A Simulation-based Decision Model for Designing Contract Period in Energy Performance Contracting

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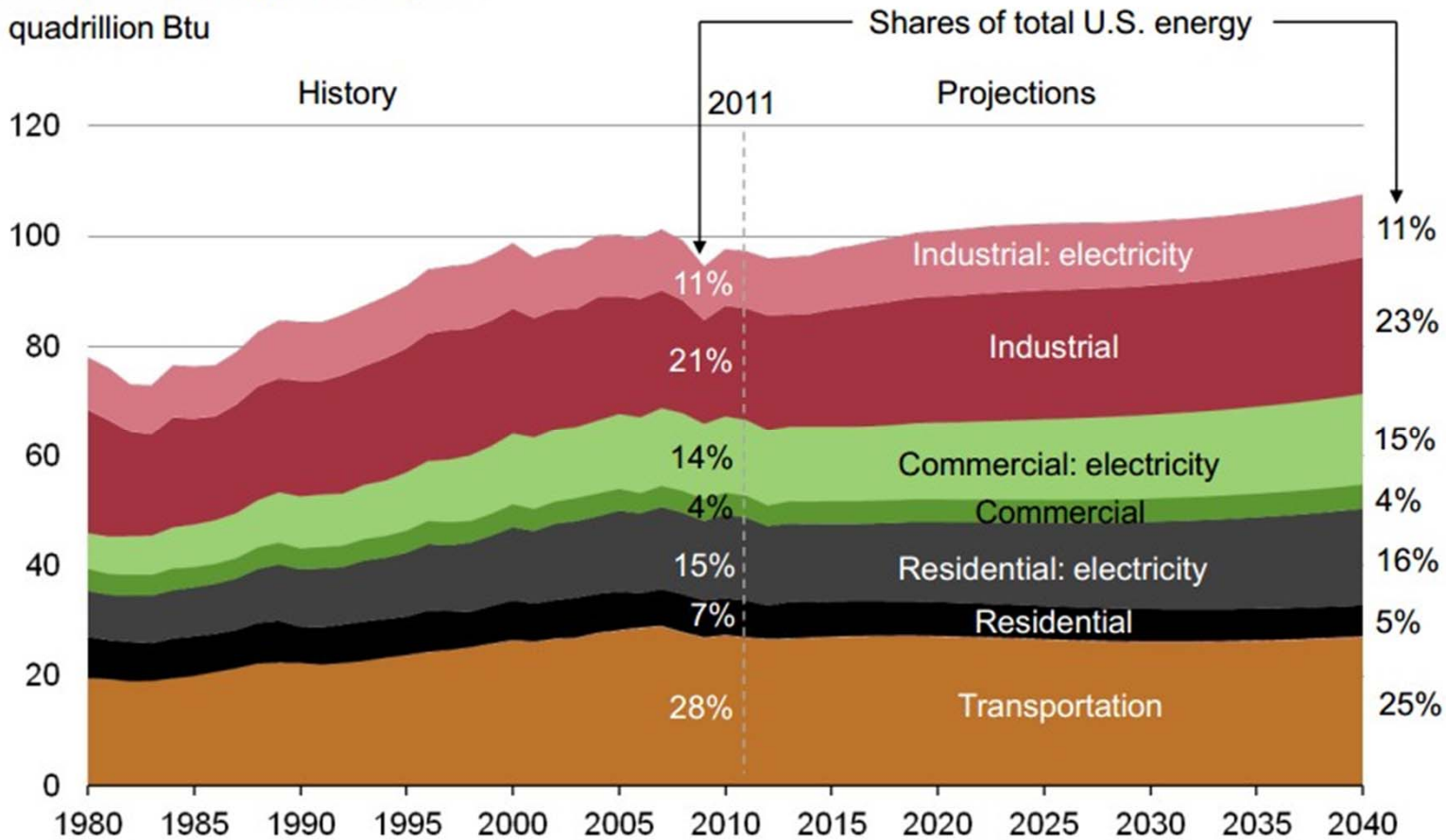
11/06/2014

Overview

- I.   Problem Statement

- II. Factors affecting contracting period decision

- III. Models for simulation

- IV. Case Study of the University of Maryland Campus

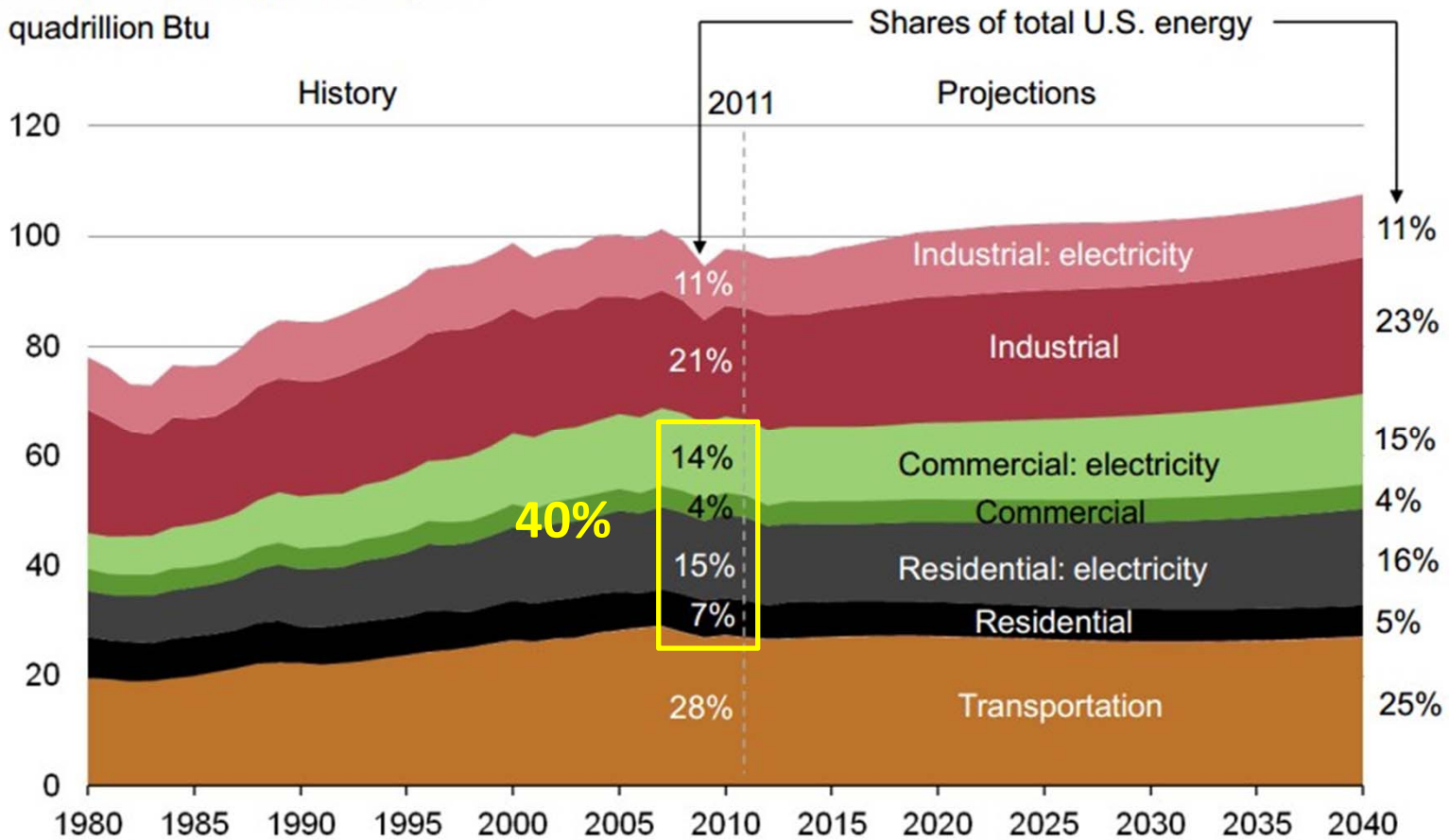- V. Conclusions and future research

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I. Problem Statement

U.S. primary energy consumption
quadrillion Btu

History — 2011 — Shares of total U.S. energy — Projections

- Industrial: electricity — 11% (2011), 11% (2040)
- Industrial — 21% (2011), 23% (2040)
- Commercial: electricity — 14% (2011), 15% (2040)
- Commercial — 4% (2011), 4% (2040)
- Residential: electricity — 15% (2011), 16% (2040)
- Residential — 7% (2011), 5% (2040)
- Transportation — 28% (2011), 25% (2040)

Source: EIA, Annual Energy Outlook 2013 Early Release

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I. Problem Statement

U.S. primary energy consumption quadrillion Btu

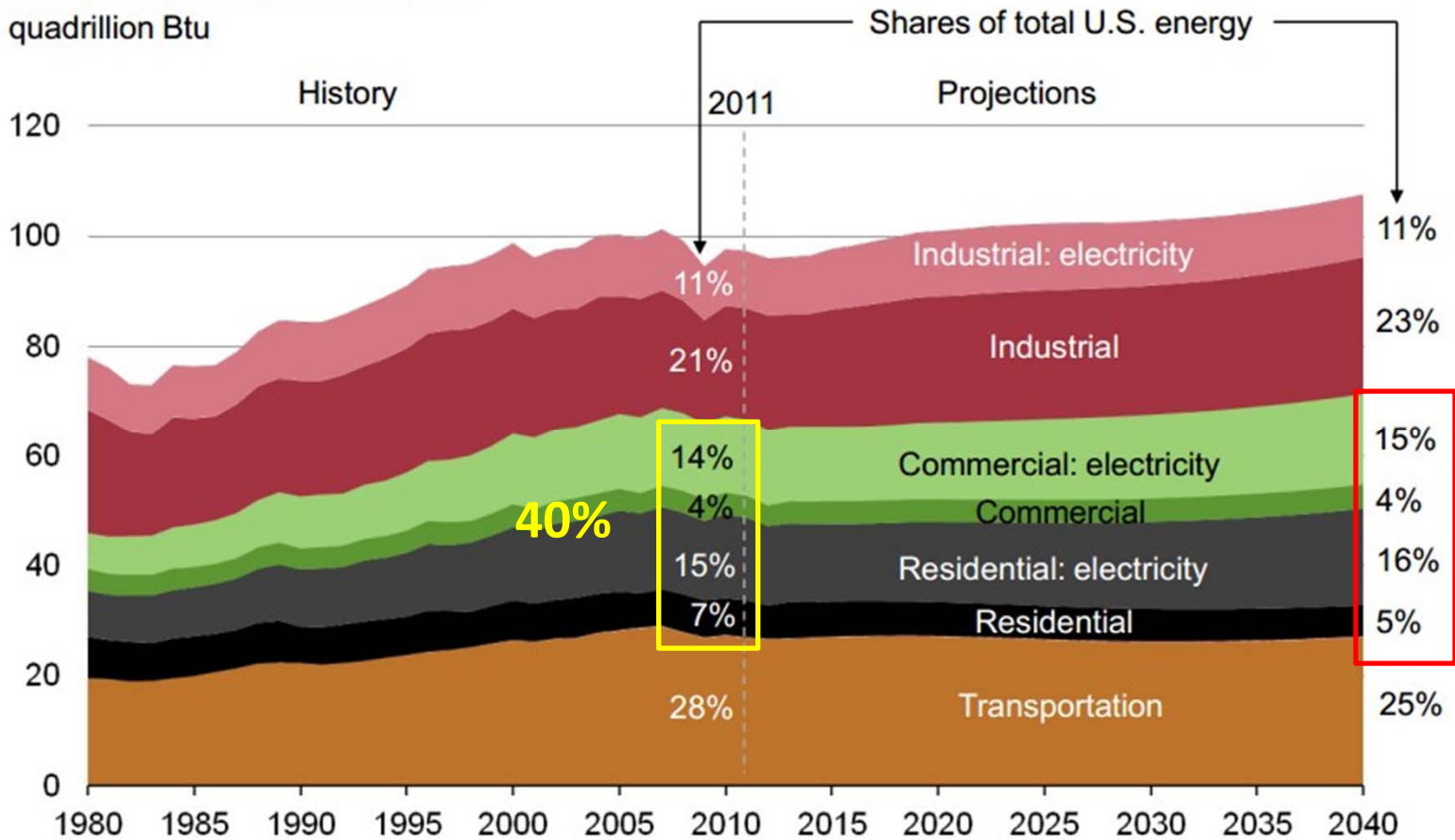Source: EIA, Annual Energy Outlook 2013 Early Release

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I. Problem Statement

U.S. primary energy consumption quadrillion Btu

Shares of total U.S. energy

History — 2011 — Projections

	2011	2040
Industrial: electricity	11%	11%
Industrial	21%	23%
Commercial: electricity	14%	15%
Commercial	4%	4%
Residential: electricity	15%	16%
Residential	7%	5%
Transportation	28%	25%

40%

40%

Source: EIA, Annual Energy Outlook 2013 Early Release

I. Problem Statement

- **Definition**

An EPC is a partnership between an Owner and an Energy Service Company (ESCO).

