International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(1), 178-184.

Analysis of Cost-benefit and CO_2 Emissions of Solar Energy-intelligent Poultry Feeding System: Application of Net Present Value and Dynamic Environmental I-O Model

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Received: 22 July 2019 **Accepted:** 26 September 2019 **DOI:** https://doi.org/10.32479/ijeep.8443

ABSTRACT

Intelligent Poultry Feeding System is the future development trend of agriculture. This is the production model of big data platform through technological innovation such as internet of things, artificial intelligence, etc. In recent years, Taiwan has proposed the Agricultural 4.0 program to combine renewable energy with technological innovation to promote the development of agriculture. Building a complete intelligent poultry house including solar power generation and Intelligent Poultry Feeding System, the purpose of this paper is to evaluate the effectiveness of this policy and analyze the economic effects and environmental protection of Solar Energy-Intelligent Poultry Feeding System (SE-IPFS). The research methodology uses the net present value for financial evaluation and the Dynamic Environmental I-O Model for energy. The results of this paper show that the investment of SE-IPFS can recover the investment cost within a reasonable period of time, and effectively improve the CO_2 emission effect, achieving the dual tasks of industrial development and environmental protection.

Keywords: Solar Energy, Intelligent Poultry Feeding System, Net Present Value, Dynamic Environmental I-O Model
JEL Classifications: Q19, Q43, C61

1. INTRODUCTION

Taiwan's agriculture has entered a low growth since 1985, and the output value and employment population have declined year by year. By 2018, the total agricultural production value only accounts for 1.82% of the total GDP, and the employed population accounts for 4.96% of the total. Among them, in 2008, the world financial crisis hit the Taiwan economy and caused huge losses, indicating the failure of long-term industrial restructuring. In order to strengthen agricultural competitiveness and sustainable development, Taiwan has proposed the development plan for Agriculture 4.0 since 2017. The Agriculture 4.0 program is based on technology to promote agricultural development, through the internet of things and artificial intelligence (AI) to build a big data platform to promote intelligent poultry feeding, combined with renewable energy policy to build Solar Energy-Intelligent Poultry Feeding System (SE-IPFS). This agricultural policy contains the settings for poultry houses. The main purpose of setting up the SE-IPFS is to improve the environmentally-friendly poultry epidemic prevention function, while also improving poultry quality and reducing management costs, and expanding the sales channel to promote industrial development through brand building.

In the Agriculture 4.0 program, a large number of intelligent poultry houses are set up according to the regional characteristics of Taiwan to form a SE-IPFS, and then extended to other regions to establish the Solar Energy-Intelligent Poultry area. Therefore, this study is based on the Solar Energy-Intelligent Poultry area as the basis for the estimation, and the effect is estimated by the number of suitable zones.

The development of the sustainable poultry industry requires both economic and environmental considerations. This paper analyzes the economic effects and environmental improvement effects with the implementation of SE-IPFS. Among them, the economic effect is evaluated by net present value (NPV), and the environmental improvement uses the Dynamic Environmental I-O Model to analyze the mitigating effect of CO_2 emissions.

2. LITERATURE REVIEW

Taiwan has experienced high economic growth, but with the economic development, the agricultural sector accounts for the proportion of the entire economy. Especially after the 2008 world financial tsunami, agriculture faced a tougher international market challenge (Hong et al., 2018). Hong et al. (2018) pointed out that agriculture has different development factors in different periods, which indirectly affects the emissions level of CO_2. Among them, the most influential factors after the financial crisis are “domestic final demand” and “production input technical coefficient.” However, technological innovation must have policy support from the public sector and provide the necessary funding and technical assistance (Hermansa et al., 2019). Numerous studies have also pointed out that public-private partnerships will lead to greater development, such as Van der Meer (2002), Turner et al. (2016) and other literature.

For a long time, technological innovation has been considered as an important factor in economic and enterprise development (Reardon et al., 2012; Reardon and Timmer; 2014). The agricultural sector is relatively backward in technological innovation compared to other high-tech industries, until technologies such as semiconductors, IOT, and AI are combined with big data platforms to introduce agricultural production systems. Technological innovation also opens up new opportunities for development in agriculture. Turner et al. (2017) emphasized that agricultural innovation systems can improve improving lamb survival and sustainable land management. In addition, Pigford et al. (2018) also proposed that circular economy, agro ecology, smart or digital elements should be included in the design of sustainable agriculture and food-related industrial systems.

