Study on Investment Income Calculation Method of Building Energy Saving

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Abstract. With the rapid development of China economy and society, the resource shortage and other problems become more obvious and even aggravate increasingly. The energy problem attracts more and more attention from various countries in the world. The energy use is involved with all sides of life. Protecting environment, saving energy and realizing sustainable development are great challenge that we should face. The whole course is involved with energy consumption, including building engineering, engineering construction, completion and delivery for use. According to investigation, the building energy consumption accounts for about 25~40% of energy consumption in the whole world, so the building energy saving will be key for energy saving. The purpose of this paper is to establish the investment income model of building efficiency, provide tool for scheme optimization, and analyze and verify the model correctness by examples. Also, this paper puts forward the problem and solution of building energy saving and looks ahead the development prospect of building energy saving. It is to accelerate the whole society to concern and support the application of green building in real estate development and to promote the sustainable development.

1. Introduction
The building energy consumption includes energy consumption during construction and use. The energy consumption during construction includes the energy consumption during production and transportation of building material, building structure member and building equipment and during building construction and installation. The energy consumption during use includes the energy consumption for heating, ventilating, air conditioning, illuminating, household appliances, elevator and cold and hot water supply during the use of housing building and structure [1-3]. The specific realization course of building energy saving is, during the planning, design, construction (reconstruction, extension), modification and use of building, to implement the energy-saving standard, adopt the energy-saving technology, process, equipment, material and product, improve the heat-insulating performance and heating and cooling efficiency, intensify the operation management of building energy consumption system and utilize the renewable energy so as to reduce the energy consumption for heat supply, air conditioner heating and cooling, illuminating and hot water supply when the indoor thermal environment quality is guaranteed. When the building comfort and living and work quality are guaranteed and improved, the reasonable and effective use of energy resource during the use of building can reduce energy consumption and improve energy efficiency [4-5].
2. Problems in Building Energy Efficiency Work

2.1. Low Awareness of Building Energy Efficiency
The persons employed in the field of building are of different background and level. Many persons have huge shortfall in basic building energy-saving knowledge and they rarely think about the importance of energy saving and environmental protection to the society too much. In case of selection of building, many owners attach more importance to the building appearance and its internal structure but ignore the role of energy saving in the humanized design. In order to meet the consumer demand, therefore, the developers establish their planning focus on appearance and structure design but ignore the input to building energy saving. This not only increases the survival cost of owner but also is extremely unfavorable for social sustainable development. Meanwhile, this also reflects the absence of social responsibility [6-8].

2.2. Obstructed Exchange of New Technology
The quality demand for domestic building is greatly improved against the background of continuous renewal and development of technology. Therefore, the improvement of relevant standard and assessment system and the establishment of new building use standard cannot be separated from the input of new technology and new equipment. However, it should be noted that the current domestic building sector seldom has an authoritative technical exchange platform for them to realize the in-depth discussion about the use and management mode of energy saving technology. Particularly, the great growth of building scale in recent years enables that the input speed fails to meet the demand of total building increase. This not only aggravates the energy consumption problem but also causes the resource waste, environmental pollution and other social issues [9].

2.3. Imperfect Laws and Regulations
The implementation of building energy saving objective is a systematic engineering system, which is involved with many design standards, building water and electricity and other contents and also needs the support from many governmental agencies including economy, construction and other functional departments. Therefore, it is necessary to establish the appropriate laws and policies based on building energy saving to enable that the implementation of each building management measure has laws to abide by. Also, it is necessary to enhance the supervision on responsible persons to guarantee the effective implementation of building energy saving work [10].

