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Electric Power Leveler by Polymer Electrolyte Fuel Cell Co-generation System and Its Economic Implication

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Introduction

PEFC co-generation system role whether it can serve as *electric power leveler* or not when it is introduced in *residential and commerce sector*

Backgrounds of such study are

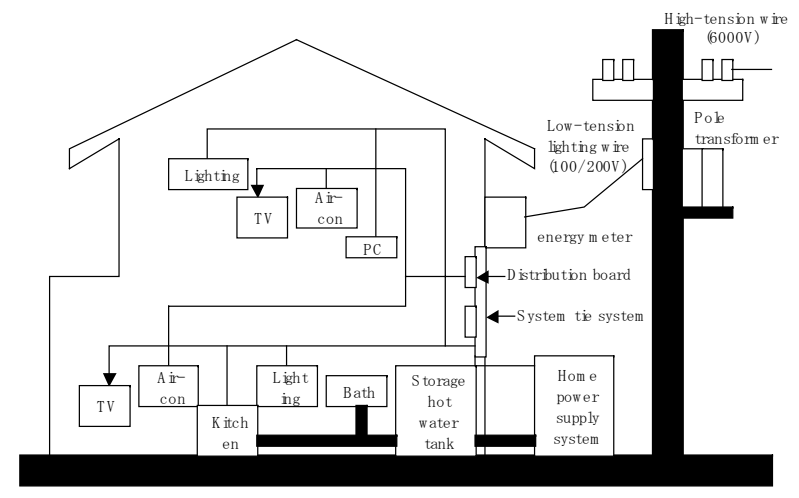
1)There is less of a *need to build large*, *expensive power stations* such as *nuclear power plant* when extra *capacity is needed*. As keeping *social acceptance*, its sites become very remote from large demand area so that *inadmissible transmission loss and cost are increasing*

2)Technology advances create *a paradigm shift*, i.e. *instead of pushing scale of economy* which is represented by *nuclear power* as an example, *distributive generation* is *friendly to the environment and reliable*.

Analyses are made base on *a long-term total Japanese energy system*. Time horizon covers *80 years from 2000*. *MARKAL computer soft* is used for system optimization.

PEFC Co-generation System

Residential PEFC installation



Introduction starts from 2005

Merit

1. *Over all efficiency of generating electricity and heat is high*
2. *Infrastructure of fuel acquisition is realistic*
3. *Operation and maintenance of FC system is simple*
4. *Onsite setting of equipment is easy*

Demerit

1. *Cost – expensive*
2. *Durability degradation and a low life time*

PEFC Co-generation system is set out-of-door, and can supply electric power and heat through co-generation.

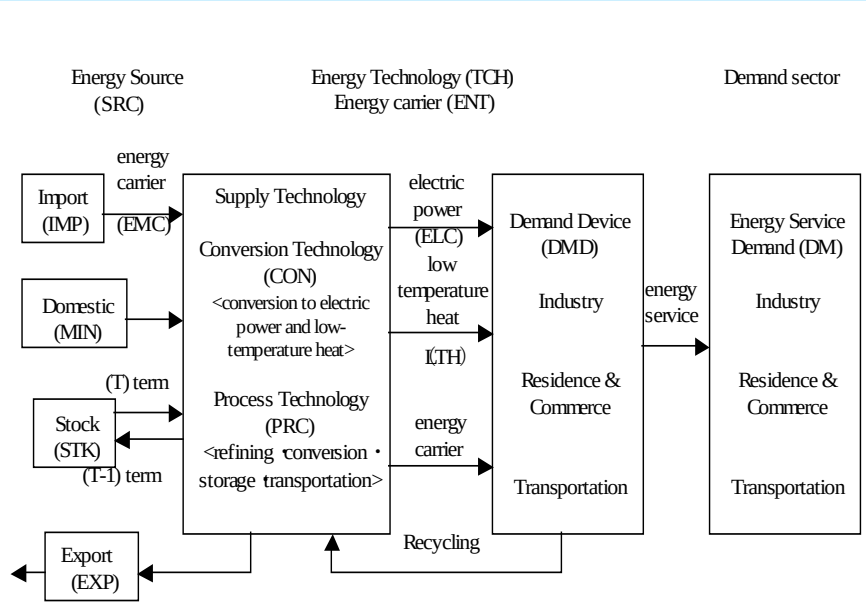
Technical Characteristic of PEFC Co-generation System[Tokyo Gas]

