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# The Driving Force of China Rural Electrification

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# Contents

- Demand and Supply of China Rural Electricity
- Process of China Rural Electrification
- Overall Performance and problem of Rural Electrification
- Driving Force of Rural Electrification
- Concluding Remarks

# 1-1a The Rural Electricity Consumption Demand Function for Living Purpose

- Assume the Utility Function of Rural Residents is:  $U=U(B, N)$
- The budget restriction of consumers:  $Y=P_b B+P_e E+P_s S$
- Max  $L=U[B, N(E, S)]+M(Y- P_b B-P_e E-P_s S)$
- Let  $U=B^{f1} N^{f2}$
- Let  $N=\exp(S^{g1} E^{g2})$
- $E=K P_s^{t1} P_e^{t2} Y^{t3}$

# 1-1b The Rural Electricity Consumption Demand Function for Living Purpose

- Let  $E = F(R)X_{er}$
- $P_e E = P_x X_{er} = P_x [E/f(R)]$
- $X_{er} = h(R)P_s^{t_1}P_x^{t_2}Y^{t_3}$
- Where  $h(R) = Kf(R)^{-1-t_2}$
- Let  $t_2 = k_0 + k_1 \ln P_x$
- $X_{er} = h(R)P_s^{t_1}P_x^{(k_0+k_1 \ln P_x)}Y^{t_3}$
- $\ln X_{er} = G(R) + t_1 \ln P_s + k_0 \ln P_x + k_1 (\ln P_x)^2 + t_3 \ln Y \quad (1)$

# 1-1c The Demand Function of Electricity for Production Purposes in Rural Areas

- Let  $X = F(K, L, M, Q_1, \dots, Q_n; S')$ ,
- $Q_e = Q_e(P_K, P_L, P_M; P_1, \dots, P_n; X; S')$
- $Q_e = Q_e(P_L/P_K, P_M/P_K, P_1/P_K, \dots, P_n/P_K; X/P_K; S')$
- Let  $O = O(J, N)$
- $\text{Min } L = P_e E + P_s S + P_j J + M[O' - O(J, N(E, S))]$

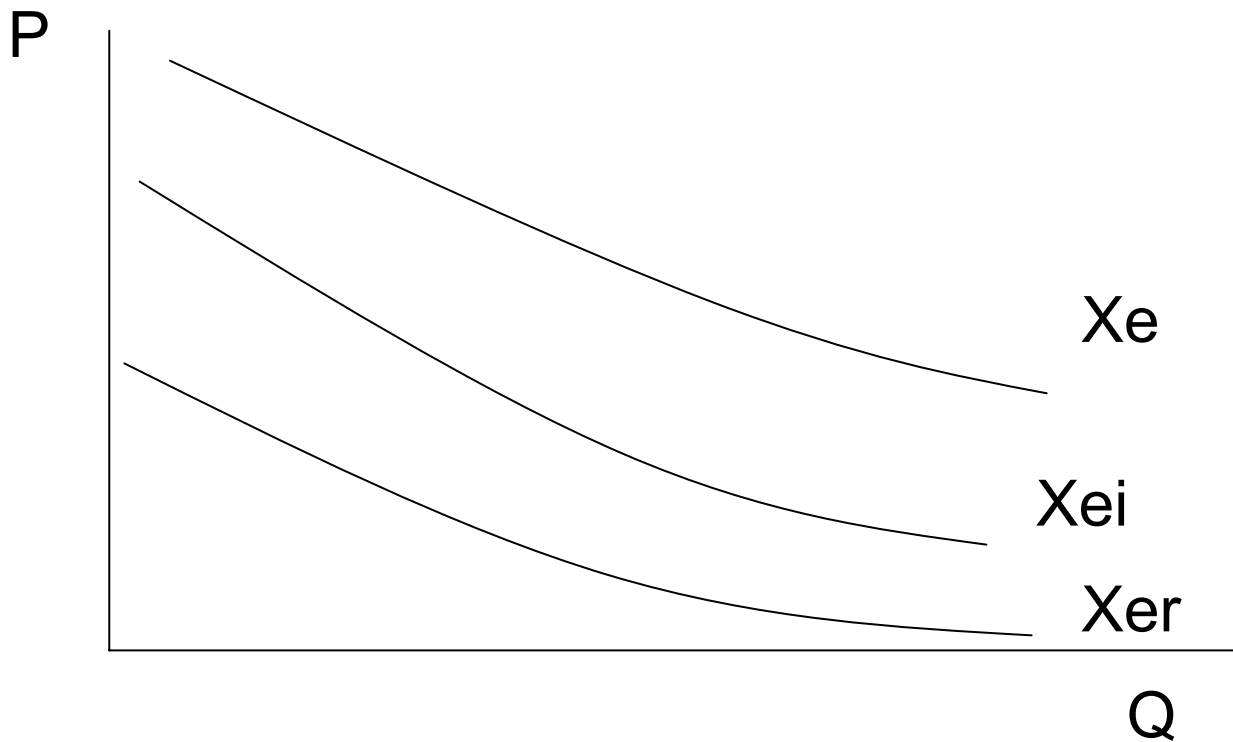
# 1-1d The Demand Function of Electricity for Production Purposes in Rural Areas