3. Investment Income Model of Building Energy Efficiency
The building energy saving is mainly involved with the energy consumption for power supply and distribution, heating, ventilating, air conditioning, illuminating, household appliances, elevator and cold and hot water supply during the use of housing building and structure. The building energy saving methods are as follows: 1. optimize the cold and heat sources, utilize the cooling tower and solar energy instead of air conditioning and heating equipment; 2. conduct the energy-saving modification for existing equipment. For example, lay the heat insulating material on building external wall, coat the super-lubricative high polymer material in water pump; 3. Develop and utilize the new energy, such as low grade heating energy and biomass energy in the atmosphere. The analysis of investment income model of each technology is based on the typical building energy saving technology and is given below.

3.1. Cooling Technology of Cooling Tower
Technical principle: increase the temperature control system and heat exchange equipment based on original cooling tower. In case of outdoor temperature lower than 15°C, stop the original refrigerating unit but directly use the cooling tower to meet the cooling requirement so as to realize the energy saving purpose.
Scope of application: a place where the cooling is required in case of outdoor temperature lower than 15℃, including
- Public building: large-sized data center, commercial office building, metro station, terminal building, etc.
- Industrial factory building: process cooling water system in chemical industry, manufacturing, food, pharmaceutical processing and other factory buildings.

The cooling technology parameters are shown in Table 1.

### Table 1. Cooling technology parameter table of cooling tower

| Classification        | Name                                                                 | Variable | Unit     | Remark                                      |
|-----------------------|-----------------------------------------------------------------------|----------|----------|---------------------------------------------|
| Input parameter       | Rated water supply of refrigerating unit of original cooling water system | W        | kW       | From site nameplate                        |
| Built-in parameter    | Investment of unit cooling capacity                                   | 300      | Yuan/kW  |                                             |
| Output parameter      | Total modification investment                                          | Q        | 10,000 Yuan |                                             |
|                       | Payback period                                                       | t        | Yuan     | 2-4 years (direct output in result)        |

(1) Investment calculation
Total investment per kW cooling capacity \( Q_0 = 300 \text{ Yuan/kW} \)
Total project investment \( Q_0 = Q_0 \times P \)

(2) Economical calculation
Average investment payback period: 2~4 years
A computing example of cooling technology is as shown in Table 2.

### Table 2. Computing example table of cooling technology

| Rated power of refrigerating unit of original cooling water system/kW | 400 | Cooling cop | 5          |
|---------------------------------------------------------------------|-----|-------------|------------|
| Rated cooling capacity of refrigerating unit of original cooling water system/kW | 2,000 | Project investment/10,000 Yuan | 60         |
| Static payback period/Year                                          | 2~4 years |

3.2. Direct-Expansion Solar-Assisted Heat Pump

Technical principle: This system is based on the air source heat pump to integrate heat collecting equipment and evaporating equipment and utilize the solar energy and air energy to improve the unit efficiency under low temperature mode.

Scope of application: this is applicable to following scenario in case of ambient temperature of: -30℃~50℃
- Hot water supply and cooling/heating air conditioner for commercial building, industrial building and civil building.
- Calculation method: the economic analysis parameters of direct-expansion solar-assisted heat pump (water heating usage scenario) are shown in Table 3.
Table 3. Economic analysis parameter table of direct-expansion solar-assisted heat pump (water heating usage scenario)

| Classification | Name                                | Variable | Unit    | Remark                                      |
|----------------|-------------------------------------|----------|---------|---------------------------------------------|
| Input parameter| Daily water consumption             | S        | Ton     |                                             |
| Equipment investment | 25,000 Yuan/Ton              | K        | 0.8 Yuan/kWh | System built-in                             |
| Annual water consumption days | 365                      | H        | generally calculate as per whole year operation |
| Heating COP    | COPh                                | 5        | Unit nameplate, not greater 6                 |
| Output parameter| Total modification investment       | Q        | 10,000 Yuan |                                             |
| Payback period | t                                    |          | 10,000 Yuan |                                             |

The calculation result is subject to the general split air conditioning unit.