Table 1

Rated power	1kW	Fixed O & M cost	10[(kYen/kW)/year]
Input fuel	Town gas	Life time	10[year]
Electrictiy generating efficiency	31[%]	Capacity availability	Spring Autumn 50[%]
Exhaust heat efficiency	40[%]		Summer 35[%] Winter 80[%]
Investment cost	500[kYen/kW]	CO2 emissions	160.5[kgCO2/GJe]

MARKAL Model

Reference Energy System



MARKAL is an analytical model which optimizes a total energy system covering from primary energy supply, via energy conversion, to end use over a given time period.

*As objective function, we use following three indices: 1) discounted system cost C, 2) cumulated environmental emission V, and 3) a linear combination of C and V, i.e. C + Q * V where a parameter Q has a meaning of indicating average marginal price given exogenously.*

Major Scenario Indicators

Calendar Year	2000	2020	2040	2060	2080
Population [M]	127	124	109	92	77
GDP [BY/y]	515	743	932	1087	1228
Crude Steel [Mt/y]	100	96	93	91	88
Cement [Mt/y]	89	84	80	78	76
Paper & Pulp [Mt/y]	31	36	38	40	41
Chemical Raw Mat. [PJ/y]	1312	1621	1674	1695	1711
Office Useful Energy [PJ/y]	1228	1608	1879	2093	2282
House Useful Energy [PJ/y]	1515	1961	2214	2376	2489
Passenger Transportation [Mmkm/y]	1458	1851	2139	2354	2535
Cargo Transportation [Mtkm/y]	586	677	742	790	831

PEFC Install Capacities and Households

Calendar Year	2010	2020	2030	2040	2050	2060	2070	2080
PEFC [GW]	2.1	10	15	20	25	30	30	30
Installed number of households [10^3]	210	100	1500	2000	2500	3000	3000	3000

Case

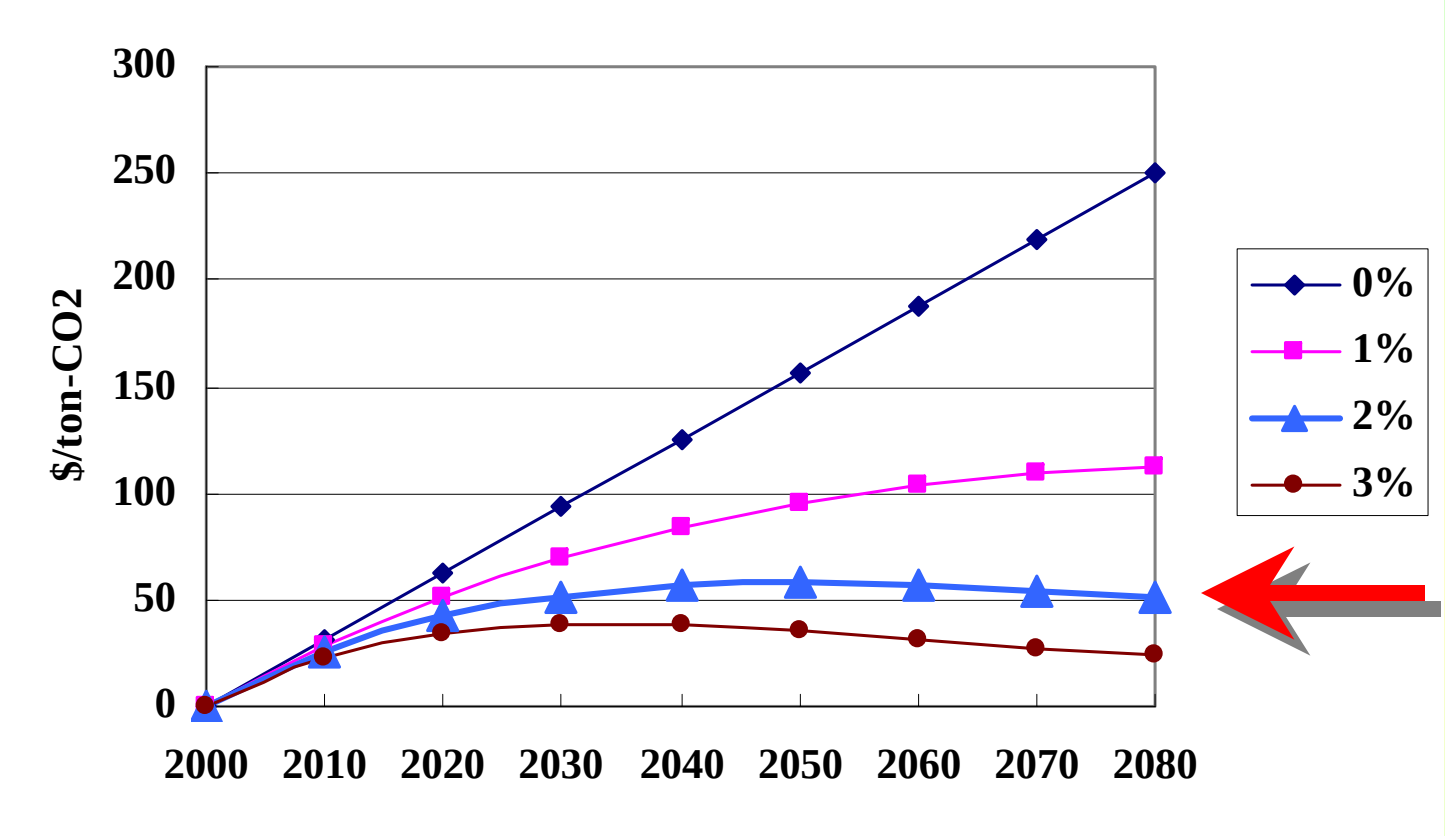
Case1	No PEFC introduction
Case2	PEFC characteristic of Table 1
Case3	INVCOST300[kYen]+EFF40[%]+LIFE20[year]
Case4	INVCOST150[kYen]+EFF50[%]+LIFE30[year]