The climate in Taiwan is hot and must overcome the breeding environment of some poultry. Olaniyi et al. (2014) pointed out that if the tropical chicken farm relies heavily on labor, not only the increase in production costs but also the disease in poultry will adversely affect poultry growth, which in turn will reduce yields. Arulogun et al. (2010) pointed out that poultry farming introduces mobile intelligent poultry feed dispensing system, which will reduce labor and improve economic efficiency.

3. EMPIRICAL MODEL

To analyze the effects of the SE-IPFS, the research methodology of this paper uses NPV and Dynamic Environmental I-O Model. This section will explain the processing of data and the establishment of research models, as follows: (1) Data Description and Cost Structure (2) NPV method, and (3) Establishment of Dynamic Environmental I-O Model.

3.1. Data Description and Cost Structure

The cost of SE-IPFS includes the setting of solar power generation and intelligent poultry house. This section will explain the cost structure and set the estimated size separately.

3.1.1. Solar energy’s cost structure

The solar power generation equipment of this study is based on the poultry house area specification (204.5KWp) of the Intelligent Poultry Feeding System. The cost of construction is shown in Table 1.

It can be seen from Table 1 that the cost of solar power system equipment accounts for the highest proportion of motor-related equipment, which is about 68.26% of the total cost, and the most is NT$4,229,480 of the module equipment. Followed by 19.09% of the construction cost.

3.1.2. Cost structure of the intelligent poultry feeding system

On the other hand, the construction cost of the Intelligent Poultry Feeding System is shown in Tables 2 and 3, which represent the cost of the poultry house cost of the meat duck and local chicken, respectively.

Table 2 shows that the cost of building a meat duck -Intelligent Poultry Feeding System is NT$ 8,998,404, which accounts for 38.90% of the total cost of the cloud intelligent monitoring system (electric box equipment), followed by 22.63% of Foundation floor laying.

The cost of the local chicken poultry house from Table 3 is the highest in the Floor and vertical wall, accounting for 51.89% of the total cost of NT$ 4,659,022.

3.1.3. Poultry production costs and benefits

Tables 4 and 5 show the production costs and benefits per 100 meat ducks and local chickens, respectively.

The basis of this paper is that each poultry house has 40,000 feeding ducks per year. In the local chickens, the number of breeding of each poultry house is 51,000. Comparing Tables 4 and 5, it is known that the profit of feeding meat ducks is larger than that of chickens. But the number of chickens in a poultry house is higher than that of meat ducks.

3.2. NPV

The cost-benefit analysis of the SE-IPFS for chickens and ducks can use the NPV. The NPV method converts the annual net income into the sum of the present values. The estimation method is as follows:

$$NPV = \sum_{t-0}^{n}\left[\left(R_t - C_t\right)/\left(1+i\right)^t\right]$$

Where NPV is the economic NPV. R_t is the benefit of the t-year; C_t is the cost of the t-year. i is the discount rate. t is the setting and operation year. n is the estimation period.

3.3. Establish Dynamic Environmental I-O Model

3.3.1. Static I-O model

The supply and demand of each industry can be expressed by the following simultaneous equations.

Table 1: Solar photovoltaic power generation cost content

Item	Price
Motor related equipment cost	9,075,039
Modules	4,229,480
Converter	1,918,034
Array frame (aluminum)	1,351,997
Array installation (steel)	616,511
Step-up transformers	612,905
Wiring	346,111
Construction cost	2,538,150
Basic civil engineering construction	576,852
Other constructions	1,961,297
Other costs	1,682,267
Business	108,160
Management	633,117
Transport	129,792
Other related costs	811,198
Total cost	13,295,455

Unit: NT$

Table 2: The cost of construction of meat duck poultry house

Poultry house equipment construction content	Price	Percentage
Foundation floor laying	2,036,300	22.63
Vertical wall	248,000	2.76
Environmental control related equipment	650,000	7.22
Automatic feeding equipment system	1,458,000	16.20
Lighting equipment	182,000	2.02
Front wall and poultry house cooling equipment	364,100	4.05
Ventilation equipment	559,604	6.22
Cloud intelligent monitoring system/electric box equipment	3,500,400	38.90
Total cost	8,998,404	100.00

Unit: NT$

Table 3: The cost of construction of local chicken poultry house

Poultry house equipment construction content	Price	Percentage
Floor and vertical wall	2,417,500	51.89
Spray system	265,272	5.69
Negative pressure system	555,660	11.93
Automatic water supply system	241,960	5.19
Automatic feeding equipment system	460,530	9.88
Cloud intelligent monitoring system/management room	127,500	2.74
Cloud intelligent monitoring system/poultry house equipment	590,600	12.68
Total cost	4,659,022	100.00