EPC utilizes the future energy savings revenues to repay the initial energy efficiency investment.

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- Energy Performance Contracting (EPC)

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- Energy Performance Contracting (EPC)

- Energy Management Contracting (EMC)

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- Energy Performance Contracting (EPC)

- Energy Management Contracting (EMC)

- Energy Savings Performance Contracting (ESPC)

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I. Problem Statement

- **Energy Service Company (ESCO/ESCo)**

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I. Problem Statement

- **Energy Service Company (ESCO/ESCo)**

- **Energy Conservation Measures (ECMs)**

Lighting Upgrades, Water Conservation, HVAC, Building Envelop, Windows Upgrades, Insulation, Mechanical Improvement, etc.
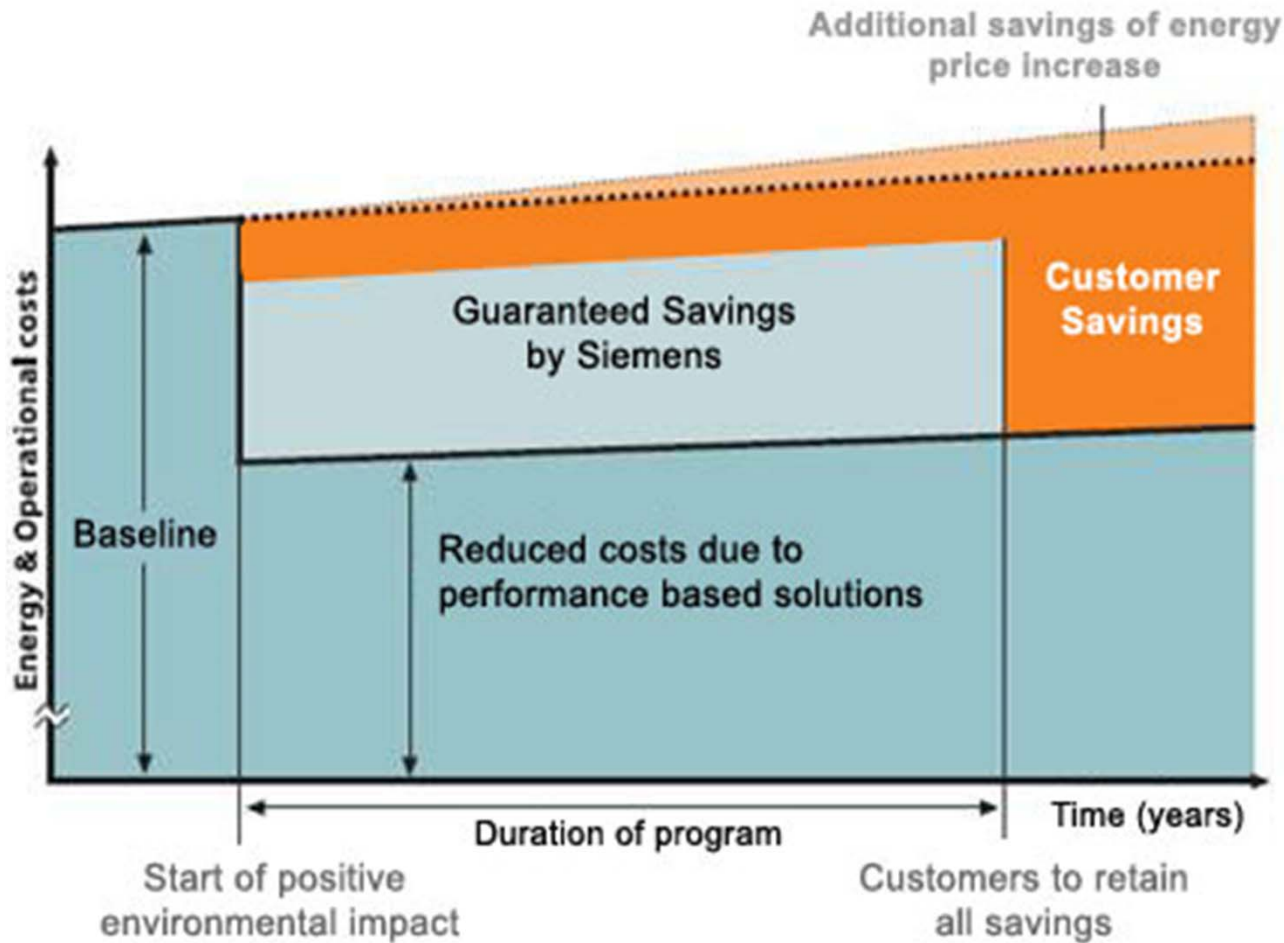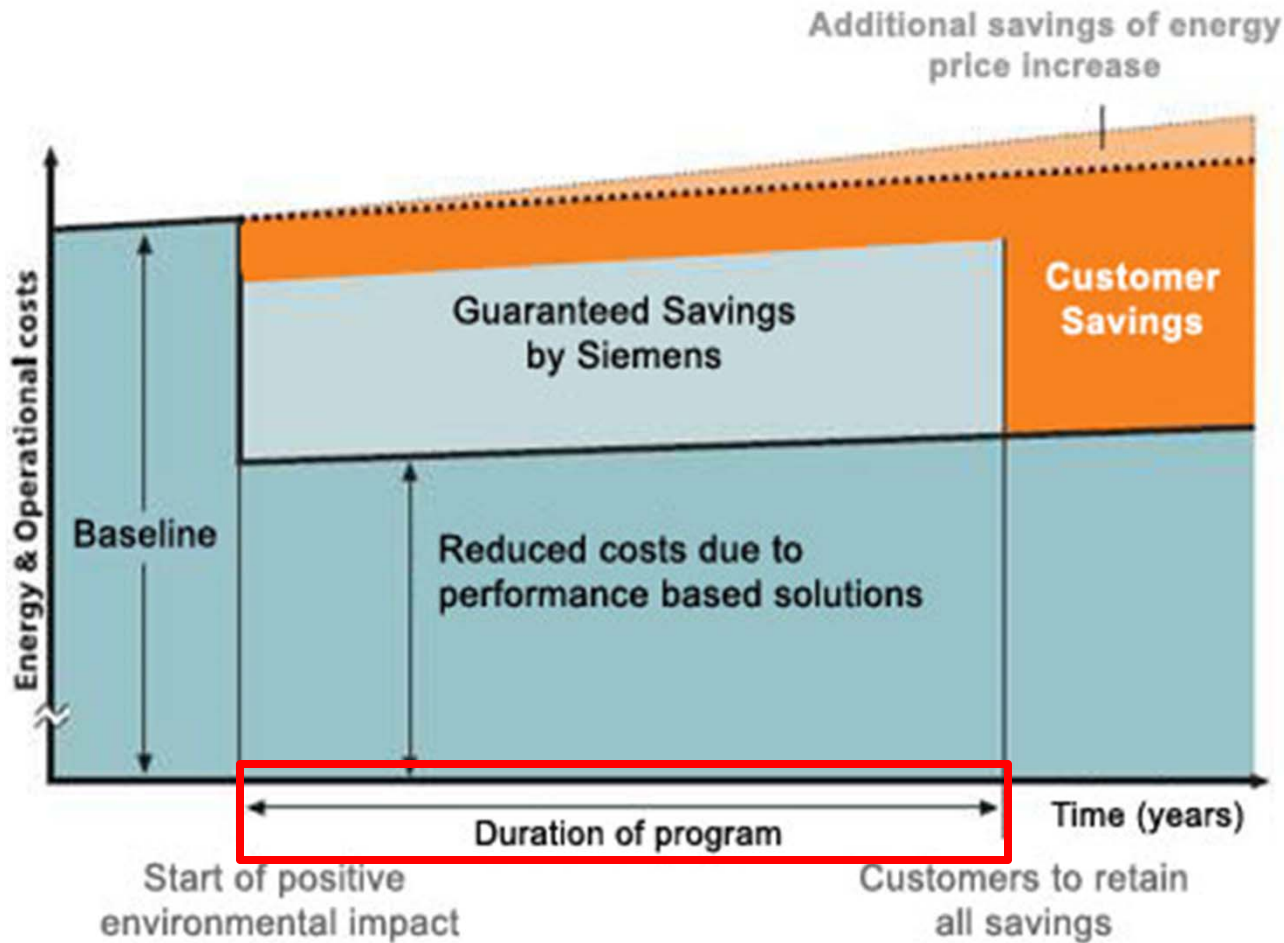
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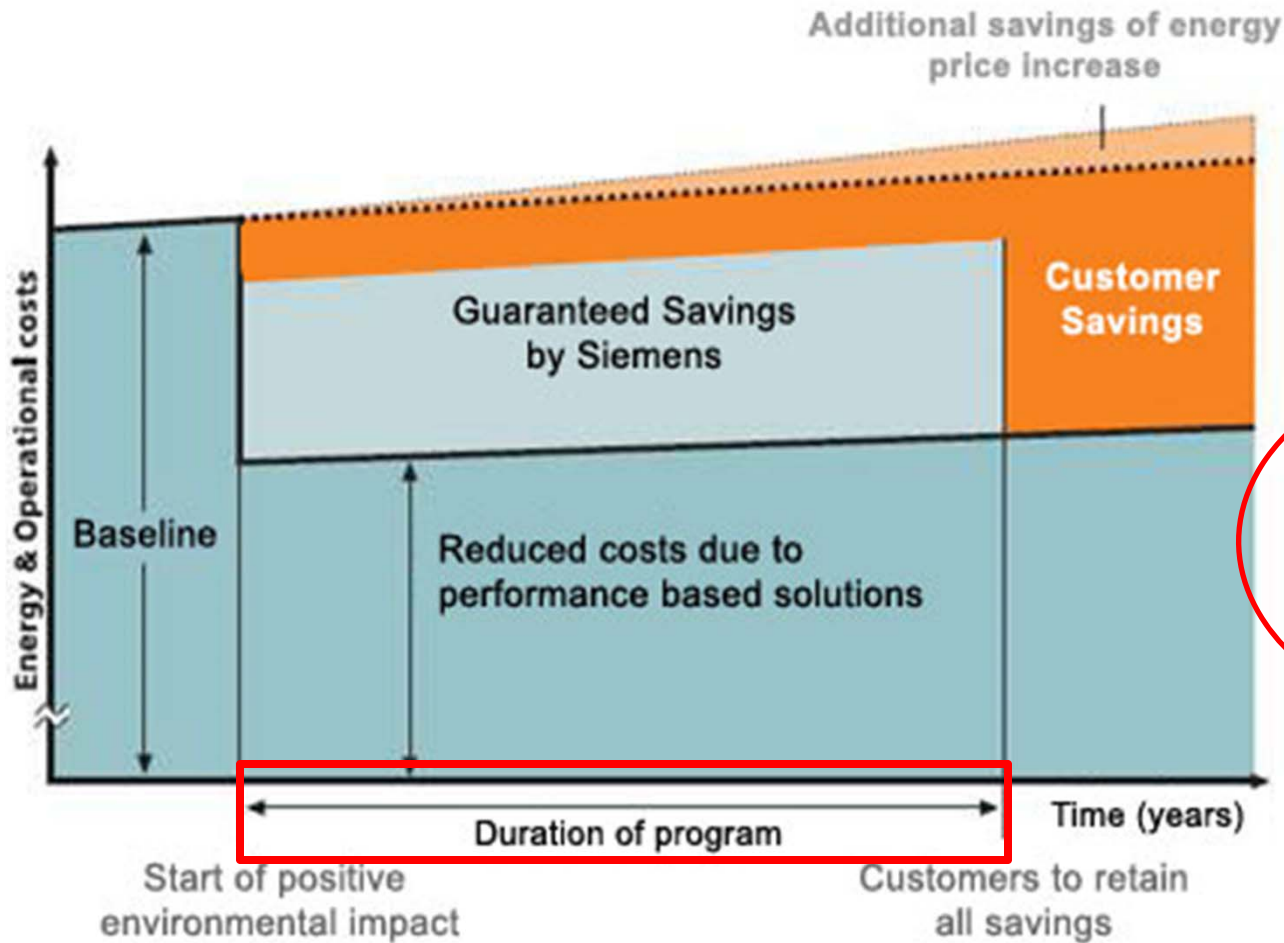DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