**INVCOST=Investment cost*

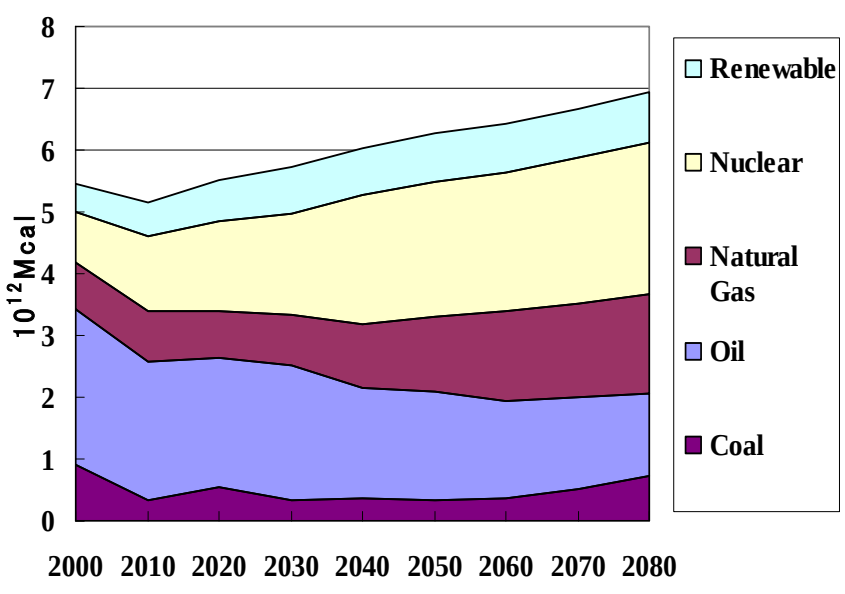
**EFF=Efficiency *LIFE=Lifetime*

In the analysis result of a MARKAL model, since ten years are made into 1 term, the introductory start of PEFC co-generation will be set up with 2010.