- Let  $O = J^{f3} N^{f4}$
- Suppose  $N = \exp(S^{g3} E^{g4})$
- $\ln X_{ei} = H(R) + r_1 \ln P_s + r_2 \ln P_x + r_3 (\ln P_x)^2 + r_4 \ln V_i \quad (2)$

# 1-1e Energy Consumption in Rural Areas Mtce

|                       |             | 1980      |        |            | 1991     |        |            | 2000     |        |            | 2002     |        |            |
|-----------------------|-------------|-----------|--------|------------|----------|--------|------------|----------|--------|------------|----------|--------|------------|
|                       |             | Sub total | Living | Production | Subtotal | Living | Production | Subtotal | Living | Production | Subtotal | Living | Production |
| Commercial energy     | Coal        | 65.1      | 37.0   | 28.0       | 197.75   | 77.52  | 120.23     | 293.28   | 118.01 | 175.27     | 353.16   | 157.35 | 195.81     |
|                       | Oil         | 15.0      | 1.0    | 14.0       | 39.34    | 1.33   | 38.01      | 53.12    | 7.57   | 45.55      | 66.54    | 8.48   | 58.06      |
|                       | Electricity | 19.0      | 3.0    | 16.0       | 40.89    | 11.63  | 29.26      | 99.13    | 34.44  | 64.69      | 75.91    | 24.76  | 51.15      |
|                       | Subtotal    | 99.0      | 41.0   | 58.0       | 277.98   | 90.48  | 187.5      | 445.53   | 160.02 | 285.51     | 495.61   | 190.59 | 305.02     |
| Non-commercial energy | Wood        | 112.0     | 103.0  | 9.0        | 123.65   | 103.03 | 20.62      | 95.48    | 80.52  | 14.96      | 138.31   | 114.01 | 24.30      |
|                       | Straw       | 117.0     | 117.0  |            | 162.13   | 162.13 |            | 123.6    | 123.6  |            | 141.47   | 141.47 |            |
|                       | Subtotal    | 229.0     | 220.0  | 9.0        | 285.78   | 265.16 | 20.62      | 219.08   | 204.12 | 14.96      | 279.78   | 255.48 | 24.3       |
| Total                 |             | 328.0     | 261.0  | 67.0       | 563.76   | 355.64 | 208.12     | 670.47   | 370.0  | 300.47     | 782.79   | 453.47 | 329.32     |