Unit: NT$

$$
\begin{aligned}
&x_{11}+x_{12}+x_{13}+\cdots+x_{1n}+F_1+E_1=X_1+M_1\\
&x_{21}+x_{22}+x_{23}+\cdots+x_{2n}+F_2+E_2=X_2+M_2\\
&\vdots\\
&x_{n1}+x_{n2}+x_{n3}+\cdots+x_{nn}+F_n+E_n=X_n+M_n
\end{aligned}
\tag{1}
$$

The simultaneous equation (1) can also be written as (2).

Table 4: Production costs and benefits of meat ducks

Feeding cost content	Cost amount
1. Production costs per 100 ducks	30,676
Direct cost	30,125
Indirect costs	252
The first production cost	30,377
The second production cost	30,676
2. Production income per 100 ducks	34,674
3. Production profit per 100 ducks	3,998

Unit: NT$/100 ducks. Source: Council of Agriculture, Executive Yuan, Taiwan

Table 5: Production costs and benefits of local chickens

Feeding cost content	Cost amount
1. Production costs per 100 chickens	16,029
Direct cost	15,737
Indirect costs	175
The first production cost	15,861
The second production cost	15,977
2. Production income per 100 chickens	17,243
3. Production profit per 100 chickens	1,214

Unit: NT$/100 chickens. Source: Council of Agriculture, Executive Yuan, Taiwan

$$\sum_{j=1}^{n} x_{ij}+F_i+E_i=X_i+M_i \quad (i=1,2,\cdots n) \tag{2}$$

Where F represents the final demand of the industry ($n\times1$). M is the import coefficient matrix of the industry ($n\times n$). I is the identity matrix ($n\times n$). The definitions of M and m can be written as (3) and (4), respectively.

$$M_i=m_i\left(\sum_{j=1}^{n} a_{ij}X_j+F_i+E_i\right),\ (i=1,2,\cdots n) \tag{3}$$

$$m_i=M_i\Big/\left(\sum_{j=1}^{n} a_{ij}X_j+F_i+E_i\right) \quad (i=1,2,\cdots n) \tag{4}$$

Where a_{ij} is the input coefficient of the industry, defined as

$$a_{ij}=\frac{x_{ij}}{X_j}.$$

The static I-O model can be obtained by combining equations (1-4), such as equation (5).

$$X=\left[I-\left(I-M\right)A\right]^{-1}\left[\left(I-M\right)F+E\right] \tag{5}$$

Where A is the input coefficient matrix ($n\times n$).

$$A\equiv\begin{pmatrix} a_{11} & \cdots & a_{1n}\\ \vdots & \ddots & \vdots\\ a_{n1} & \cdots & a_{nn}\end{pmatrix}$$

3.3.2. Dynamic I-O model establishment process

3.3.2.1. Establishment of capital coefficient matrix

To establish a dynamic I-O model, a capital stock table needs to be established, and then the capital stock (S) of each industry is used to estimate the capital coefficient to establish a coefficient matrix, as shown in Table 6. For example, S_i can be represented by $\sum_{j=1}^{n} S_{ji}$, and the capital coefficient can be written as S_{ji}/X_j.

Table 6: Capital stock table

Industry sector	1. Agroforestry 2. Aquaculture 3. Food industry ..... ⋮ ***i*** Petrochemical industry ⋮ ***n.***	Industry total
1. Agroforestry 2. Aquaculture 3. Food industry ..... ⋮	$S_{11}S_{12}\ldots\ldots S_{1i}\ldots\ldots S_{1n}$	$S_1=\sum_{j=1}^{n}S_{1j}$
i Petrochemical industry	$S_{21}S_{22}\ldots\ldots S_{2i}\ldots\ldots S_{2n}$	$S_2=\sum_{j=1}^{n}S_{2j}$
⋮	$S_{31}S_{32}\ldots\ldots S_{3i}\ldots\ldots S_{3n}$	$S_3=\sum_{j=1}^{n}S_{3j}$
	$S_{41}S_{42}\ldots\ldots S_{4i}\ldots\ldots S_{4n}$	$S_4=\sum_{j=1}^{n}S_{4j}$
	⋮ ⋮	⋮ ⋮
n.	$S_{i1}S_{i2}\ldots\ldots S_{ii}\ldots\ldots S_{in}$	$S_i=\sum_{j=1}^{n}S_{ij}$
	⋮ ⋮ $S_{n1}S_{n2}\ldots\ldots S_{ni}\ldots\ldots S_{nn}$	$S_n=\sum_{j=1}^{n}S_{nj}$
Industry total	$S_1=\sum_{j=1}^{n}S_{j1}\cdots S_i=\sum_{j=1}^{n}S_{ji}\cdots S_n=\sum_{j=1}^{n}S_{jn}$	
Total output	$X_1\ X_2\ldots\ldots X_i\ldots\ldots X_n$	

