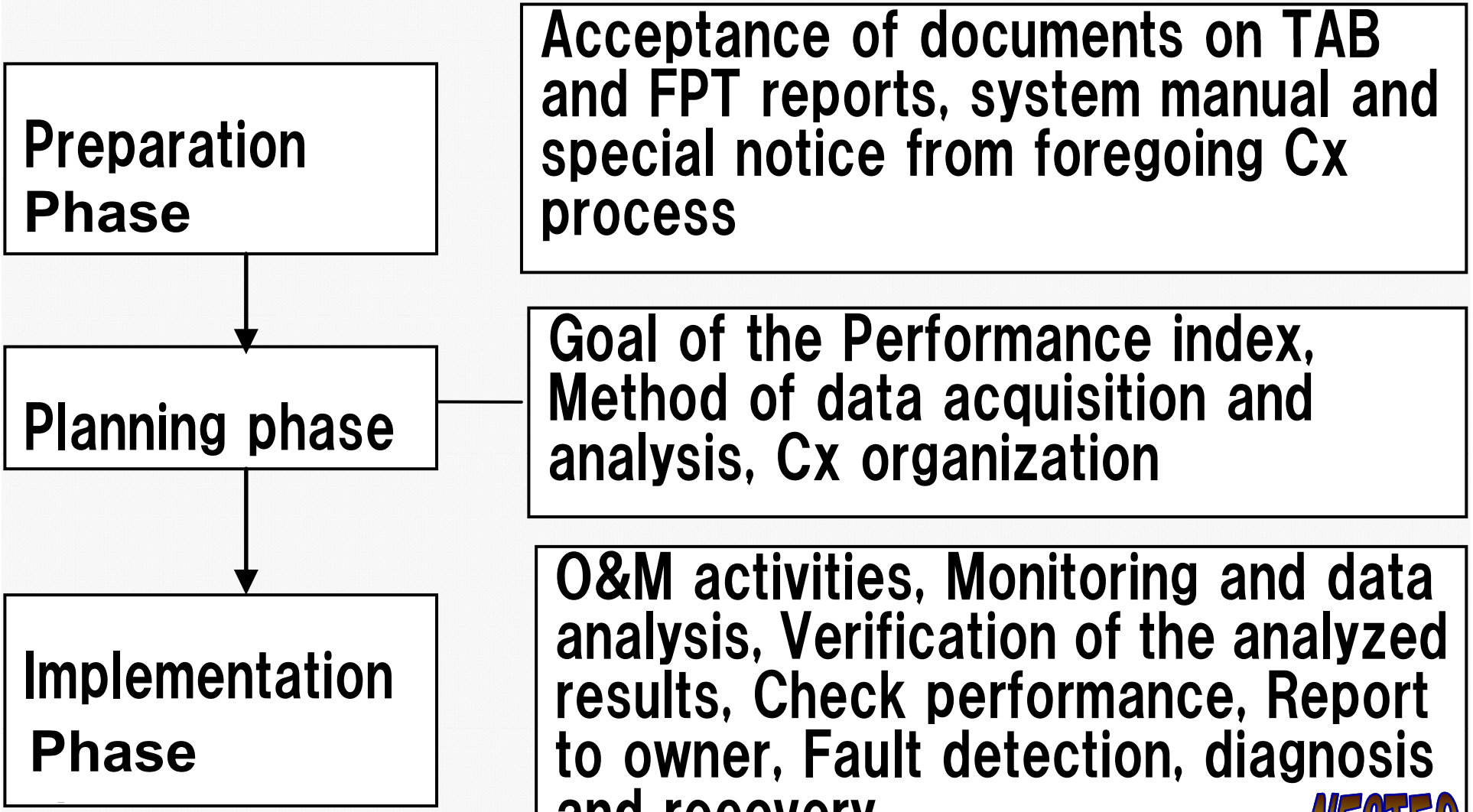
O&M's Organization for Building Services Systems