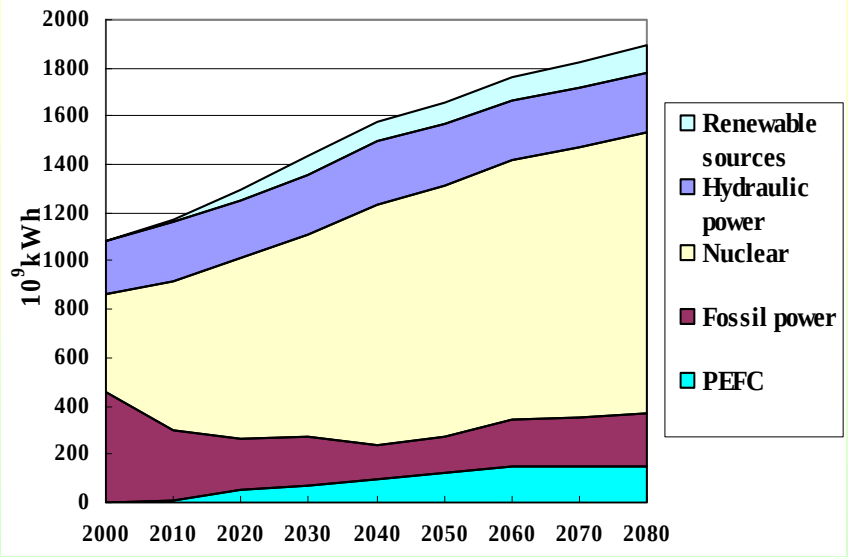
Surcharge Introduction



CO2 surcharge ($/ton-CO2) is introduced from 2000 as $0 to 2080 as $250/ton-CO2. In the analysis, 2% of discount rate is used as a reference.



Primary Energy supply mix



Electric Power supply mix

Total primary energy supply of Case2 (i.e. the case of PEFC installation) is 4% lower as primary energy supply accumulation.

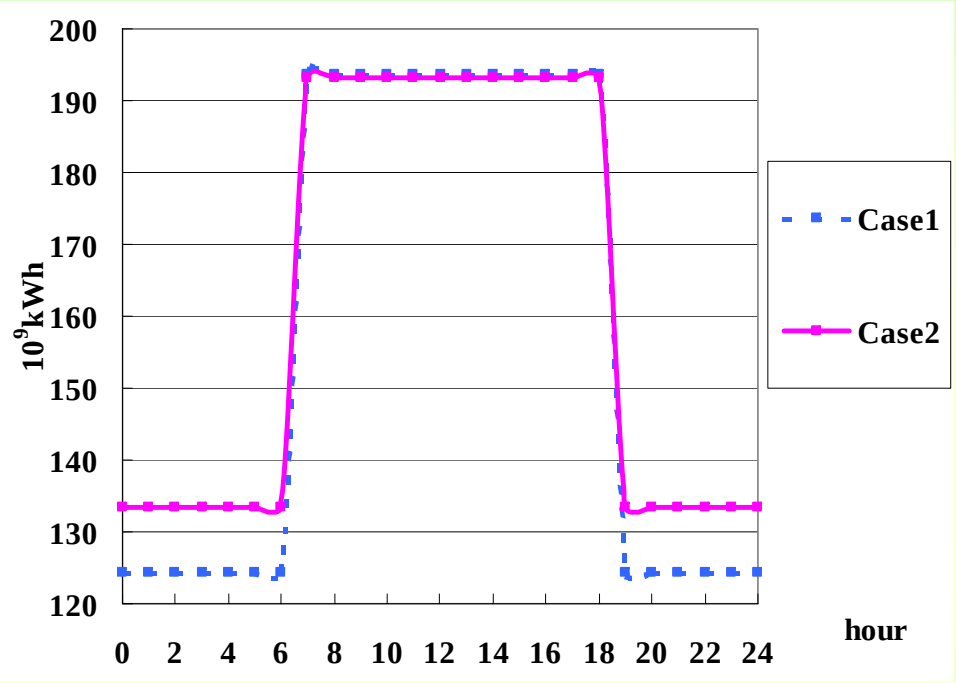
Contributes to energy saving.

Fossil power decreases.

Nuclear increases sharply.

About 6% of total electric power is expected by PEFC co-generation in 2040.