I. Problem Statement

Energy Performance Contracting (Siemens Building Technologies, 2010)

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Trade-off in contracting period design exists

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Theoretically

1) Owners expect short contracting period

2) ESCOs expect long contracting period

I. Problem Statement

Trade-off in contracting period design exists

Theoretically

1) Owners expect short contracting period

2) ESCOs expect long contracting period

Practically

3) Uncertainties of energy price, energy conservation measures performances, operation and maintenance activities, measurement and verification practices …

I. Problem Statement

Energy Policy Act (2005)

The whole contracting period of EPC shall not exceed 20 years to allow longer payback periods for retrofits.

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I. Problem Statement

Energy Policy Act (2005)

The whole contracting period of EPC shall not exceed 20 years to allow longer payback periods for retrofits.

State Energy Conservation Offices

10 years –> 7 states (Illinois, Indiana, Michigan, etc.)

15 years –> 11 states (DC, Hawaii, Maryland, etc.)

20 years –> 8 states (Alabama, Delaware, Florida, etc.)

25 years –> 3 states (Arizona, Colorado, Idaho)

35 years –> 1 states (New York)

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II. Factors affecting contracting period

1) Investment?

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II. Factors affecting contracting period

1) Investment?

Initial capital investment + Operation & Maintenance investment

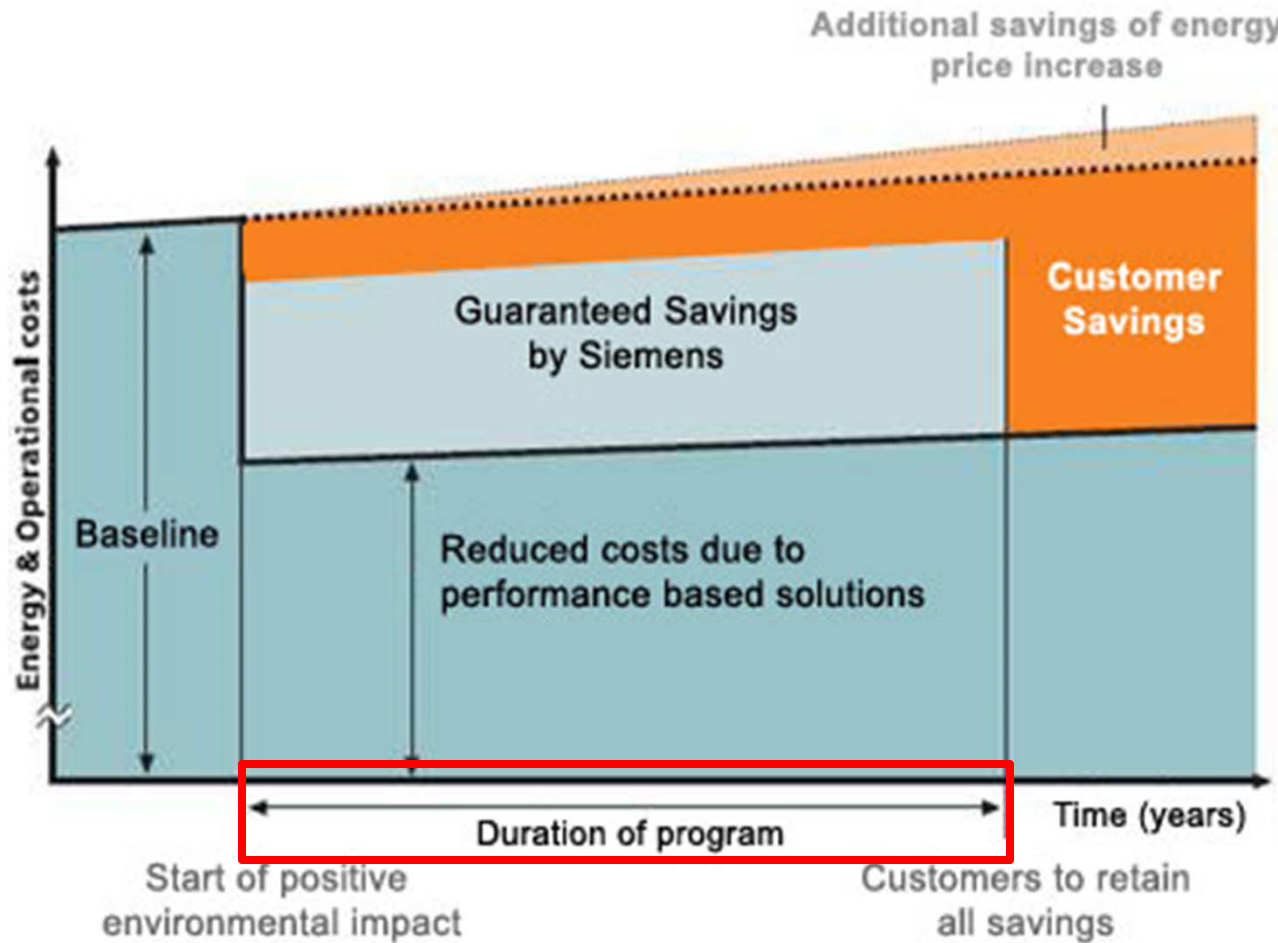CENTER FOR EXCELLENCE IN PROJECT MANAGEMENT
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II. Factors affecting contracting period

1) Investment?

Initial capital investment + Operation & Maintenance investment

2) Revenue?

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Energy cost savings (Amount of energy savings + Energy price)

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3) Profit sharing?

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Contract design (Guaranteed energy cost savings + Profit sharing percentage + Excess profit sharing beyond guarantee)

II. Factors affecting contracting period

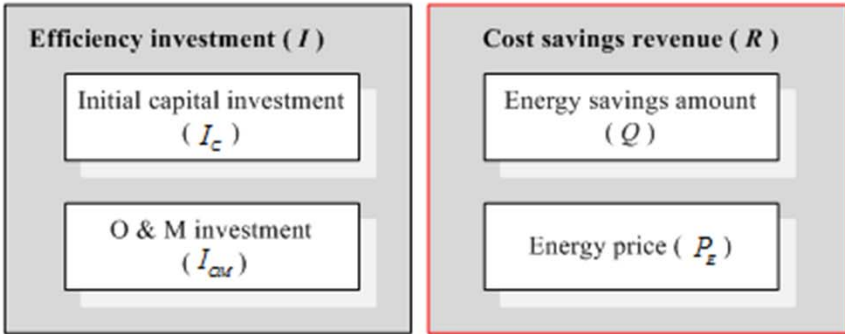*Energy Performance Contracting (Siemens Building Technologies, 2010)*

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II. Factors affecting contracting period

Contract design
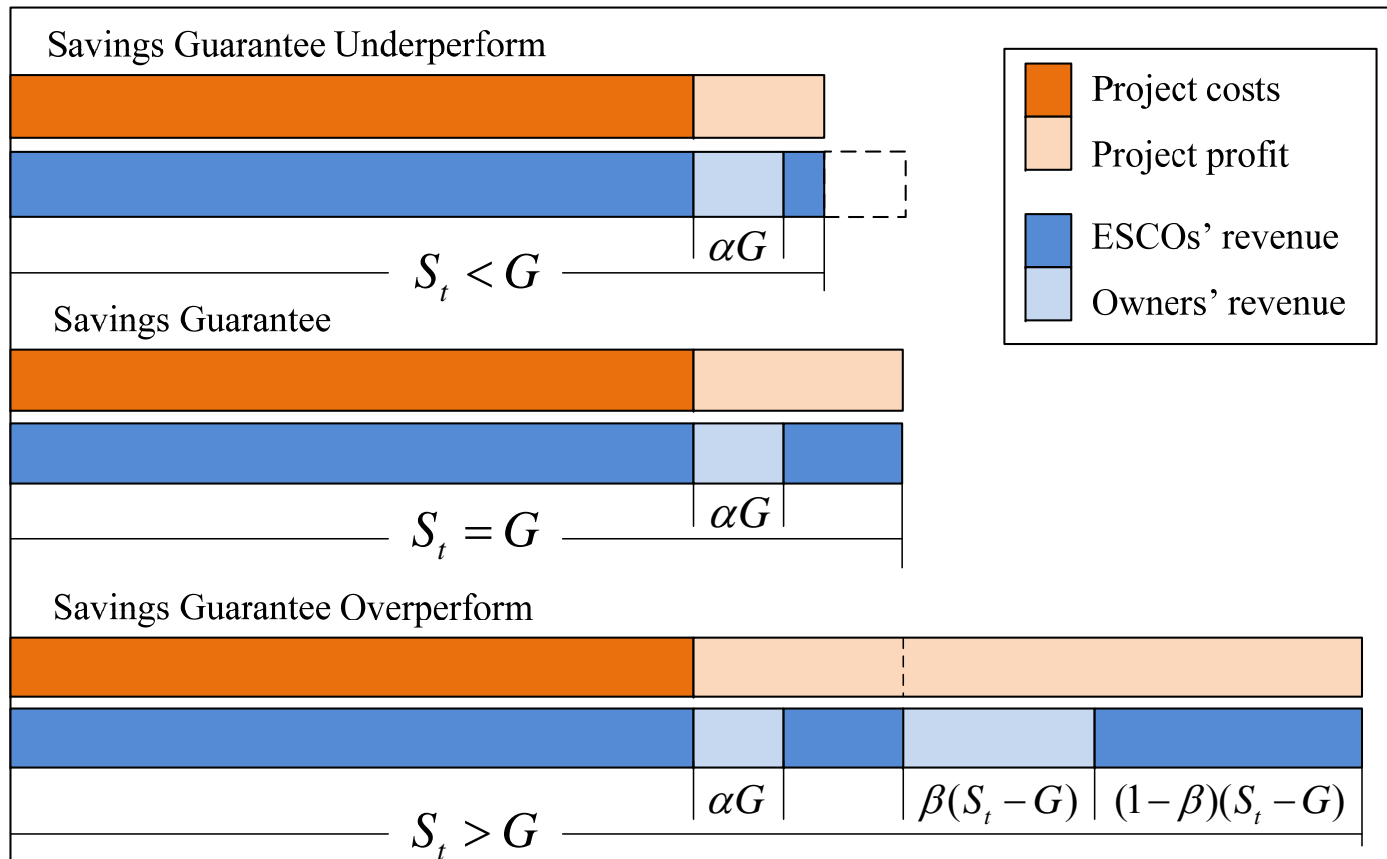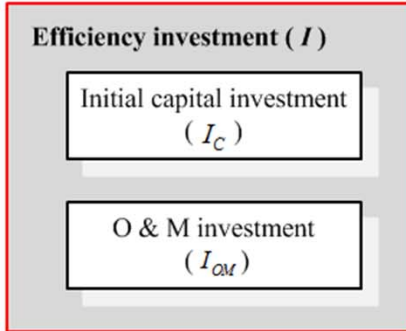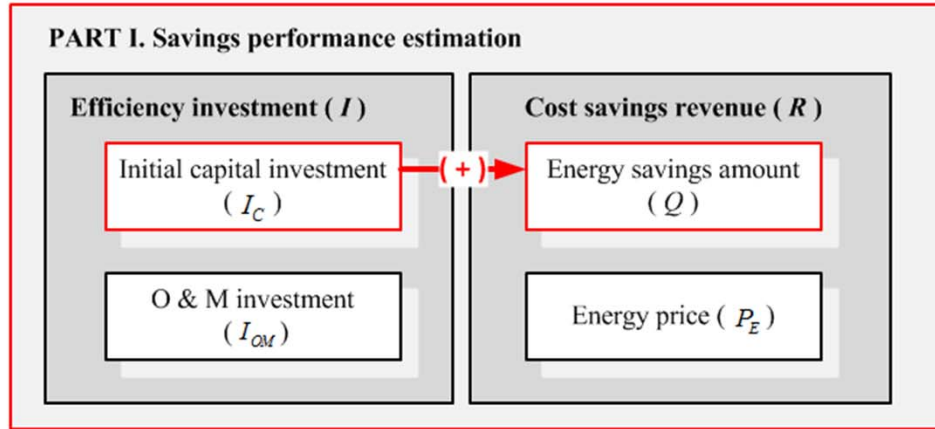
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III. Simulation model