Relation among Commission Types and Structure of Continuous Cx



On-going Commissioning Process Phases



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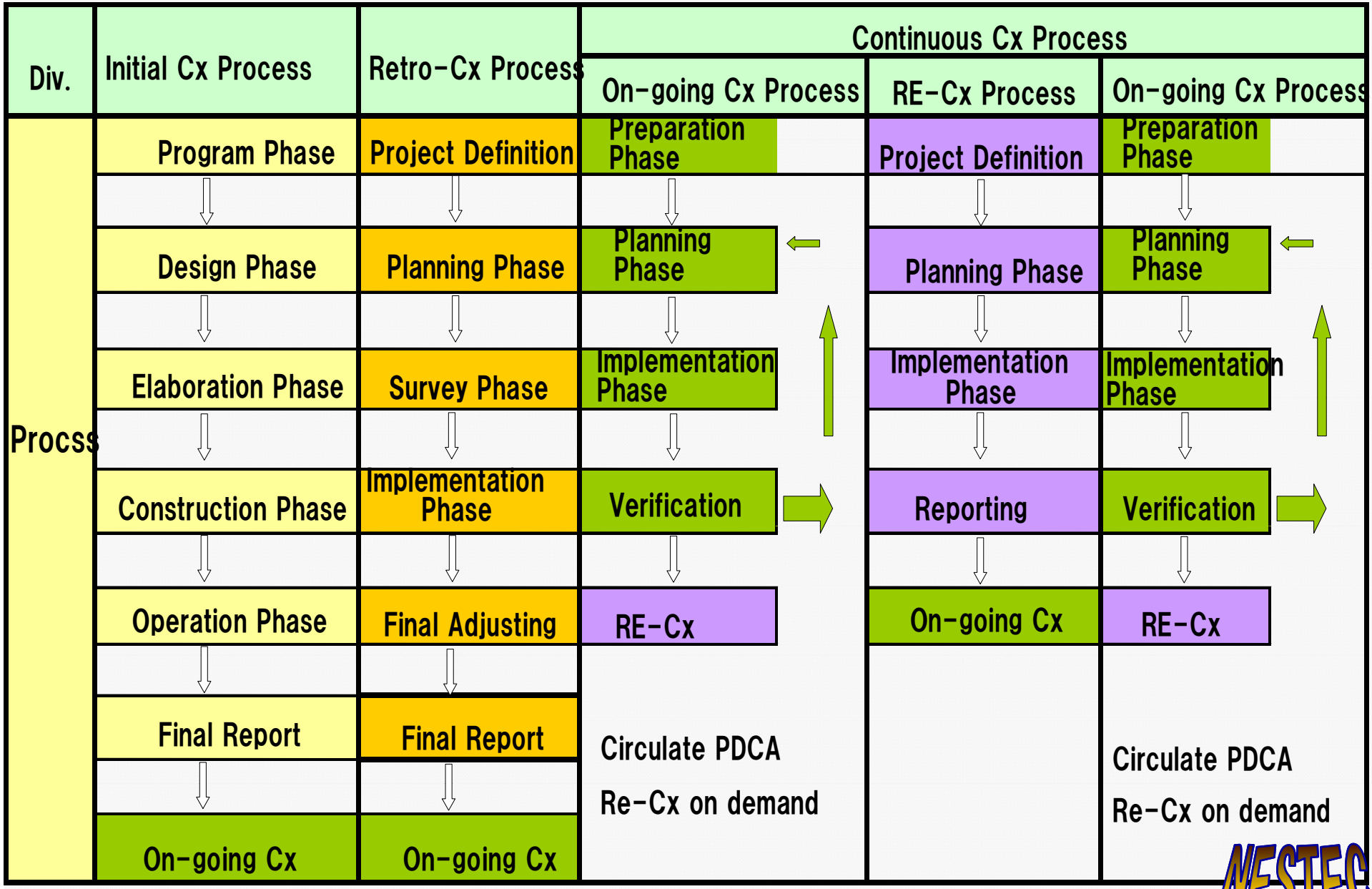
Life-cycle Commissioning