Effects of Electricity Load Lever



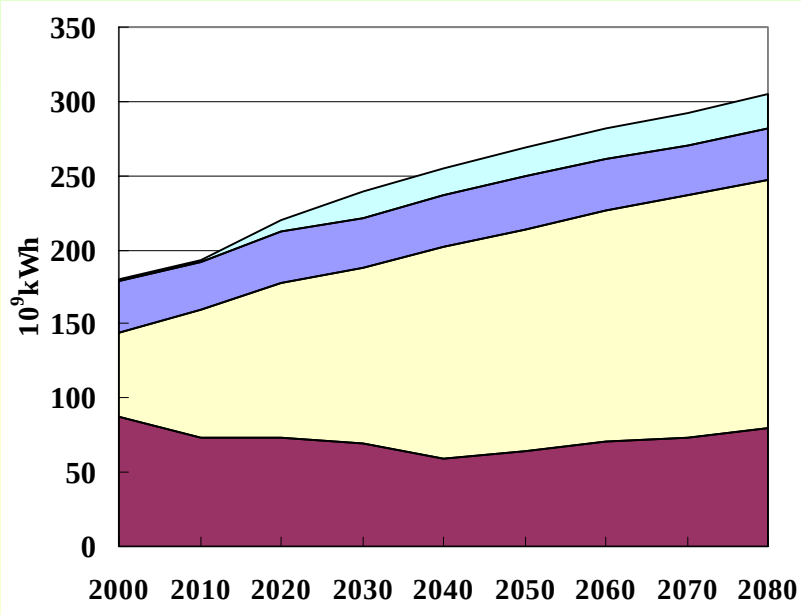
In the MARKAL model, time divisions are taken as six intervals, i.e. seasonally three, daily two which are a time zone of 6A.M.-7P.M and a zone of 7P.M-6A.M.

[Summer in 2010]

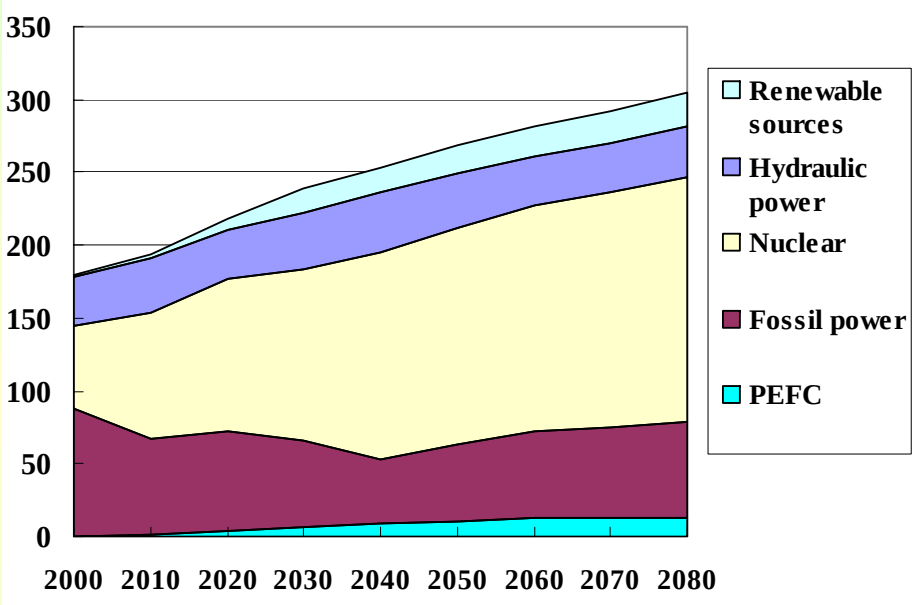
Comparing Case 1 and Case 2, there is almost no power difference in daytime but in night time difference being 9000GWh.

PEFC co-generation has a function of contributing to electricity load leveler through bottom up.