The capital coefficient matrix can be represented by the following $S^{Capital}$.

$$S^{Capital}=\begin{pmatrix} k^{c}{}_{11} & \cdots & k^{c}{}_{1n} \\ \vdots & \ddots & \vdots \\ k^{c}{}_{m1} & \cdots & k^{c}{}_{mn} \end{pmatrix} \tag{6}$$

3.3.2.2. Dynamic I-O model

The dynamic I-O model can be obtained by combining equations (5) and (6) as shown in (7).

$$X(t)=AX(t)+C+S\left[X(t+1)-X(t)\right] \tag{7}$$

Where C is the scale of consumption. Equation (8) can be derived from (7)

$$X(t+1)=\left[S^{-1}(I-A-C)+I\right]X(t) \tag{8}$$

The Dynamic I-O Model can be obtained from equations (5) and (8) as shown in (9).

$$X(t+1)=\left(S^{-1}D+I\right)\left[I-A\left(I-\bar{M}\right)\right]^{-1}\left[E+\left(I-\bar{M}\right)F^{d}\right] \tag{9}$$

Where D=I-A-C, I and C represent the unit matrix and consumption scale, respectively.

3.3.3. Dynamic environmental I-O model

Estimating the level of CO_2 emissions can be divided into direct and indirect effects (spillover effects), so the dynamic model of equation (9) is written (10), and the economic spillover effect of the SE-IPFS investment is first estimated, and then the environmental I-O model is established.

$$\underbrace{TESE}_{\text{Total Economic Spillover Effects}}=\underbrace{\left(I-\bar{M}\right)\delta F_1^{d}}_{\text{Direct Spillover Effects}}+\underbrace{\Gamma^{*}\left[\left(I-\bar{M}\right)\delta F_1^{d}\right]}_{\text{First Indirect Spillover Effects}}+\underbrace{\Gamma^{*}\left[\left(I-\bar{M}\right)\delta F_2^{d}\right]}_{\text{Second Indirect Spillover Effects}} \tag{10}$$

Where Leontief inverse matrix $(S^{-1}D+I)\,[I-A(I-\bar{M})]^{-1}$ be Γ^{*}

The equation (10) and the CO_2 emissions coefficient can be derived from the Dynamic Environmental I-O Model as shown in (11).

$$CO_2 \text{ emissions} = \underbrace{\hat{E}\left(I-\bar{M}\right)\delta F_1^d}_{\text{Direct Spillover Effects}} + \underbrace{\hat{E}\Gamma^*\left[\left(I-\bar{M}\right)\delta F_1^d\right]}_{\text{First Indirect Spillover Effects}} + \underbrace{\hat{E}\Gamma^*\left[\left(I-\bar{M}\right)\delta F_2^d\right]}_{\text{Second Indirect Spillover Effects}} \quad (11)$$

Where the emissions coefficient $e_j = {CO_{2_j}}/{x_j}$, and $\hat{E}$ is the diagonal matrix of the elements of the emissions coefficients for various industries. $\hat{E}$ is defined as follows

$$\hat{E} = \begin{pmatrix} e_1 & L & 0 \\ M & O & M \\ 0 & L & e_n \end{pmatrix}$$

4. EMPIRICAL RESULTS

4.1. Cost-benefit Analysis of Local Chicken Poultry House and Solar System

Table 7 is the net income and NPV of the intelligent poultry feeding system of the investment chicken. The projections show that the cumulative amount of net income and NPV (I = 0.01) for the 7th year has exceeded NT$ 4,659,022 of the total investment, indicating that the investment of the intelligent poultry feeding system can recover costs after the 8th year. On the other hand, when NPV (i = 0.03), the total amount of NT$ 5,170,710 accumulated in the 1st year to the 8th year of investment will exceed the total investment cost. This means that the investment in the intelligent poultry feeding system will begin to earn a net profit from the 9th year.