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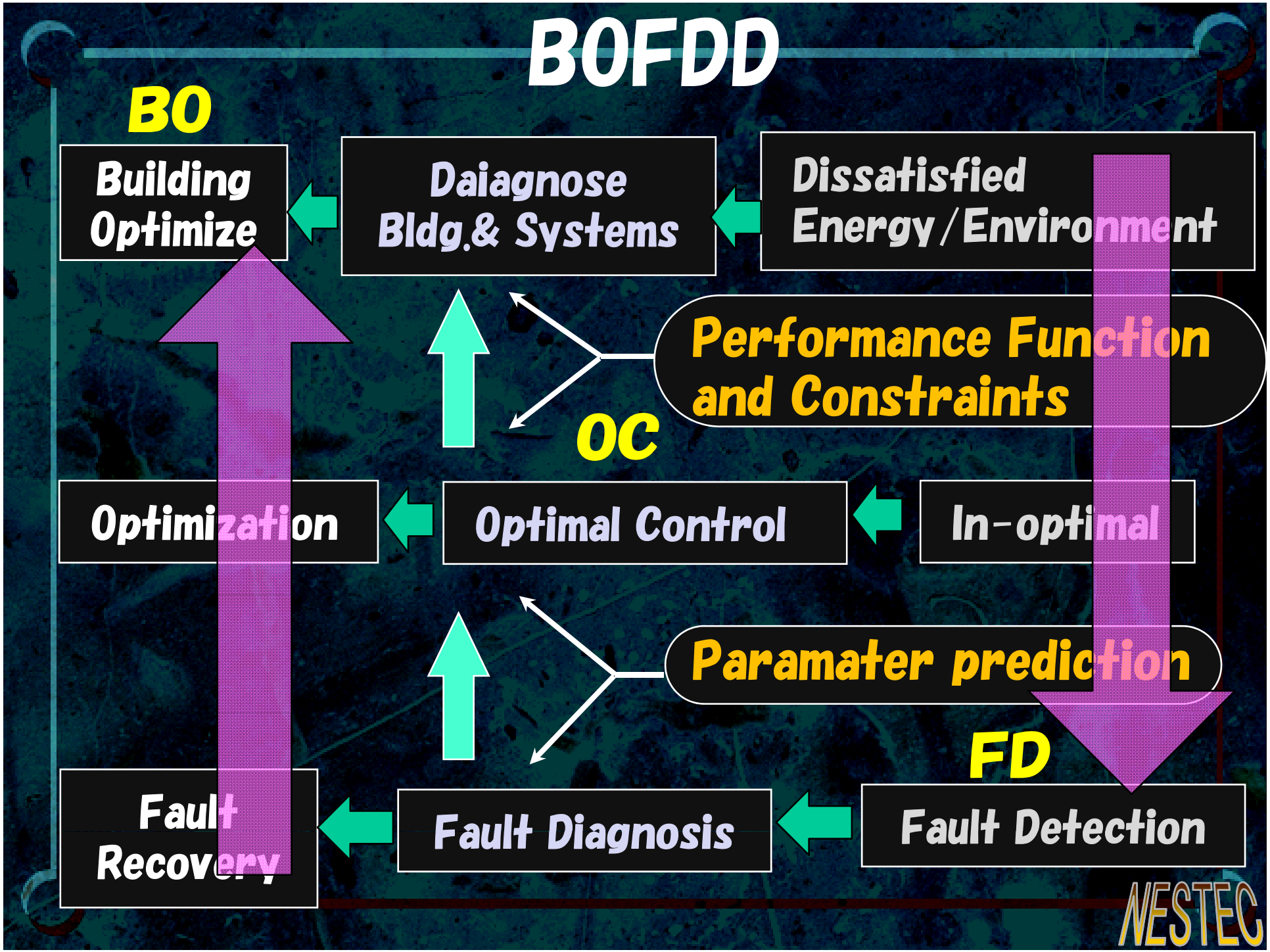
BOFDD
BO
Building Optimize
Daiagnose Bldg.& Systems
Dissatisfied Energy/Environment
Performance Function and Constraints
OC
Optimization
Optimal Control
In-optimal
Paramater prediction
FD
Fault Recovery
Fault Diagnosis
Fault Detection
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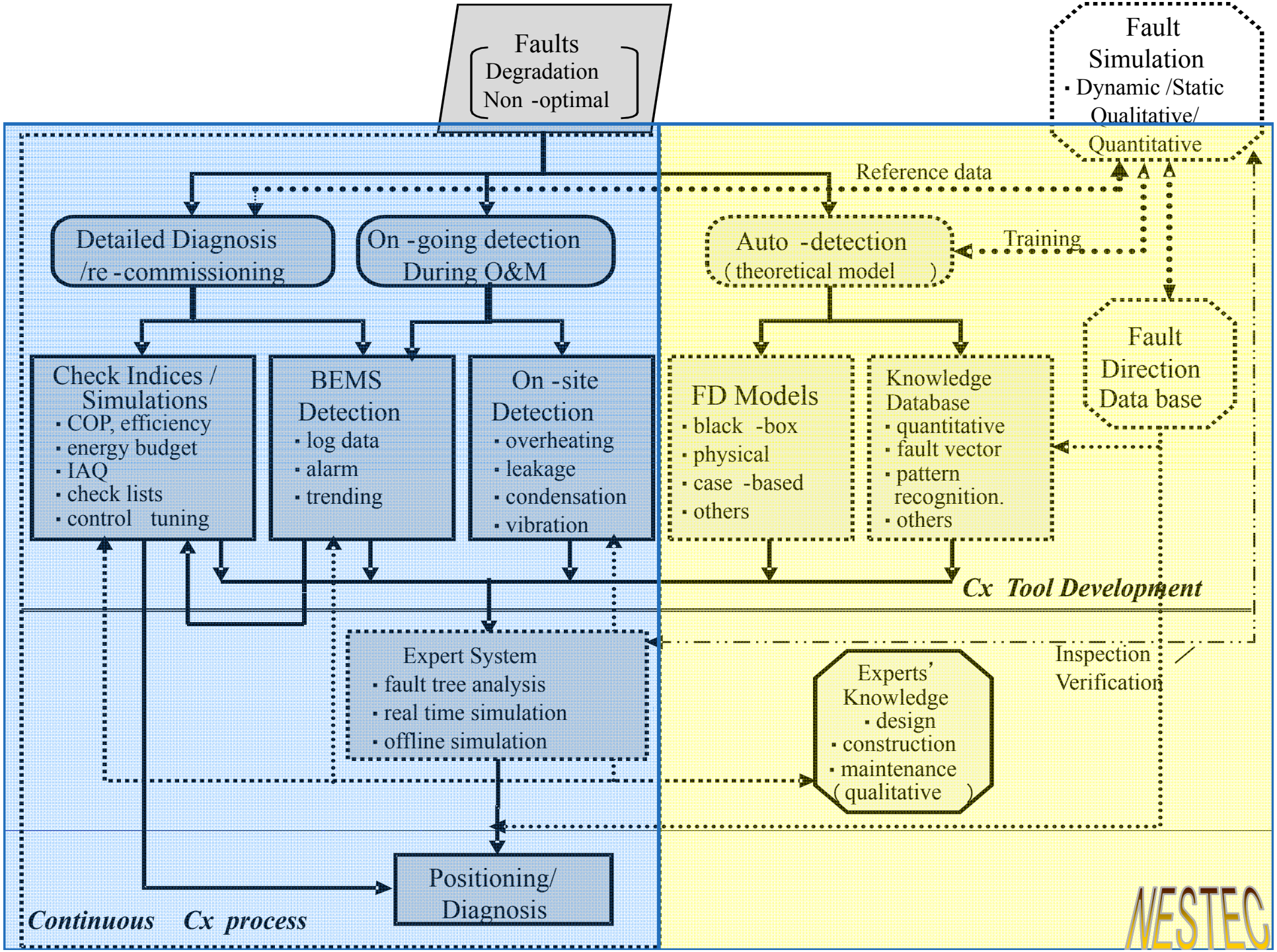
Faults
Degradation
Non -optimal
Fault Simulation