Efficiency investment (I)

Initial capital investment
(I_C)

O & M investment
(I_{OM})

III. Simulation model

Efficiency investment (I)	Cost savings revenue (R)
Initial capital investment (I_c)	Energy savings amount (Q)
O & M investment (I_{OM})	Energy price (P_E)

III. Simulation modeling

PART I. Savings performance estimation

Efficiency investment (I)

Initial capital investment (I_C)

O & M investment (I_{OM})

Cost savings revenue (R)

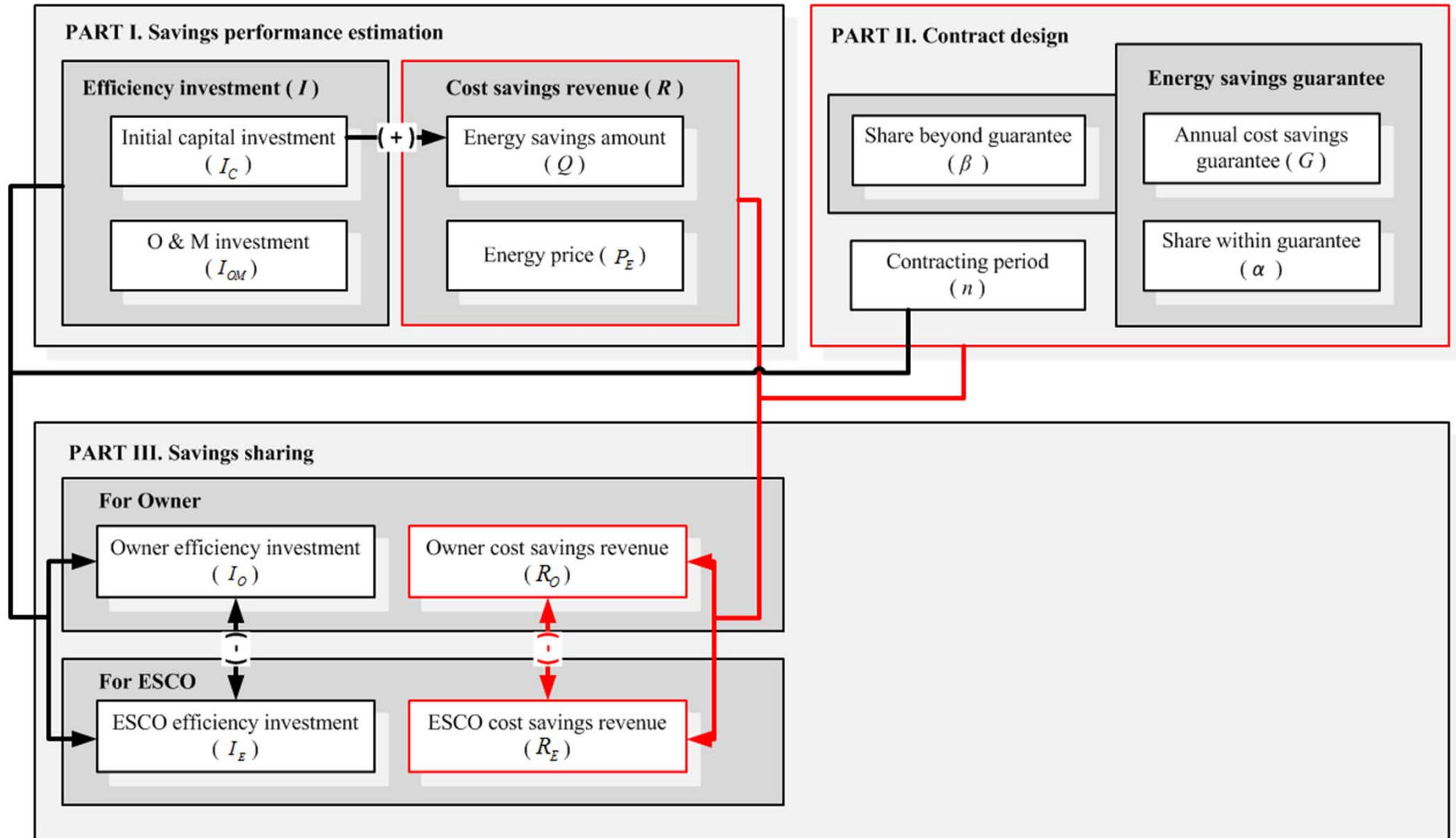Energy savings amount (Q)

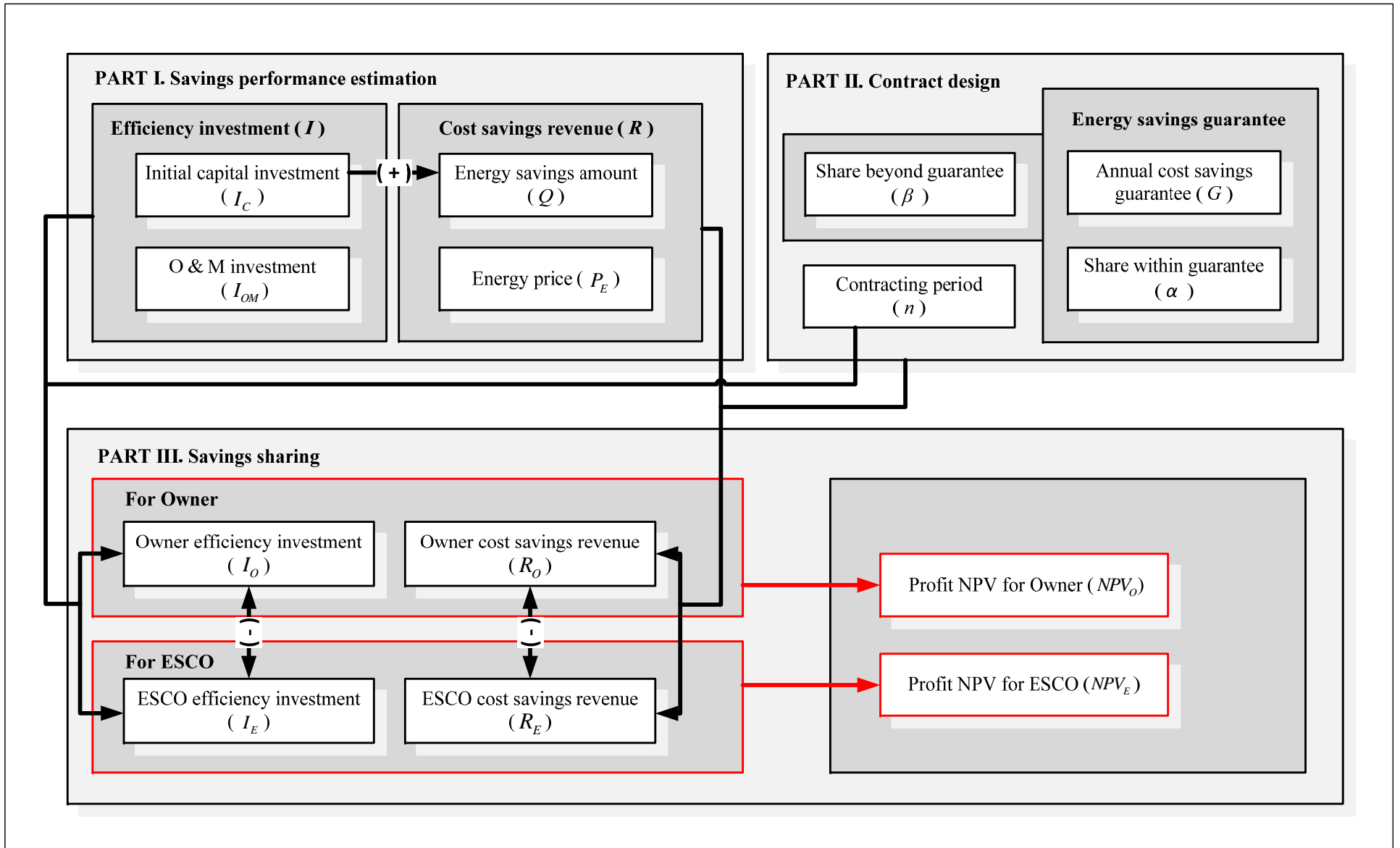Energy price (P_E)

(+)