Electric Power Consumed in Residential and Commercial sector



Case 1[daytime]

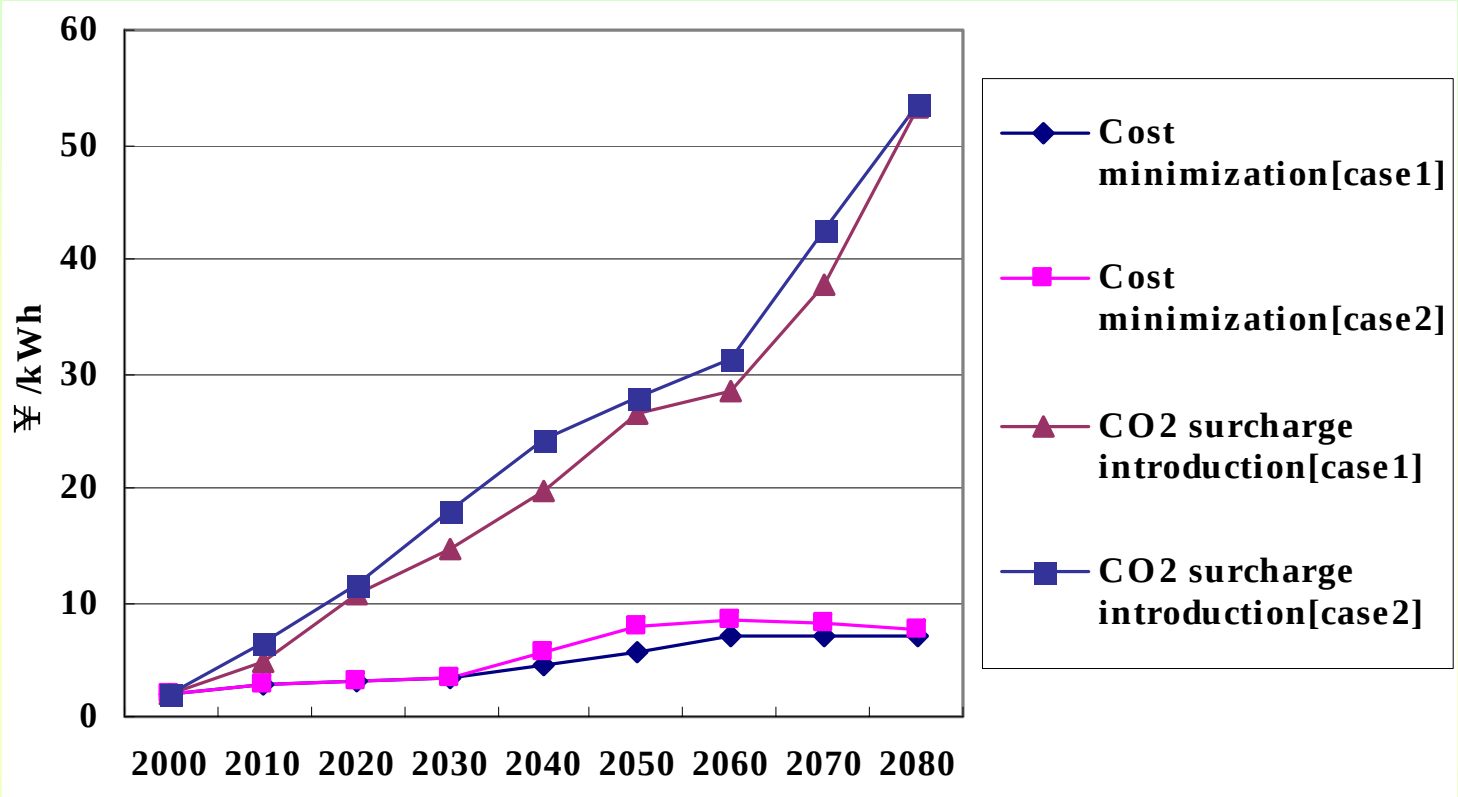


Case 2[daytime]

The installed capacity of fossil steam power is reduced when PEFC is introduced in demand side.

This brings to electric power supply system to protect excessive capacity installation, and leads to CO2 emission reduction also.