▪ Dynamic /Static
Qualitative/
Quantitative
Reference data
Detailed Diagnosis /re -commissioning
On -going detection During O&M
Auto -detection (theoretical model)
Training
Check Indices / Simulations
▪ COP, efficiency
▪ energy budget
▪ IAQ
▪ check lists
▪ control tuning
BEMS Detection
▪ log data
▪ alarm
▪ trending
On -site Detection
▪ overheating
▪ leakage
▪ condensation
▪ vibration
FD Models
▪ black -box
▪ physical
▪ case -based
▪ others
Knowledge Database
▪ quantitative
▪ fault vector
▪ pattern recognition.
▪ others
Fault Direction Data base
Cx Tool Development
Expert System
▪ fault tree analysis
▪ real time simulation
▪ offline simulation
Inspection
Verification
Experts' Knowledge
▪ design
▪ construction
▪ maintenance
(qualitative)
Positioning/ Diagnosis
Continuous Cx process
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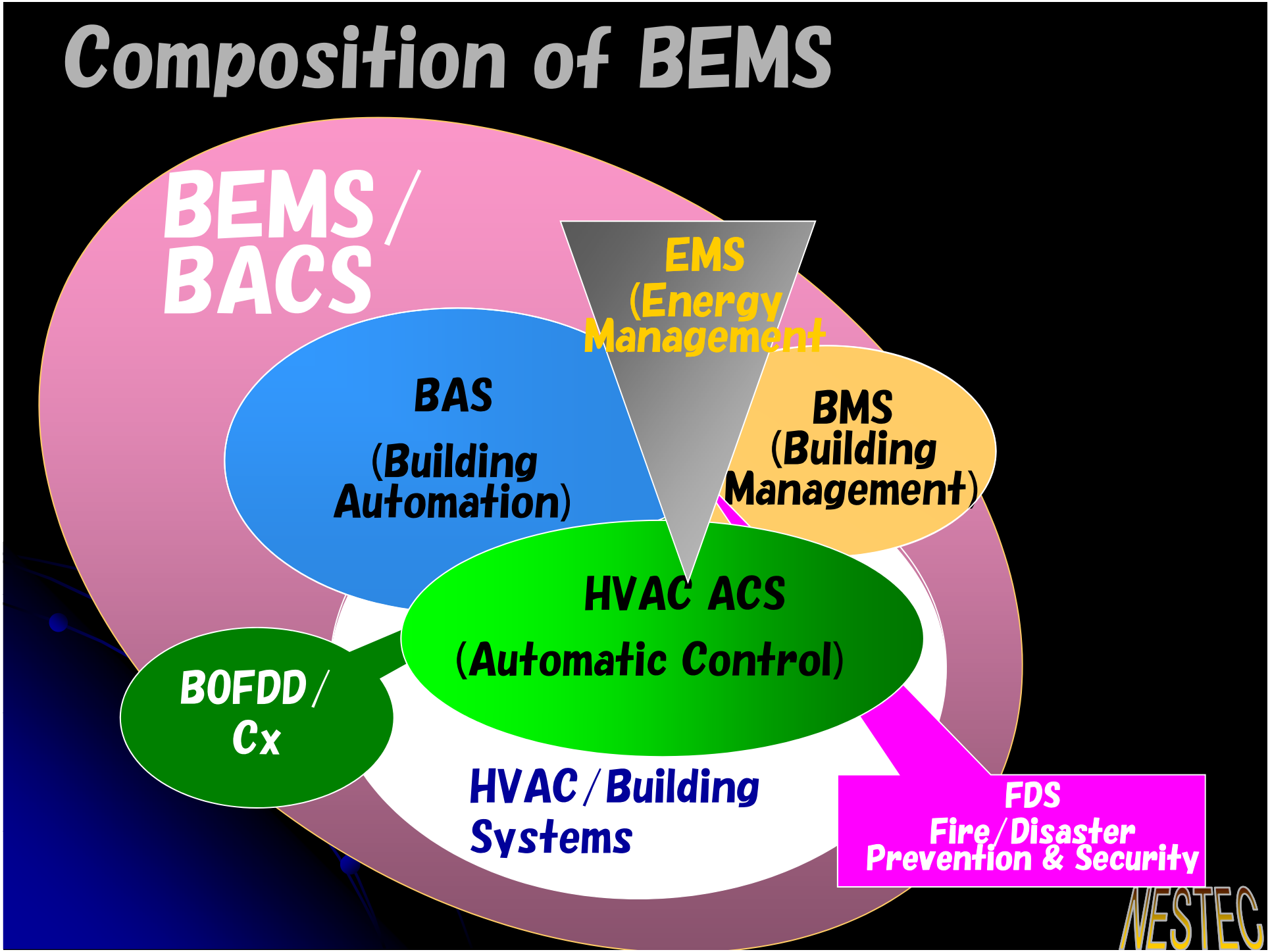
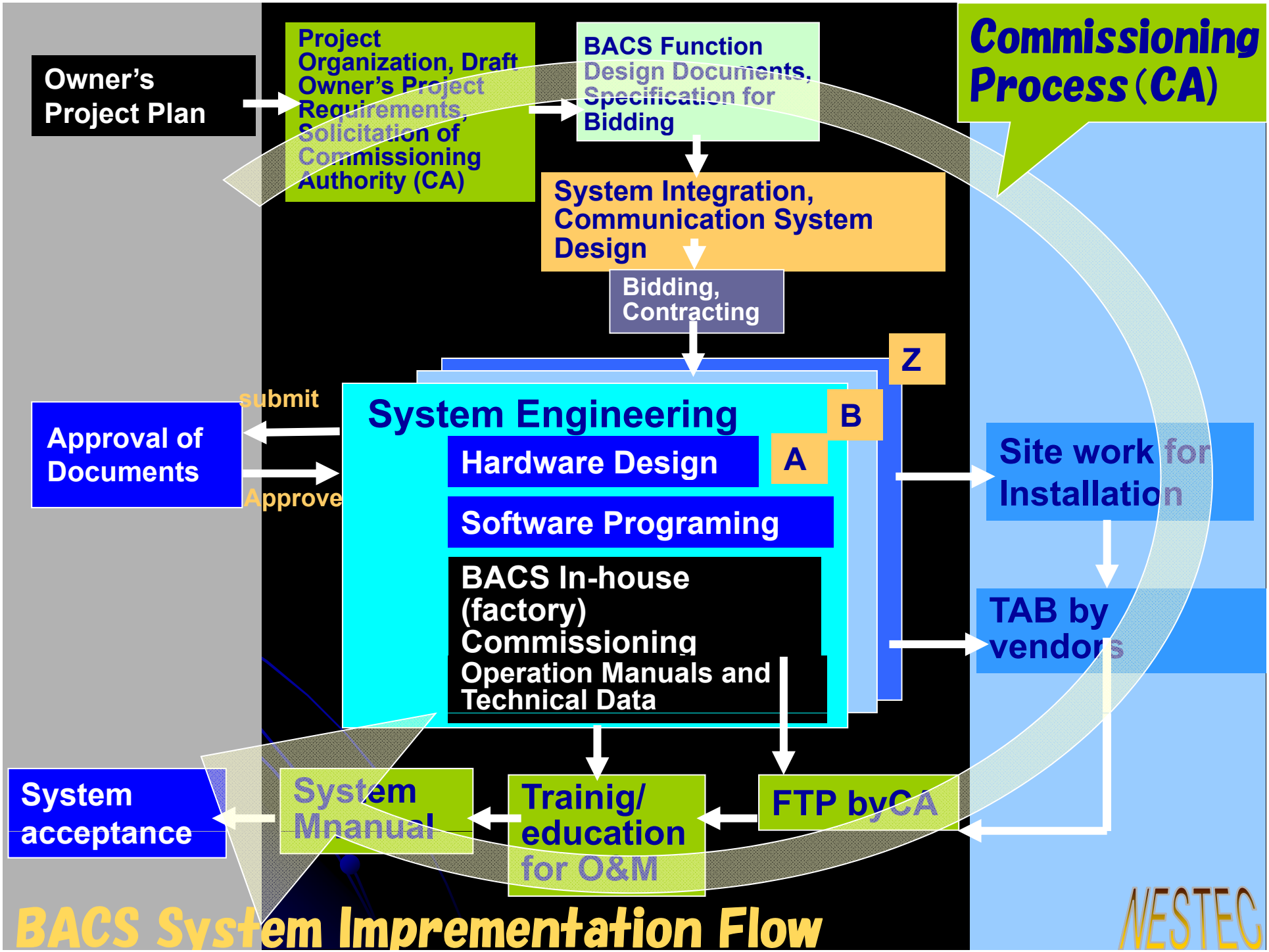
Composition of BEMS