III. Simulation modeling
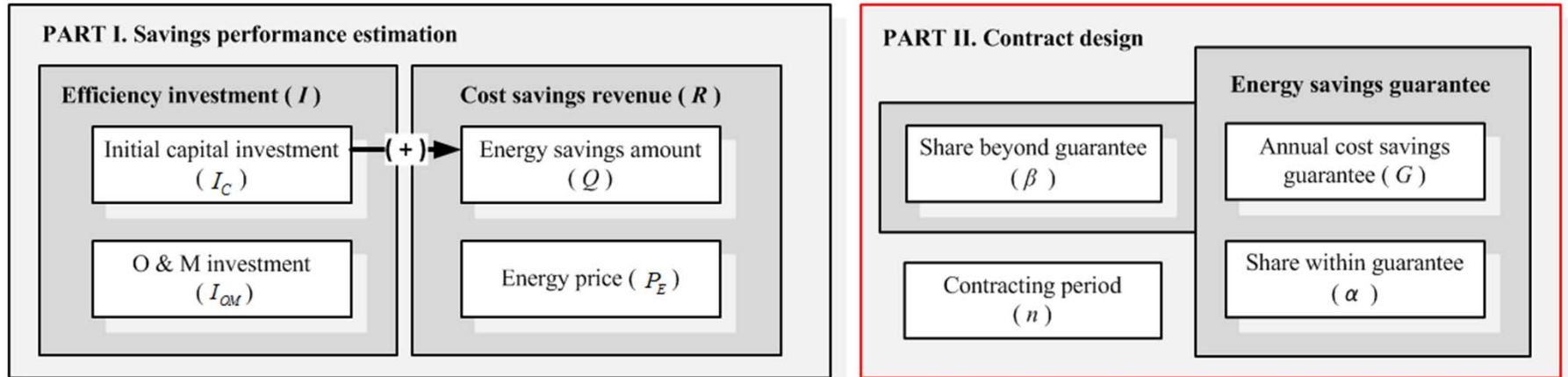
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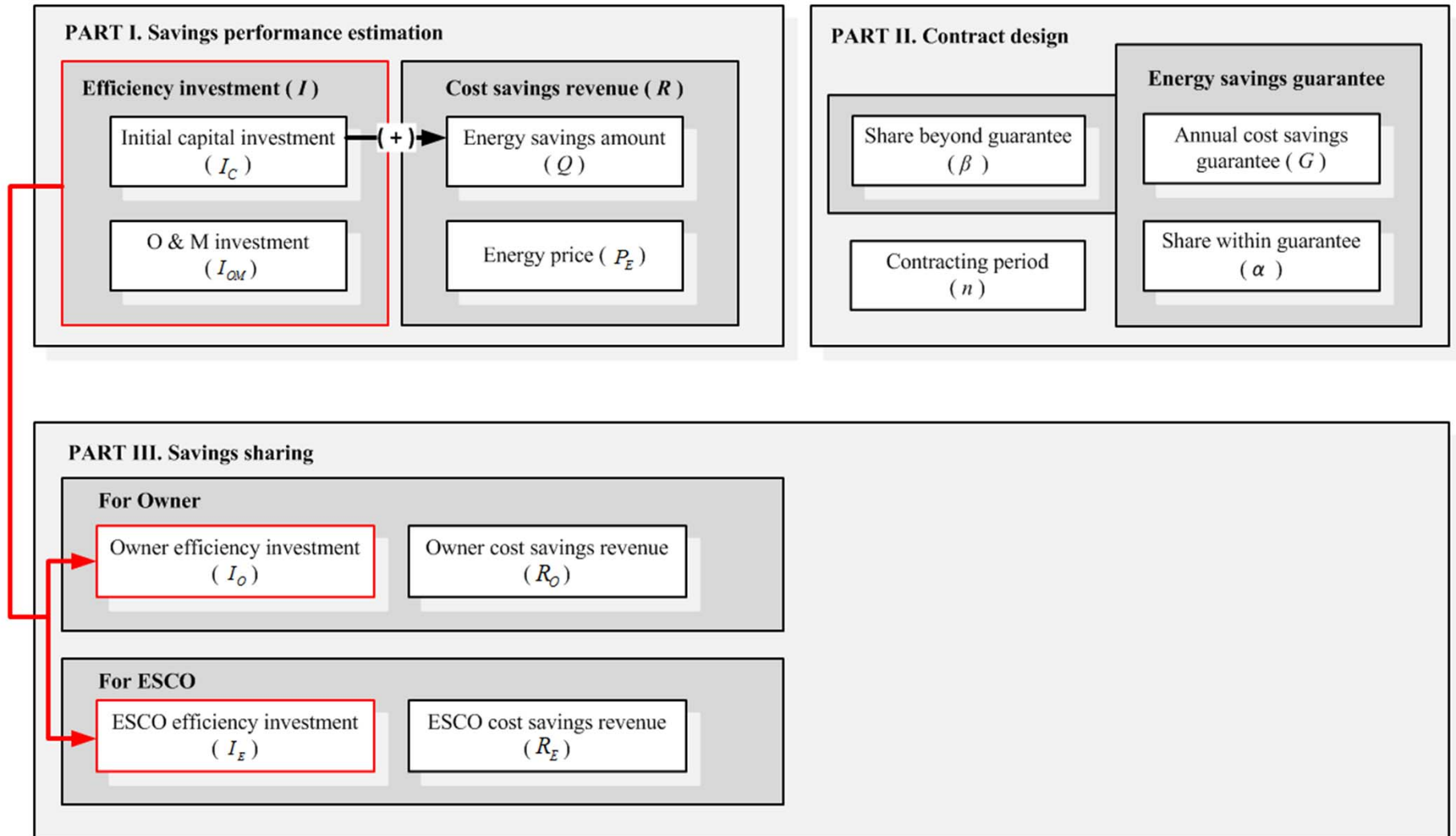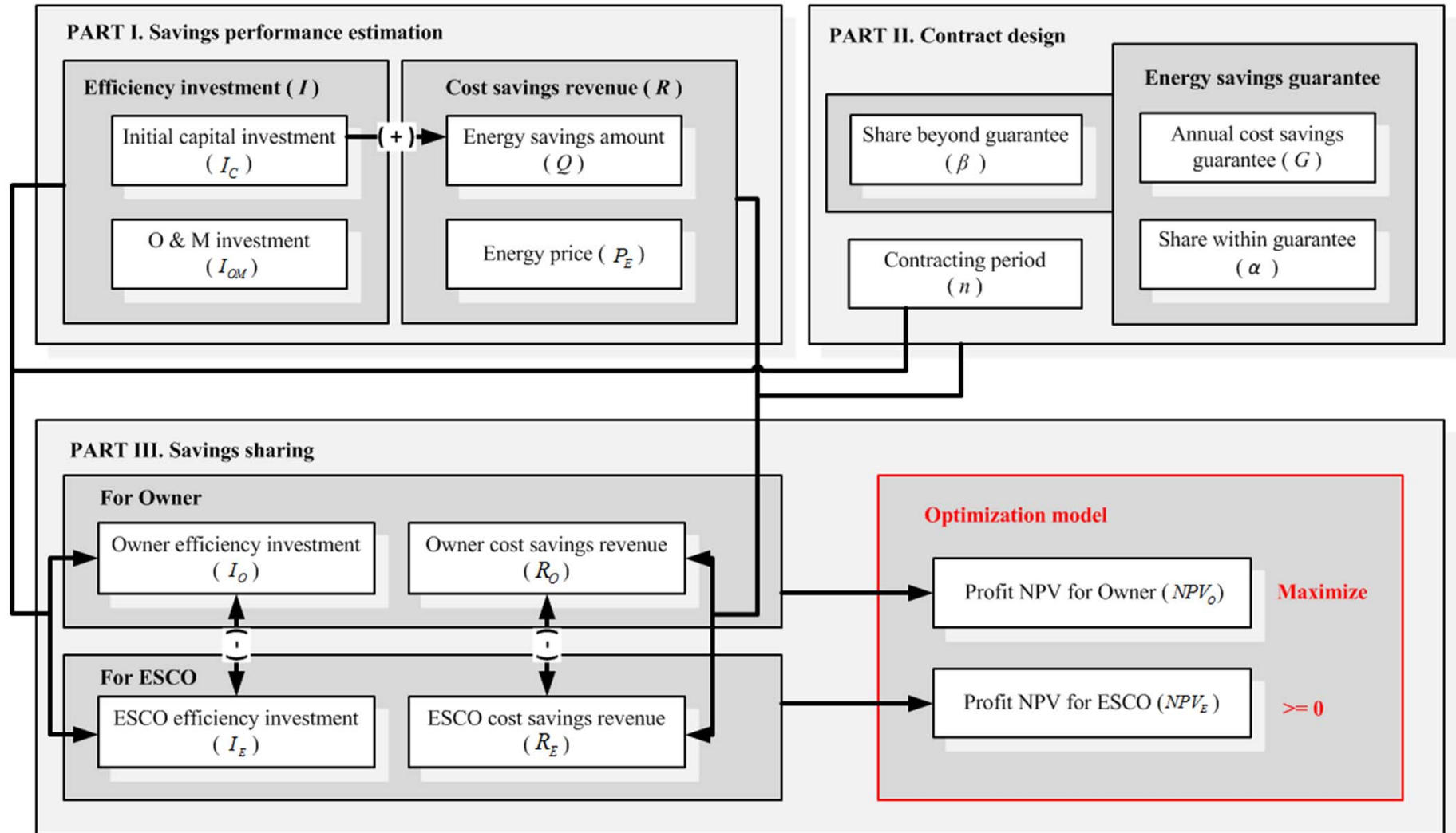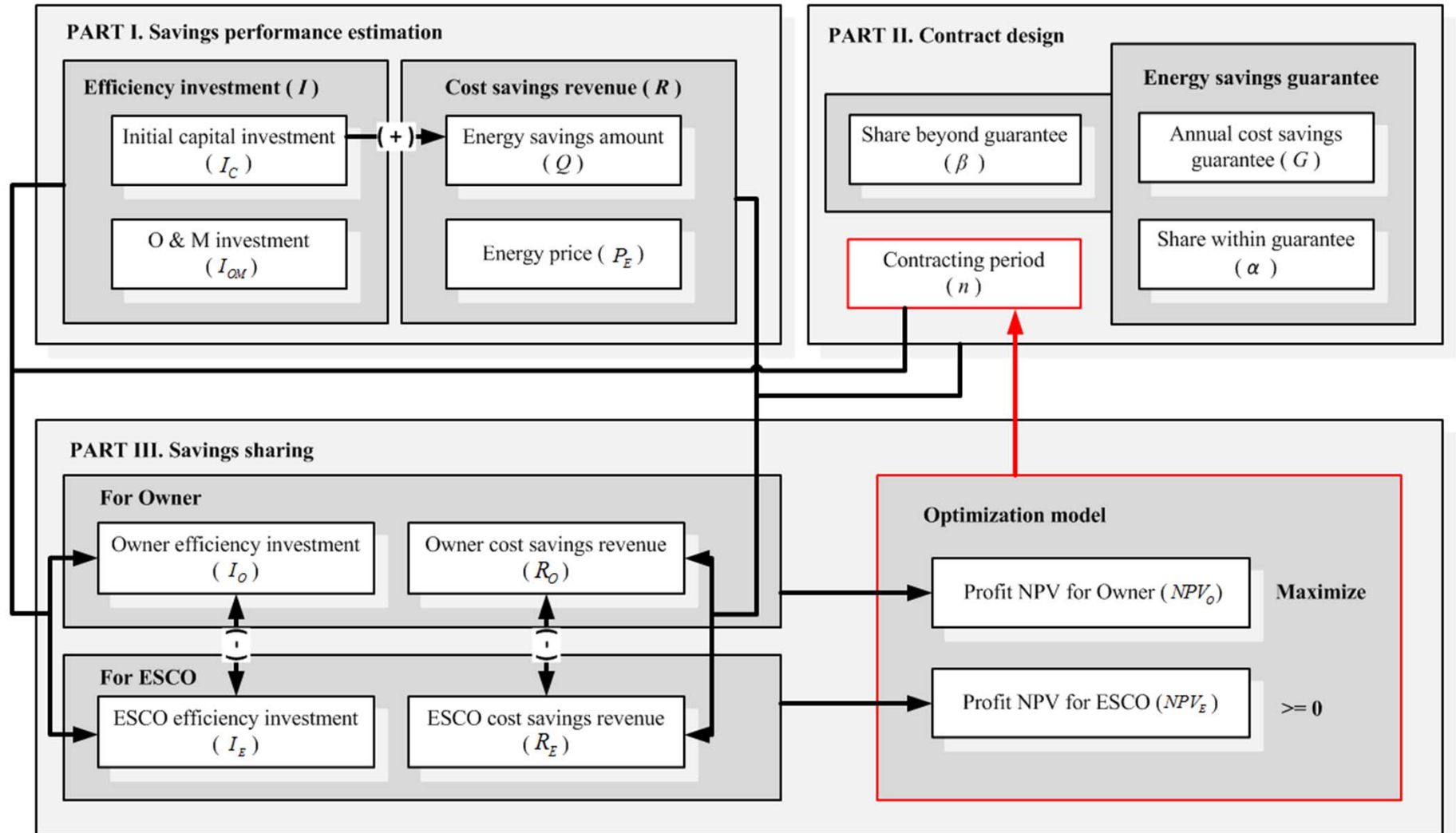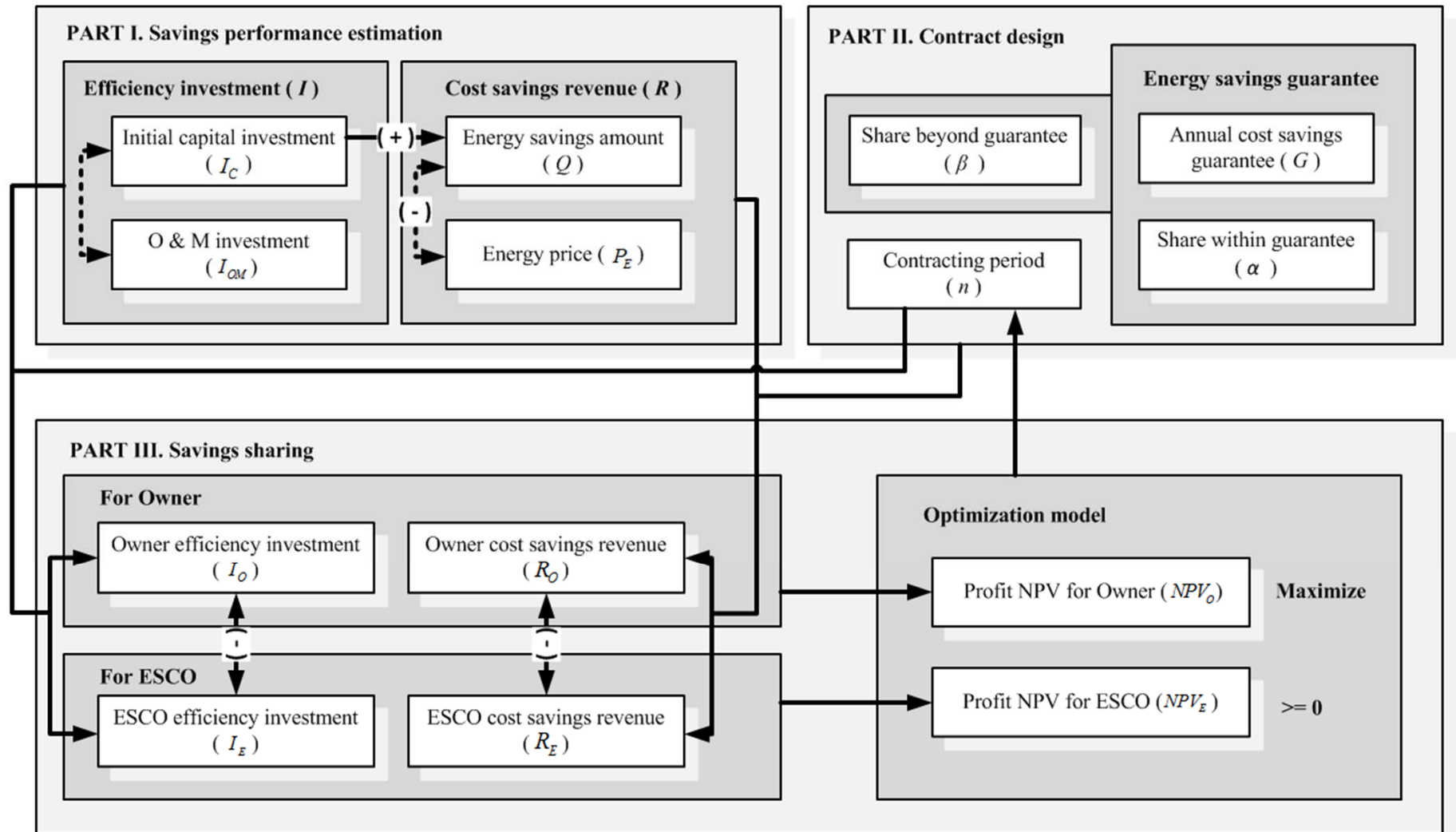