Based on the 30-year evaluation period, the investment in the chicken poultry's intelligent poultry feeding system will receive an investment income of NT$ 24,055,842 with an average annual return of 17.21%. Therefore, the investment return rate of the chicken's intelligent poultry feeding system is higher than the current market rate of 3%, nearly 5.7 times.

Table 8 shows the solar system for investing in intelligent poultry feeding. The results show that the investment will recover the cost in the 12th year without considering the present value. In addition to the electricity demand for intelligent poultry feeding, the remaining electricity can be sold to increase the operating income of the farm. Using the NPV method, it was found that the NPV with a discount rate of 0.01 and 0.03 can recover the cost in the 13th and 16th years, respectively. When the discount rate is set to 0.01, the solar system installation cost is recovered in the 13th year, the cumulative NPV is NT$13,689,920 over the cost of NT$13,295,455, and the total NPV accumulated during the 20 years of operation is NT$ 20,848,028,

Table 7: Cost-benefit analysis (NPV) of the intelligent poultry feeding system for local chicken poultry house

Year (t)	Net income (R_t-C_t)	Net present value (i=0.01)	Net present value (i=0.03)	Remarks
1	691,560	691,560	691,560	
2	698,476	691,560	678,132	
3	705,460	691,560	664,964	
4	712,515	691,561	652,068	
5	719,640	691,563	639,396	
6	726,837	691,567	626,962	
7	734,105	691,573	614,777	Recovery cost in the 7th year (i=0.01) (NT$ 4,659,022; NT$ 4,840,944)
8	741,446	691,583	602,851	Recovery cost in the 8th year (i=0.03) (NT$ 4,659,022; NT$ 5,170,709)
9	748,860	691,532	591,143	
10	756,349	691,551	579,667	
11	763,912	691,573	568,429	
12	771,552	691,541	557,399	
13	779,267	691,575	546,547	
14	787,060	691,556	535,962	
15	794,930	691,544	525,539	
16	802,880	691,542	515,327	
17	810,908	691,547	505,333	
18	819,018	691,563	495,534	
19	827,208	691,588	485,907	
20	835,480	691,565	476,464	
21	843,835	691,555	467,214	
22	852,273	691,556	458,137	
23	860,796	691,569	449,244	
24	869,404	691,540	440,517	
25	878,098	691,579	431,965	
26	886,879	691,578	423,574	
27	895,747	691,536	415,351	
28	904,705	691,565	407,286	
29	913,752	691,555	399,385	
30	922,890	691,562	391,619	

Unit: NT$. NPV: Net present value

Table 8: Solar system setup costs and benefits

Year (*t*)	Net income (R_t-C_t)	Net present value (*i*=0.03)	Net present value (*i*=0.01)	Remarks
1	1,199,244	1,164,300	1,187,400	
2	1,187,131	1,119,000	1,163,700	
3	1,175,017	1,075,300	1,140,500	
4	1,162,904	1,033,200	1,117,500	
5	1,150,790	992,680	1,094,900	
6	1,138,677	953,620	1,072,700	
7	1,126,563	916,000	1,050,800	
8	1,114,449	879,760	1,029,200	
9	1,102,336	844,850	1,007,900	
10	1,090,222	811,230	986,960	
11	1,078,109	778,850	966,330	
12	1,065,995	747,670	946,020	Return to the 12th year without considering the net value
13	1,053,881	717,640	926,010	Return to the 13th year (*i*=0.01)
14	1,041,768	688,730	906,300	
15	1,029,654	660,900	886,890	
16	1,017,541	634,100	867,780	Return to the 16th year (i=0.03)
17	1,005,427	608,300	848,960	
18	993,314	583,470	830,430	
19	981,200	559,560	812,180	
20	969,086	536,560	794,210	
	Total	17,517,078	20,848,028	
	Rate of return	18.46%	32.29%	

Unit: NT$

Table 9: Cost and benefits of the solar energy-intelligent poultry feeding system in the agricultural zone