Commissioning Process (CA)
Owner's Project Plan
Project Organization, Draft Owner's Project Requirements, Solicitation of Commissioning Authority (CA)
BACS Function Design Documents, Specification for Bidding
System Integration, Communication System Design
Bidding, Contracting
Z
B
A
System Engineering
Hardware Design
Software Programing
BACS In-house (factory) Commissioning
Operation Manuals and Technical Data
submit
Approve
Approval of Documents
Site work for Installation
TAB by vendors
FTP byCA
Trainig/ education for O&M
System Mpanual
System acceptance
BACS System Impremention Flow
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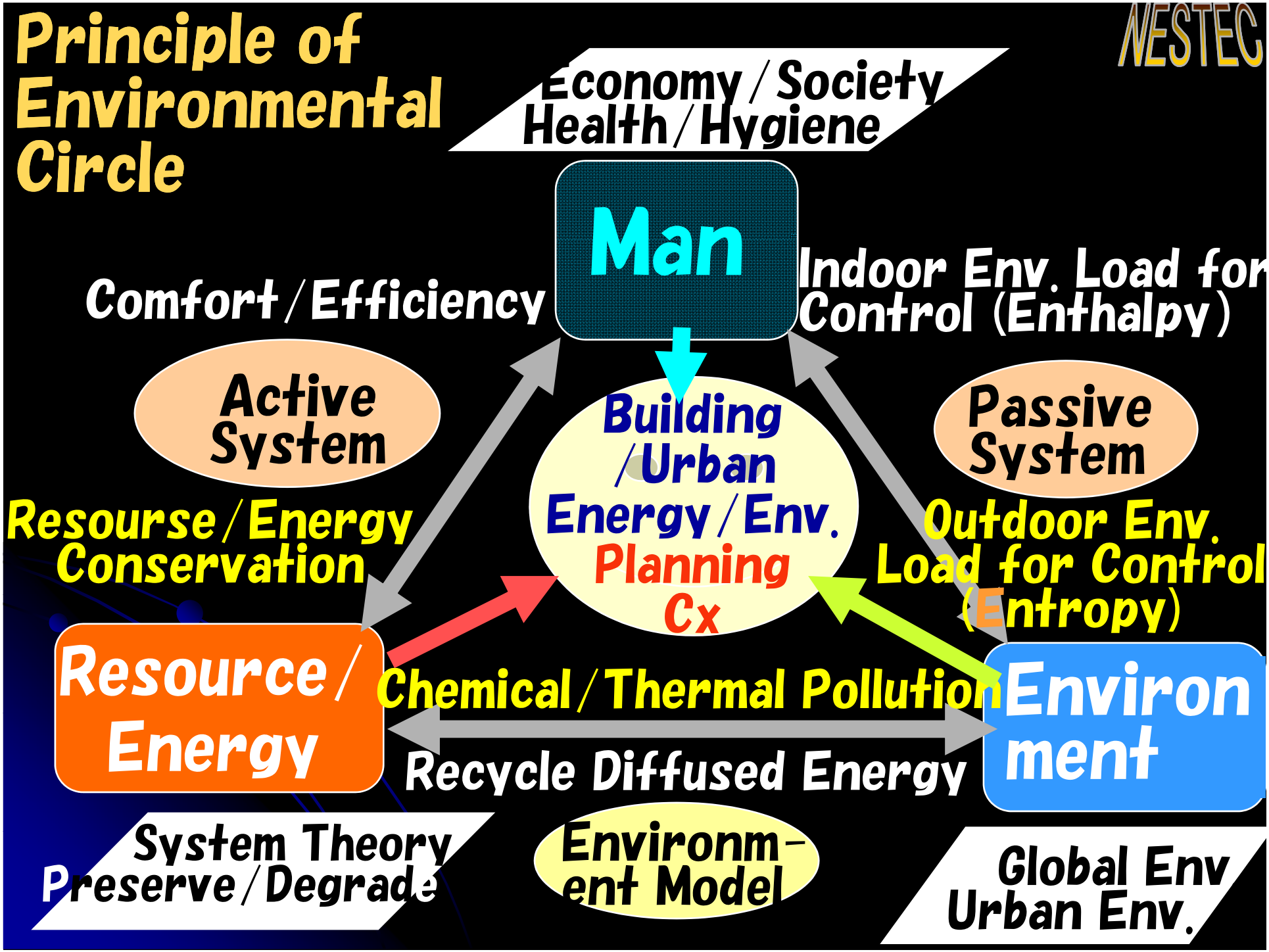
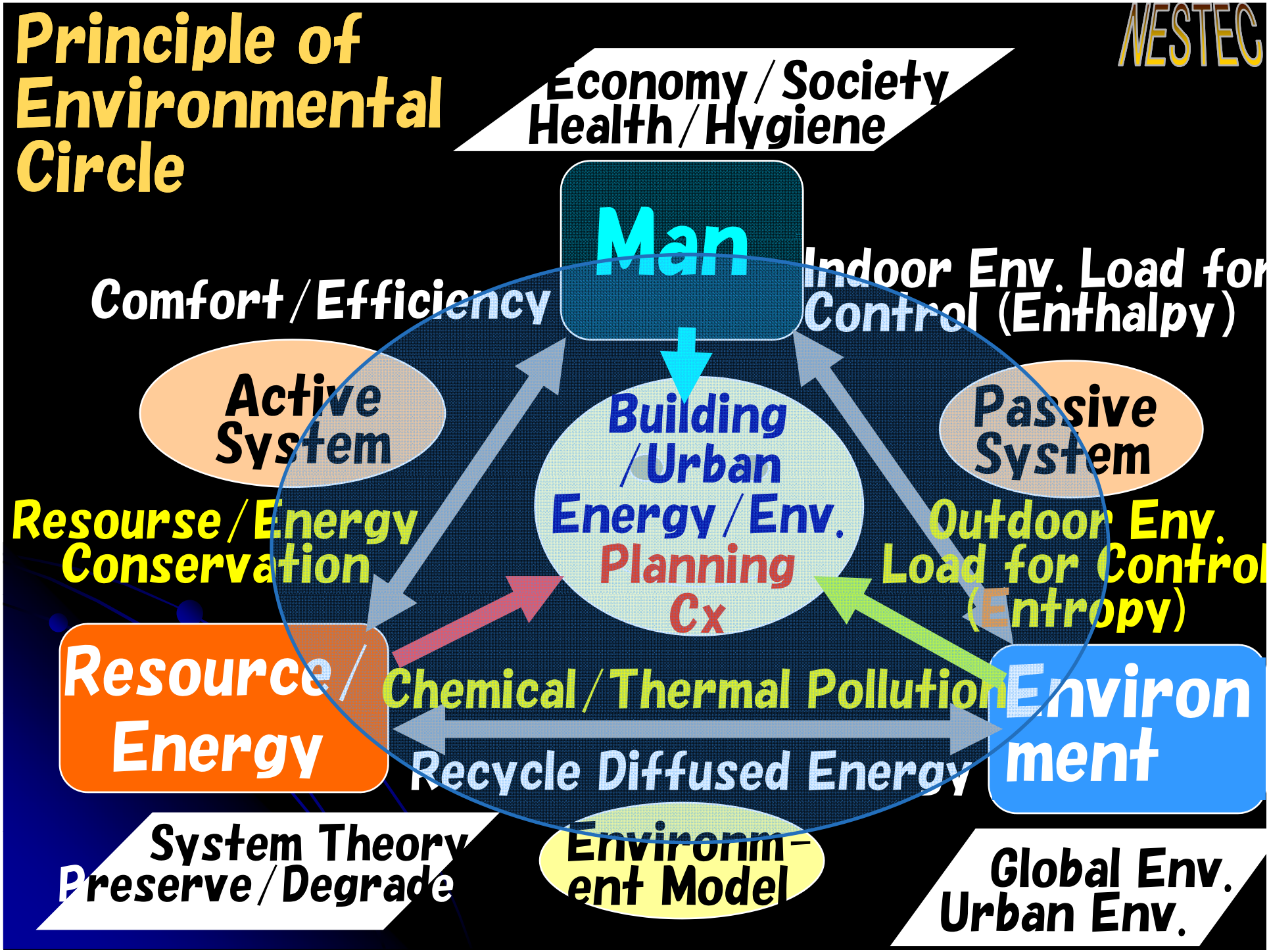