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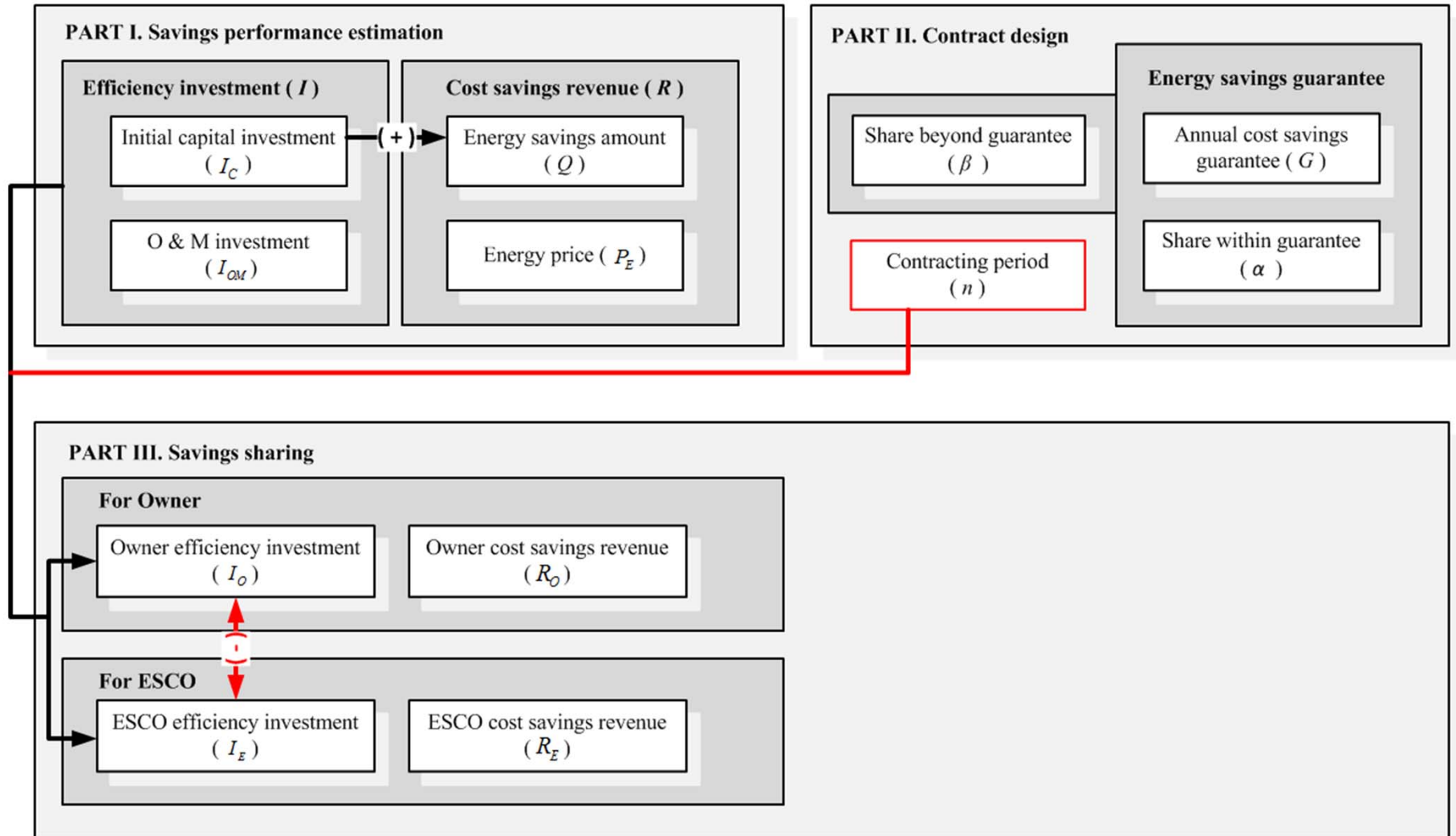
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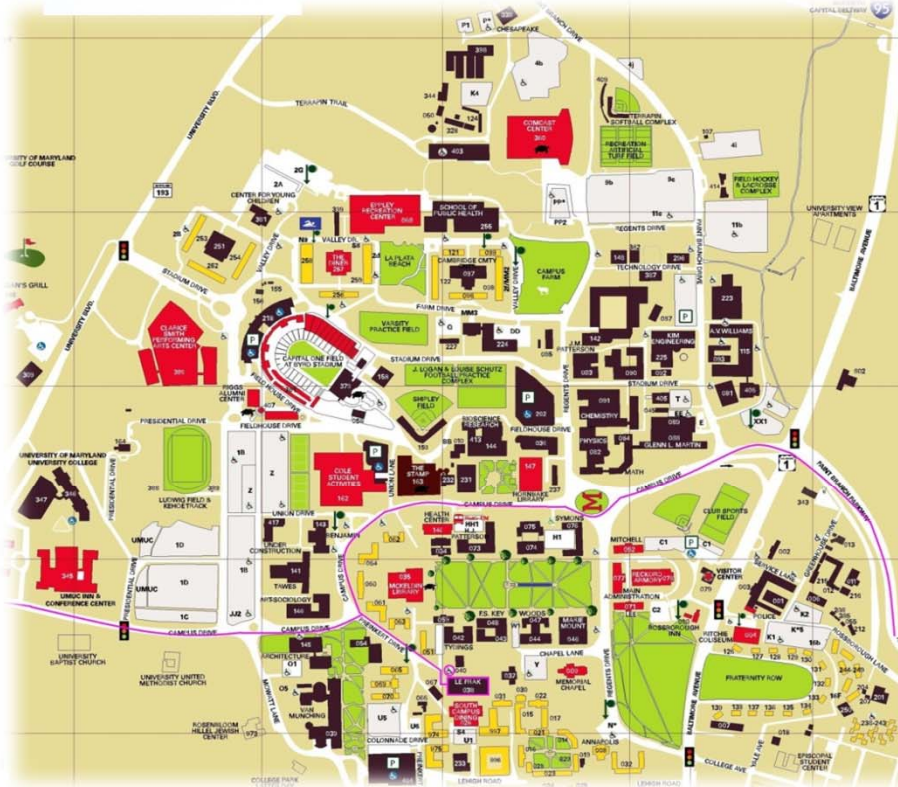
III. Simulation modeling