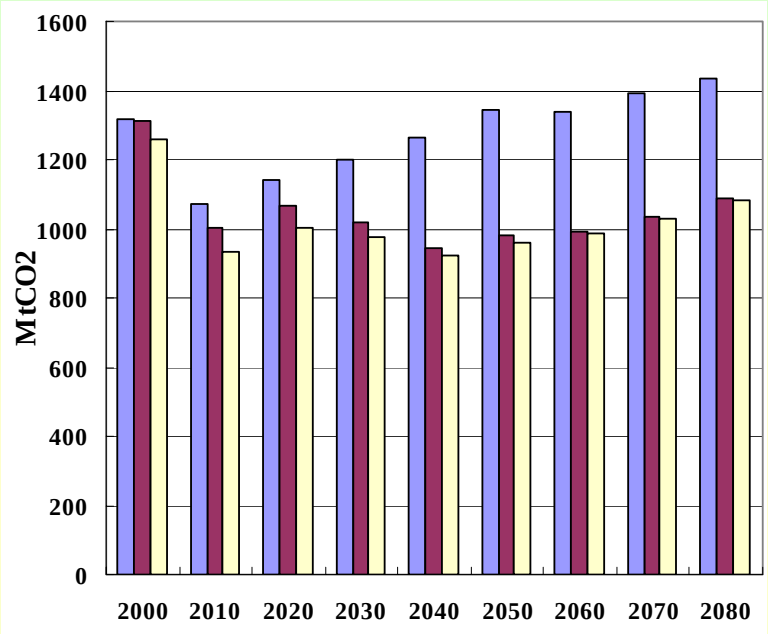
Electricity Shadow Price

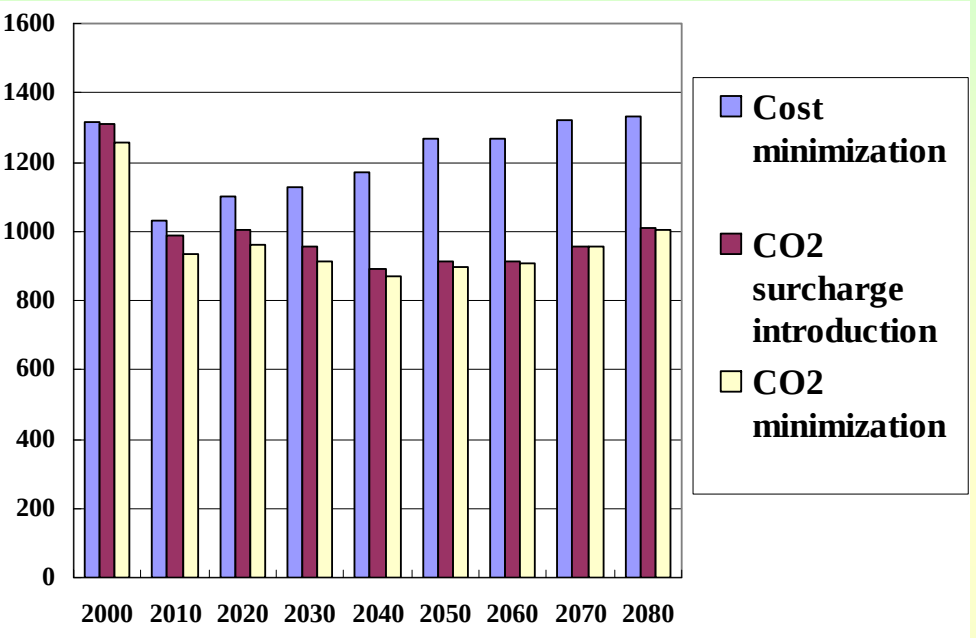


Demand sector summer

In any case, its time trend goes up to rightist, and the steepest in the case of PEFC installation and CO2 surcharge. This proves that PEFC installation is economically viable.

CO2 Emissions From Total System





Case 1 *Case 2*

From the RES total point of view, *additional CO2 reduction is expected from industry and transport sectors indirectly.*

Electricity surplus from residential PEFC *flows in transmission line and compensates some portion of electricity demand of industry and transportation sector.*

Fossil steam power can also be reduced and further CO2 emission reduction is expected through it.

Conclusions

1. About 4% of primary energy, about 6% of total generating electricity.

2. PEFC brings on an electricity bottom-up function. Some surplus of electricity from PEFC can be consumed in industry and transport sector. And leads to large utility capacity saving.

3. Electricity marginal price goes always up to rightist.

4. By PEFC installation CO2 emission reduction can be realized with not only directly in residential sector but also indirectly in energy conversion sector.