Principle of Environmental Circle
NESTEC
Economy / Society
Health / Hygiene
Man
Comfort / Efficiency
Indoor Env. Load for Control (Enthalpy)
Active System
Building /Urban Energy / Env. Planning Cx
Passive System
Resourse / Energy Conservation
Outdoor Env. Load for Control (Entropy)
Resource / Energy
Chemical / Thermal Pollution
Environment
Recycle Diffused Energy
System Theory
Preserve / Degrade
Environment Model
Global Env
Urban Env.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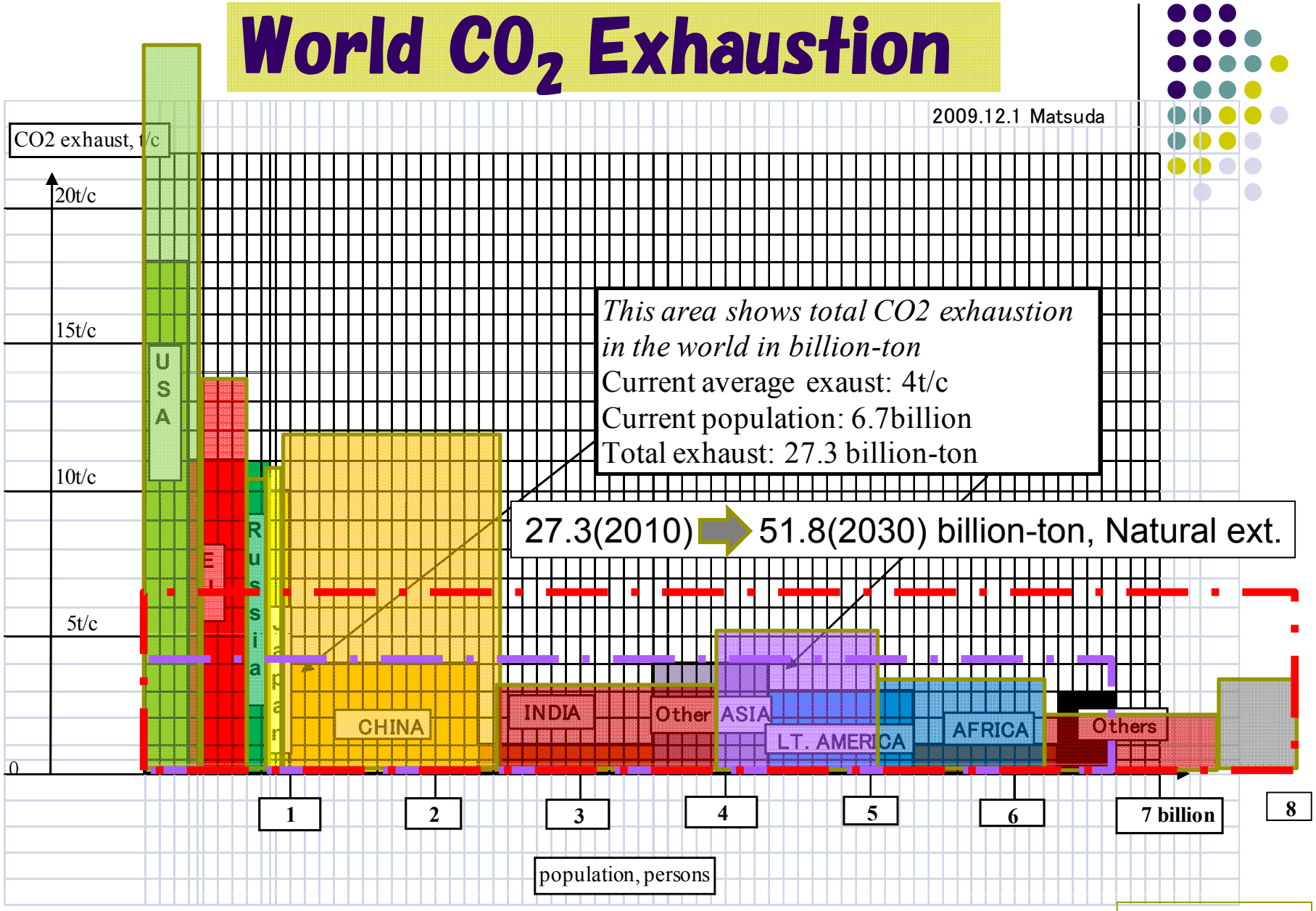
Environment Model
Global Env.
Urban Env.