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IV. Case study

Comprehensive Energy Efficiency and Guaranteed Savings Program

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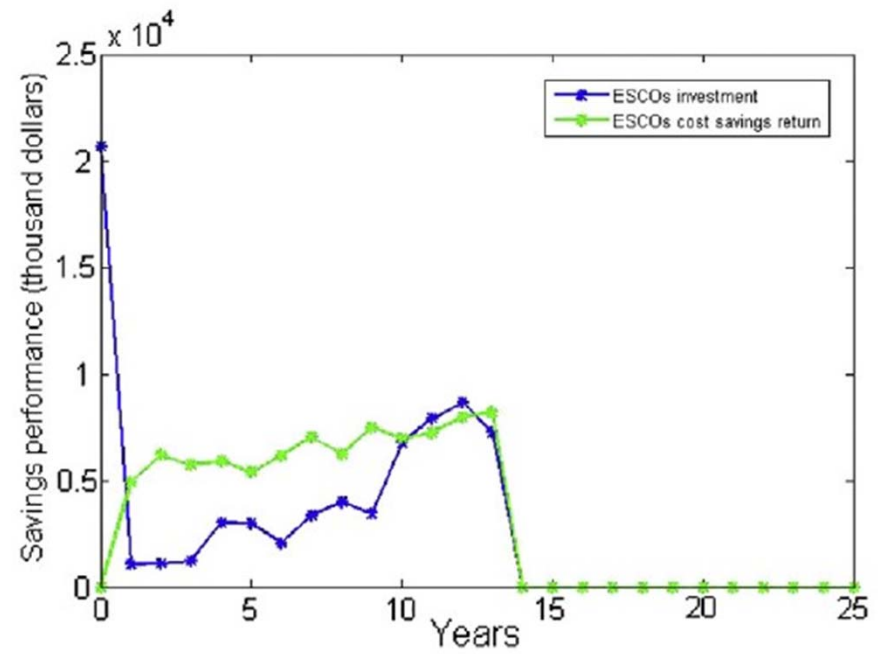| Parameters	Symbols	Values
Economic lifetime of the energy efficiency system	N	25 years
Capital cost of the energy efficiency investment	I_C	$20,668,991
Depreciation coefficient	δ	1.05
Initial value of the O&M cost coefficient	H_0	0.05
Volatility of the O&M cost coefficient	σ_H	0.25
Initial value of the energy savings amount coefficient	K_0	0.004
Volatility of the energy savings amount coefficient	σ_K	0.01
Initial value of the energy price	P_{E0}	$26,025 per million Btu
Energy price drift effect	α_E	0.0523
Energy price volatility effect	σ_E	0.0856
Annual energy cost savings guarantee	G	$3,000,000
Owners' expected revenue share within the guarantee	α	5%
ESCOs' expected revenue share within the guarantee	$1 - \alpha$	95%
Owners' excess revenue share beyond the guarantee	β	20%
ESCOs' excess revenue share beyond the guarantee	$1 - \beta$	80%
Owners' expected rate of return	r_O	8%
ESCOs' expected rate of return	r_E	15%

IV. Case study
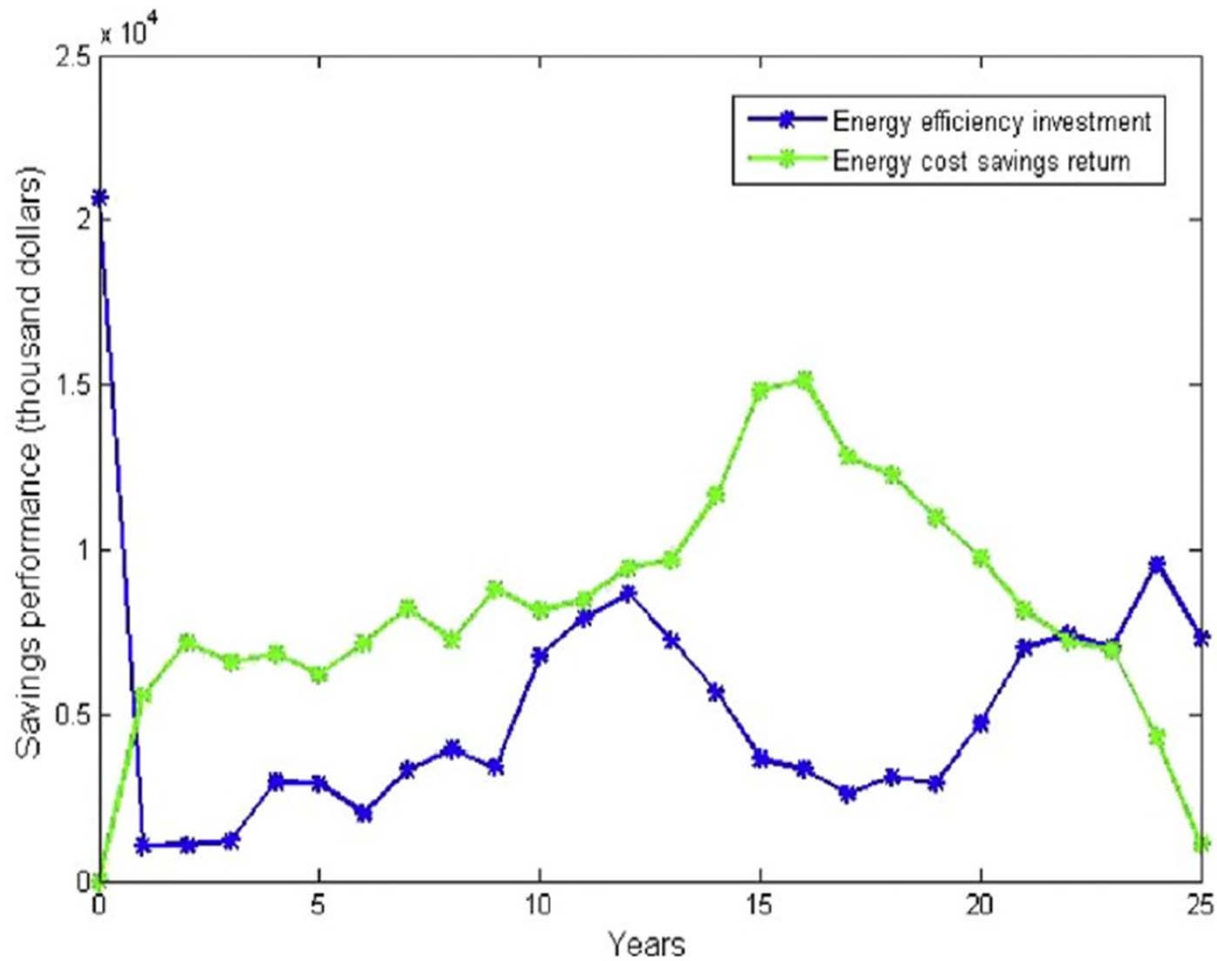
Sample paths of energy savings performances

IV. Case study

Sample paths of shared energy savings performance
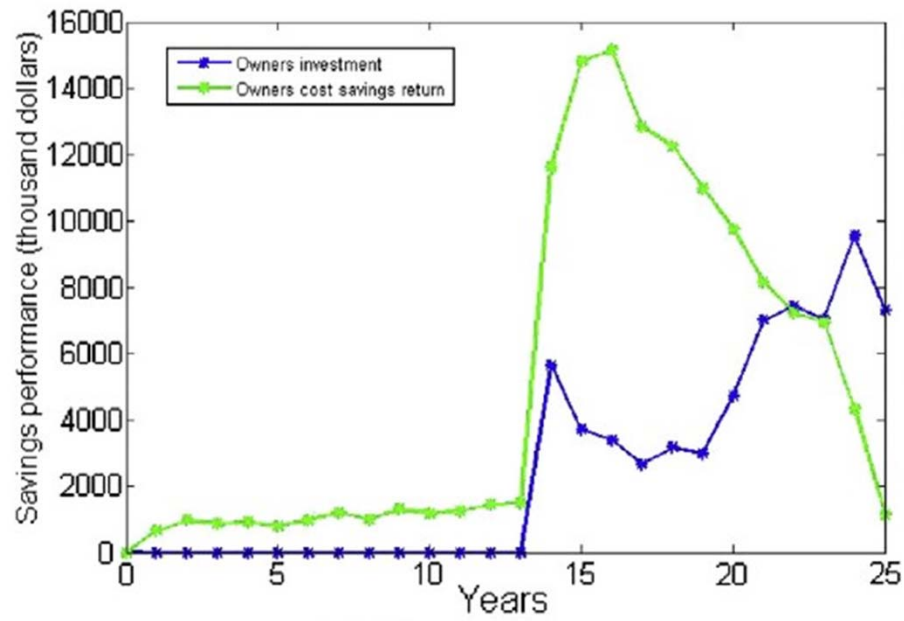
(a) For the owners

(b) For the ESCOs

IV. Case study
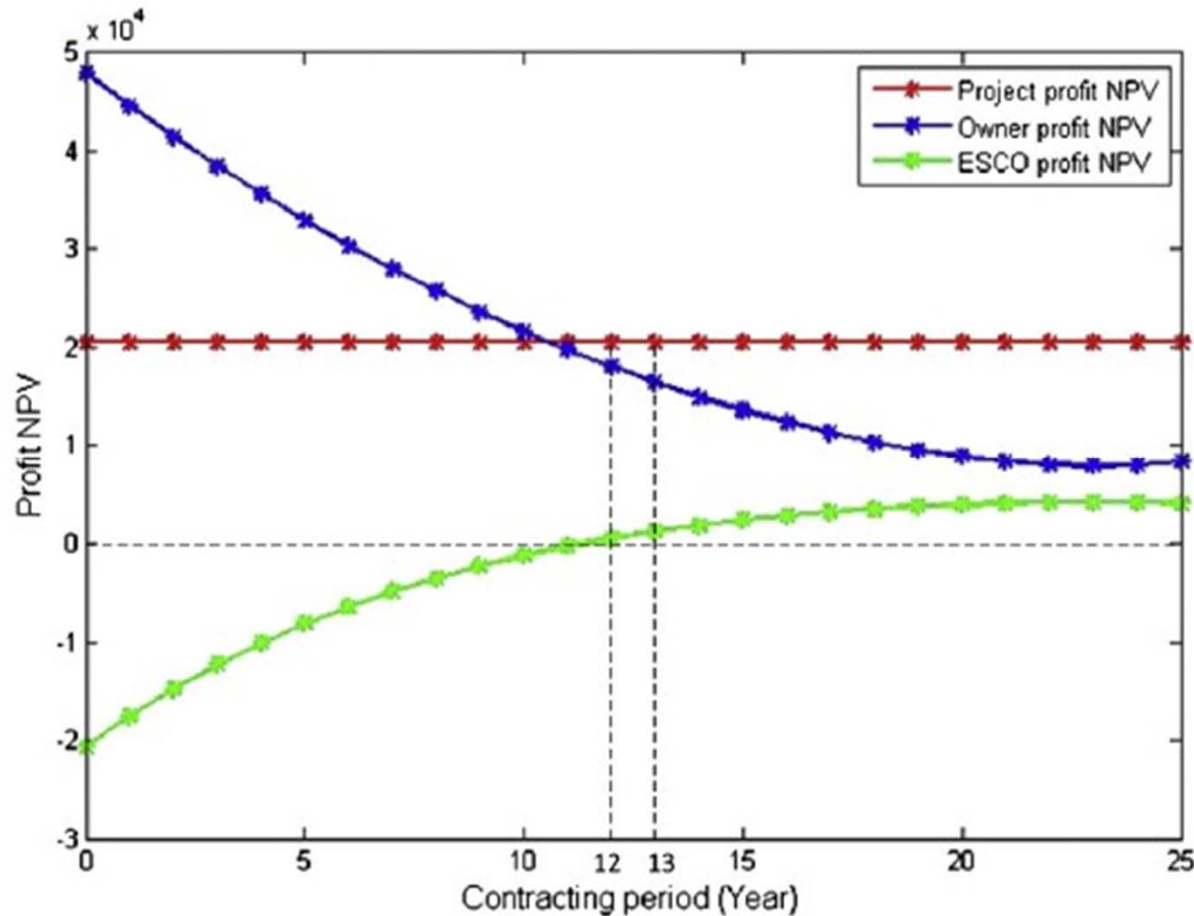
Relations between contracting period and NPV of profit

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IV. Case study

Sensitivity Analysis

Parameter	Percentage change	Adjusted value	Balanced contract period
I_C	−50%	10,334,496	10
	−20%	16,535,193	11
	0	20,668,991	12
	+20%	24,802,789	12
	+50%	31,003,487	13
G	−20%	2,400,000	12
	−10%	2,700,000	12
	0	3,000,000	12
	+10%	3,300,000	11
	+20%	3,600,000	11