Computing method (water heating usage scenario)

Total project investment $Q = 2500 \times \frac{S}{10000}$

Cost reduction (calculated as per hot water of 60°C for 20°C normal temperature)

$q = S \times 365 \times 1000 \times 4.2 \times (60 - 20) \div 3600 \times \left(\frac{1}{0.95} - \frac{1}{\text{cop}_h}\right) \times K \div 10000$

Payback period $t = \frac{Q}{q}$

Table 4 is a computing example of direct-expansion solar-assisted heat pump (water heating usage scenario).

Table 4. Computing example table of direct-expansion solar-assisted heat pump

| Daily water consumption (Ton) | 10       |
| Project investment (10,000 Yuan) | 25       | Annual amount of electricity-saving (10,000 kWh) | 14.5 |
| Annual revenue (10,000 Yuan) | 11.6     | Static payback period (Year) | 2.16 |

3.3. Water Pump Coating

Technical principle: the super-lubricative high polymer material is coated in water pump to reduce the friction loss of runner, realize the energy efficient rate up to 5~15% and reduce the water pump maintenance frequency.

Scope of application: 100Kw above water pumps which are of continuous operation in the fields of steel and iron, power plant, chemical industry, chemical fiber, paper making, prevention and other sectors.

Calculation method: the calculation method of water pump coating is shown in Table 5.

Table 5. Calculation method table of water pump coating

| Classification | Name                                | Variable | Unit        | Remark                                      |
|----------------|-------------------------------------|----------|-------------|---------------------------------------------|
| Input parameter| Water pump power                    | P        | kW          |                                             |
| Operating hours | T                                    | 8,000h   | Generally take 8,000h                         |
| Built-in parameter| Estimated investment coefficient  | $\delta$ | 10,000 Yuan/kW | System built-in                             |
| Energy efficient rate | $\eta$                           |          | 5%          | System built-in                             |
| Electricity price | K                                    | 0.8 Yuan/kWh | System built-in                             |
| Output parameter| Total modification investment       | Q        | 10,000 Yuan |                                             |
| Payback period | t                                    |          | Year       |                                             |
(1) Investment calculation
Project investment cost: \( Q = P \times \delta \)
\( \delta \): estimated investment coefficient (10,000 Yuan/kW), taken from the table 6.

**Table 6. Corresponding Table of Water Pump Power and Estimated Investment Coefficient**

| Water pump power (kW) | Estimated investment coefficient (10,000 Yuan/kW) |
|-----------------------|-----------------------------------------------|
| 100                   | 0.030                                         |
| 200                   | 0.026                                         |
| 300                   | 0.024                                         |
| 400                   | 0.020                                         |
| 500                   | 0.019                                         |
| 600 above             | 0.018                                         |

In case of power range, take the lower limit.

(2) Economical calculation
Project electricity-saving amount: \( E = P \times T \times \eta \)
\( P \): rated pump power (kW);
\( T \): Water pump operating hours (h);
\( \eta \): Modification energy efficient rate (%), empirical value: 5%,
Project cost reduction: \( q = E \times K \)
\( K \): Local electricity price, Yuan/ (kWh);
Payback period: \( t = \frac{Q}{q} \)
Abstract of computing example is shown in Table 7:

**Table 7. Computing example table of water pump coating**

| Water pump power (kW) | 100 | Annual operating hours (h) | 8,000 |
|-----------------------|-----|---------------------------|-------|
| Project investment (10,000 Yuan) | 30,000 | Annual amount of electricity-saving (10,000 kWh) | 40,000kWh |
| Annual revenue (10,000 Yuan) | 32,000 | Static payback period (Year) | 1 year |

This computing method is not applicable to those water pumps of triple stages and above.