World CO_2 Exhaustion



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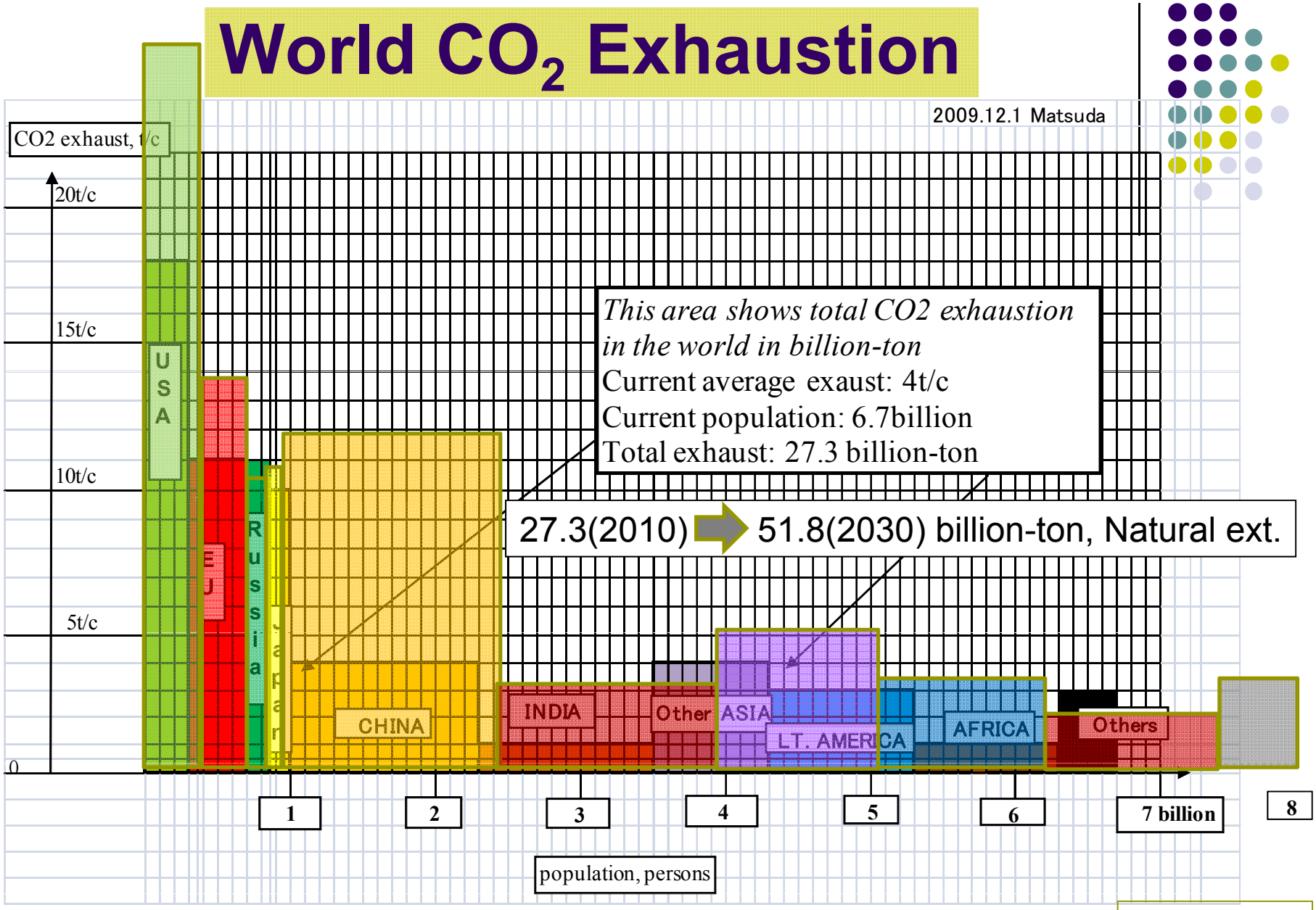

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Conclusions

- Continuous Cx in lifecycle view was introduced together with Cx activity in Japan and international viewpoint.
- HVAC simulation tools shall be used both at the initial Cx at pre-design phase and design phase for OPR and design review, and during the continual Cx for BOFD and optimal operation.
- On-going realization of building energy efficiency cannot be achieved without involving O&M's Cx activity.
- Continuous, or continual, Cx is newly defined as the combination of on-going Cx by O&M and re-Cx by Cx professionals.

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Conclusions - continued

- The new definition will give O&M staff a strong motivation for their jobs, while they should be fairly paid for their contribution. To energy and cost saving.
- Continual Cx, whether it follows the initial Cx or not, is most desirable to achieve the global goal for energy conservation.
- BEMS, or BACS, shall be well designed and commissioned in order to fully use as the continual Cx tool together with simulations.
- Principle of Environmental Circle, together with global warming gas issue, was discussed.

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Thank you
for your kind attention!

See you at the next meeting.

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