Initial capital investment

Annual guaranteed savings

Sensitivity Analysis (continue)

Parameter	Adjusted value	Balanced contract period
α	1%	11
	3%	11
Owner's expected profit share within guarantee	5%	12
	7%	12
	9%	13
β	10%	10
	15%	11
Owner's expected profit share beyond guarantee	20%	12
	25%	13
	30%	14
r_O	4%	12
	6%	12
Owner's expected rate of return	8%	12
	10%	12
	12%	12
r_E	10%	8
	12%	9
ESCO's expected rate of return	15%	12
	18%	18
	20%	25

V. Conclusion

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V. Conclusion

- This research provides an way to determine the length of contracting period in energy performance contracting (EPC)

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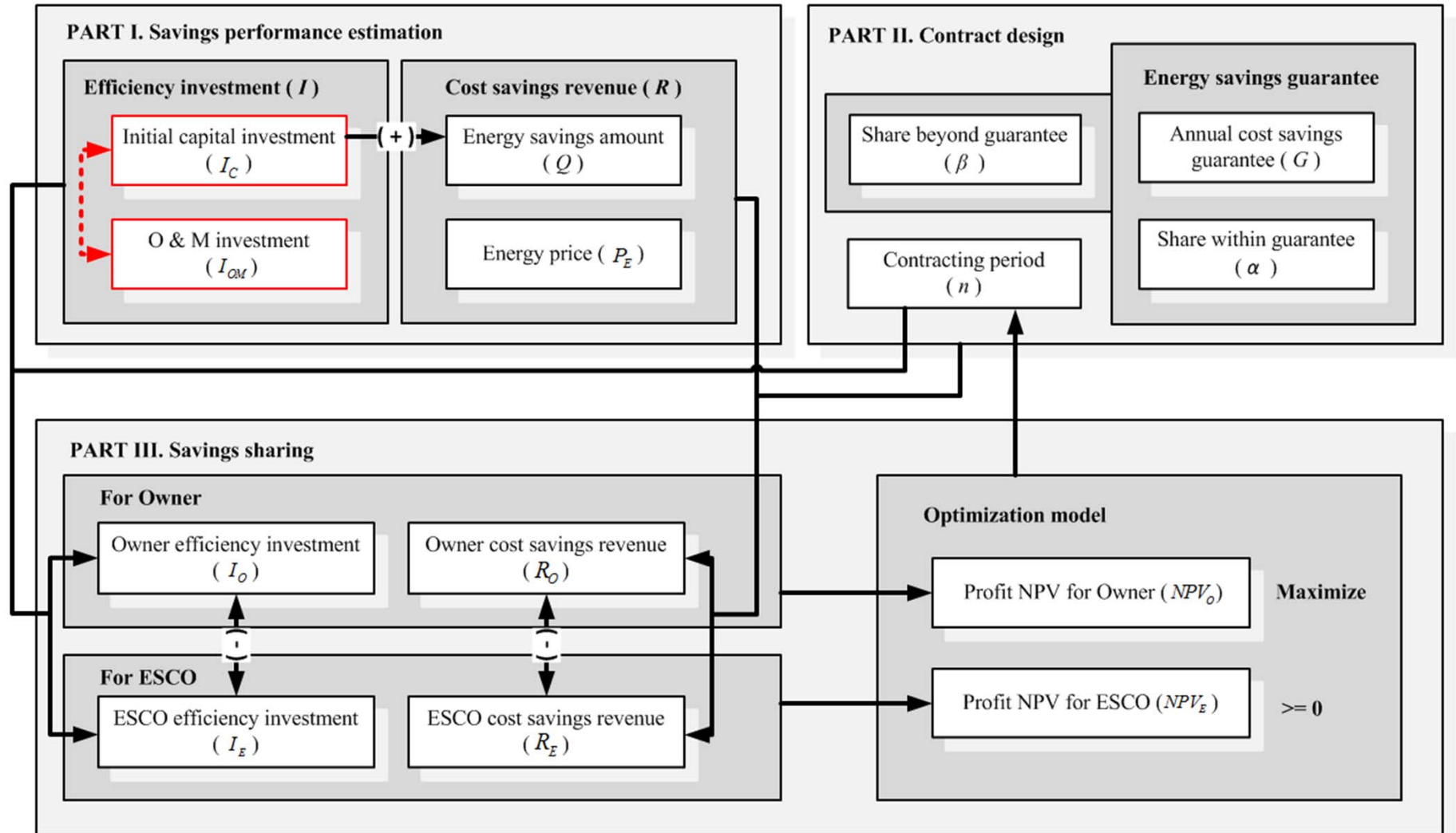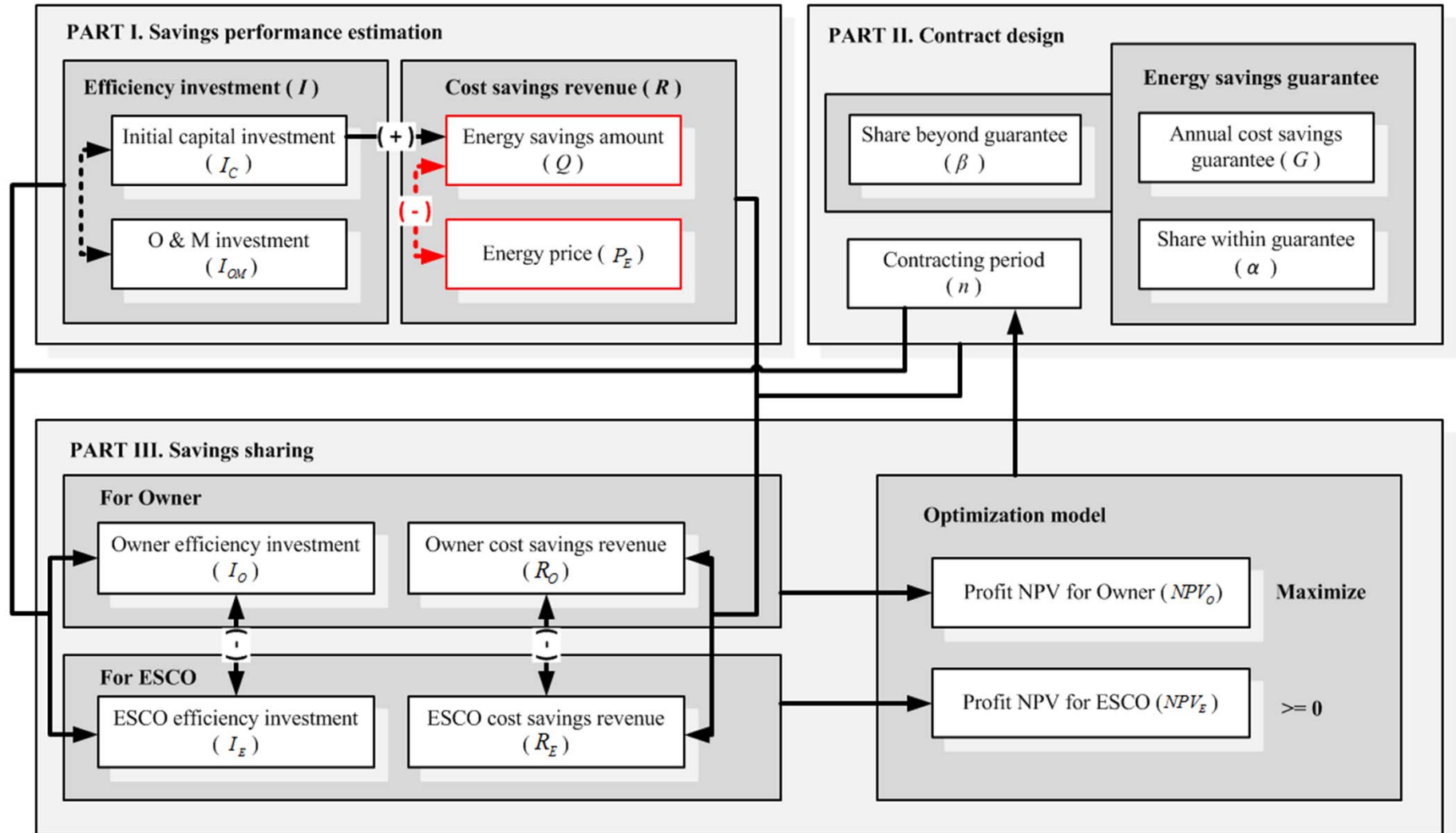- Varied uncertainty factors within the contracting period are considered

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- Varied uncertainty factors within the contracting period are considered

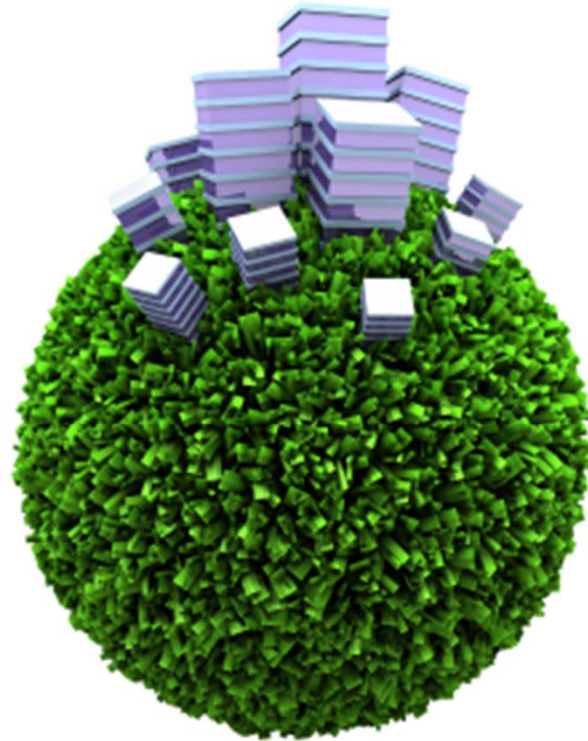- Worth popularizing in simulation performance-based contracting

V. Future research

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PART I. Savings performance estimation

Efficiency investment (I)
- Initial capital investment (I_C)
- O & M investment (I_{OM})

(+)
(-)

Cost savings revenue (R)
- Energy savings amount (Q)
- Energy price (P_E)

PART II. Contract design

Energy savings guarantee
- Share beyond guarantee (β)
- Annual cost savings guarantee (G)
- Contracting period (n)
- Share within guarantee (α)

PART III. Savings sharing

For Owner
- Owner efficiency investment (I_O)
- Owner cost savings revenue (R_O)

For ESCO
- ESCO efficiency investment (I_E)
- ESCO cost savings revenue (R_E)

Optimization model
- Profit NPV for Owner (NPV_O) **Maximize**
- Profit NPV for ESCO (NPV_E) $>= 0$

Questions?

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THANK YOU!

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