Year (t)	Net income (R_t-C_t)	Net present value (*i*=0.05)	Net present value (*i*=0.03)	Remarks
1	3,950,279	3,762,074	3,835,197	
2	3,946,241	3,579,458	3,719,751	
3	3,942,377	3,405,504	3,607,821	
4	3,938,693	3,240,355	3,499,414	
5	3,935,192	3,083,308	3,394,517	
6	3,931,881	2,934,046	3,292,887	
7	3,928,748	2,612,065	2,988,459	
8	3,925,806	2,657,130	3,099,070	From the 8th year, *i*=0.03 and *i*=0.05 cost recovery of poultry house
9	3,923,051	2,528,851	3,006,692	
10	3,920,487	2,406,844	2,917,219	
11	3,918,120	2,290,847	2,830,532	
12	3,915,943	2,180,543	2,746,581	
13	3,913,969	2,075,666	2,665,213	
14	3,912,190	1,975,910	2,586,428	
15	3,910,613	1,881,079	2,510,074	
16	3,909,235	1,790,860	2,436,122	
17	3,908,069	1,705,053	2,364,446	
18	3,907,108	1,623,470	2,295,014	
19	3,906,355	1,545,873	2,227,722	
20	3,905,812	1,472,068	2,162,566	
Total	78,450,169	48,751,004	58,185,725	

Unit: NT$

Table 10: CO_2 emissions from solar power generation

Spillover effects	Electricity systems	
	Solar power	Coal-fired power generation
Direct spillover effects	1130.5298	24.601.3110
First indirect spillover	459.9188	10.008.2321
Second indirect spillover	107.4006	2.337.1306
Total spillover effects	1697.8491	36.946.6737

Unit: Metric tons

the total return rate is 36.23%. When the discount rate is increased to 0.03, the cumulative NPV is NT$ 14,017,830.

4.2. Cost-benefit Analysis of the SE-IPFS in the Agricultural Zone

In this section, the SE-IPFS for meat ducks will be evaluated on the scale of the agricultural area. The results are shown in Table 9. Table 9 shows that the NPV of Solar Energy-Intelligent Poultry Feeding will affect the time of cost recovery and the annual average net rate of return at different discount rates. The SE-IPFS investment in the zone has accumulated NT$ 23,966,462 (*i* =0.03) and NT$ 23,322,073

($i = 0.05$) of the NPV in the 10th and 11th years respectively. The total NPV of the investment when the discount rate i =0.03 and i = 0.05 is NT$ 34,464,185 and NT$ 41,020,768 respectively.

4.3. The CO_2 Emission Effect of the SE-IPFS

This study estimates the power consumption and CO_2 emissions required for solar energy to generate economic benefits under the SE-IPFS investment, and compares the differences in CO_2 emissions from different generation methods at the same economic benefit scale. Table 10 shows the difference in CO_2 emissions from solar power generation and other sources of electricity.

The study found that the total amount of CO_2 emissions from the electricity generated by the investment in the solar energy system was 1,697.8491 metric tons, of which the direct discharge scale was 1,130.5298 metric tons, accounting for 66.59% of the total emissions. Compared with other power sources, CO_2 emissions from thermal power generation far exceed the scale of solar power generation. For example, the scale of CO_2 emissions from coal-fired power generation is as high as 36,946.6737 metric tons, which is 21.76 times that of solar power.

5. CONCLUDING REMARKS

Taiwan's economy is facing a period of industrial restructuring. In order to respond to domestic and international market demand, the traditional agricultural production and sales model must be appropriately changed. The government proposes to combine energy and agricultural policies to develop new agricultural goals and develop new renewable energy. The production system of intelligent agriculture with scientific and technological innovation. This paper analyzes the cost-benefit of SE-IPFS and estimates the effects of CO_2 emissions. The following are the results of the research.

1. Analysis of the cost-benefit of the chicken-intelligent poultry feeding system found that when the discount rate is set to 0.01, the NPV of the 7th year is NT$ 4,840,944 exceeding NT$ 4,659,022 of the total investment cost, and the investment cost can be recovered. When the discount rate is 0.03, the cost recovery of the investment is 9th year, and the average return rate during the 30-year estimation period is as high as 17.21%.
2. A Part of the Agriculture 4.0 program is to promote agricultural development through solar power combined with intelligent systems in poultry houses. When not considering the NPV, solar equipment will recover investment cost s in the 12th year.
3. The investment in SE-IPFS in the agricultural zone will be cost recovery in the 8th year when the discount rate is 0.01 or 0.03, without considering the NPV. During the 20-year estimation period, when the SE-IPFS investment has a discount rate of i =0.03 and i =0.05, the annual average return rates are 3.72% and 3.93%, respectively.
4. The results of the study found that after the SE-IPFS's technological innovation turned the thermal power into solar energy supply, the CO_2 emission effect will be significantly improved. The CO_2 emission scale of solar power generation is 1,697.85 metric tons, the CO_2 of coal-fired power generation is 36,946.67 metric tons, and the CO_2 emissions are reduced by 95.41%.

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