3.4. Intelligent Drying Technology
Technical principle: this is to convert the low-grade heat energy of 5°C above in the atmosphere into the heat energy up to 90°C by air source heat pump for drying purpose in production.
Scope of application: this is applicable to the drying process not greater than 90°C in the fields of wood, tobacco, Chinese herbal medicines, aquatic product, cereal, food and other product production and processing sectors.
Calculation method (applicable to wood industry): the calculation method of intelligent drying technology is shown in table 8.
Table 8. Calculation method table of intelligent drying technology

| Classification | Name | Variable | Unit |
|----------------|------|----------|------|
| Input parameter | Wood consumption of original wood drying room | M | m³ |
| Built-in parameter | Intelligent drying equipment investment | 3,000 | Yuan/m³ |
| Output parameter | Total modification investment | A | 10,000 Yuan |

Use the intelligent drying control, heat recovery technology and positive moisture removal technology to shorten the drying period, reduce the drying cost by about 30% (including environmental protection benefit, government award and labor cost).

(2) Investment calculation
Total modification investment: \( A = M \times 3000/10000 \)

3.5. Combined Heat and Power System of Modular Biomass Energy
Technical principle: utilize the anaerobic digestion of organic waste to produce the biogas. The treated biogas can be used as the fuel of modular combined heat and power generator to generate power and heat. This is featured by rapid installation and plug-and-play and can realize the overall energy use efficiency up to 85%.

Scope of application: it has the unit generating capacity of 50kW-2,000kW and is applicable to the treatment and use of organic wastes from agricultural and sideline product processing, agriculture and stock-raising, food processing, paper making, refuse landfill, etc.

Calculation method (high-concentration organic wastewater): the calculation method of combined heat and power system of modular biomass energy is shown in Table 9.

Table 9. Calculation method table of combined heat and power system of modular biomass energy (high-concentration organic waste water)

| Classification | Name | Variable | Unit |
|----------------|------|----------|------|
| Input parameter | Daily quantity of organic waste water | t | t/day |
| Built-in parameter | Biogas production per tonne of waste water per day | 22.4 | m³/t |
| | Unit investment of biogas generating pit | 1,500 | Yuan/m³ |
| | Unit investment of modular biogas purification system | 2,500 | Yuan/(m³/d) |
| | Lower heat value of biogas | 6 | kW/ m³ |
| | Generating efficiency of modular combined heat and power system | 38% | |
| | Modular combined heat and power equipment | 7000 | Yuan/(kW) |
| | On-grid price | 1.25 | Yuan/(kWh) |
| | Annual operating hours of unit | 8,000 | h |
| Output parameter | Total modification investment | Q | 10,000 Yuan |
| | Payback period | Pt | Yuan |

(1) Calculation of generating power
Generating power \( P = t \times 22.4 \div 24 \times 6 \div 0.38 \)
\( t \times 22.4 \): Gas production of biogas equipment (m³/d)
Volume of biogas generating pit \( v = t \times 22.4 / 0.8 \)
(2) Investment calculation
Total modification investment
\[ Q = t \times 22.4 / 24 + 2500 / 10000 + P \times 7000 / 10000 + 1500 \times V / 10000 \]

(3) Calculation of investment payback period
Payback period = \[ Q / (P \times 8000 \times 1.25 / 10000) \]

Abstract of computing example is as shown in Table 10.

**Table 10.** Computing example of combined heat and power system of modular biomass energy (high-concentration organic wastewater)

| Project name | A biogas modular unit |
|--------------|-----------------------|
| Quantity of organic wastewater (t/d) | 40 | Power of combined heat and power generation (kW) | 85.1 |
| Project investment/10,000 Yuan | 237 | Annual electricity production/10,000 kWh | 68 |
| Annual revenue/10,000 Yuan | 85 | Static payback period/Year | 2.8 |

4. Conclusion
The building energy-saving investment income model and energy-saving optimization program proposed and designed in this paper can obviously reduce the energy consumption, improve the energy use efficiency and reduce the pollutant emission. The building energy saving is a major event to implement the sustainable development strategy. Currently and in the coming years, the leaders at each lever shall attach more importance to the progress of building energy saving and enhance the administrative supervision for building energy saving to create a brand-new outlook for building energy saving work.

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