# 1-1f Aggregated Electricity Demand Curve of Rural China



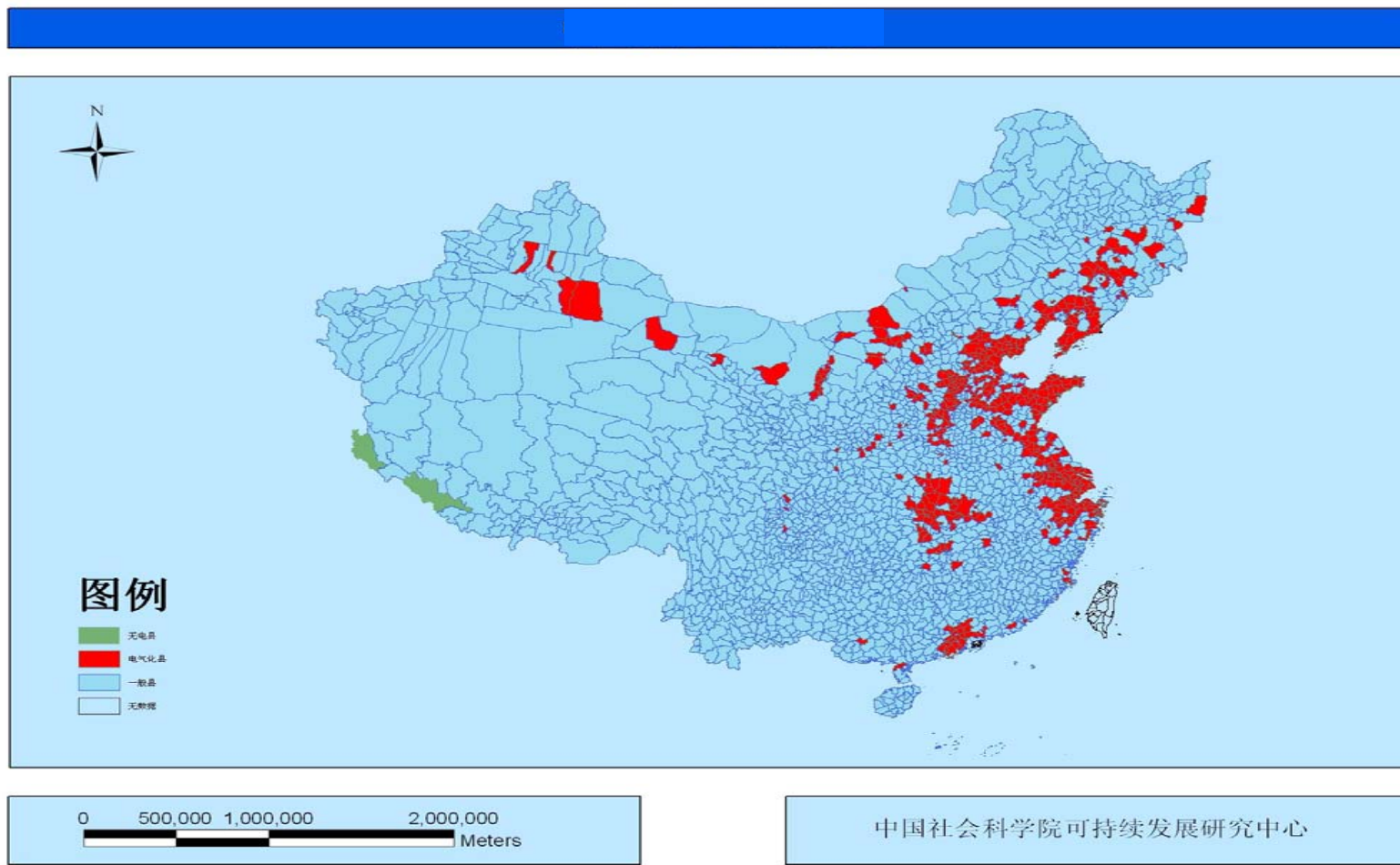


# 1-2a Types of Counties with Electricity Supply in China

| Year | Electricity Supply Pattern at County Level |                               |                      |                        |          |
|------|--|-------------------------------|----------------------|------------------------|----------|
|      | Direct Supply Through National Grid        | Supply Through Local Dispatch | Self-supply counties |                        |          |
|      |  |                               | By Small Hydropower  | By Small Thermal power | Subtotal |
| 1993 |  |                               |                      |                        |          |
| 1994 |  |                               |                      |                        |          |
| 1995 | 707  | 996                           | 567                  | 79                     | 646      |
| 1996 | 716  | 1004                          | 571                  | 81                     | 652      |
| 1997 | 727  | 1005                          | 580                  | 66                     | 646      |
| 1998 | 775  | 1065                          | 513                  | 35                     | 548      |
| 1999 |  |                               |                      |                        |          |
| 2000 | 854  | 1131                          | 433                  | 20                     | 453      |
| 2001 |  |                               |                      |                        |          |
| 2002 |  |                               |                      |                        |          |
| 2003 |  |                               |                      |                        |          |

(Source: China Electricity Yearbook)

# 1-2b The Distribution of Electrified Counties by Direct Supply



Source: China Electricity Yearbook

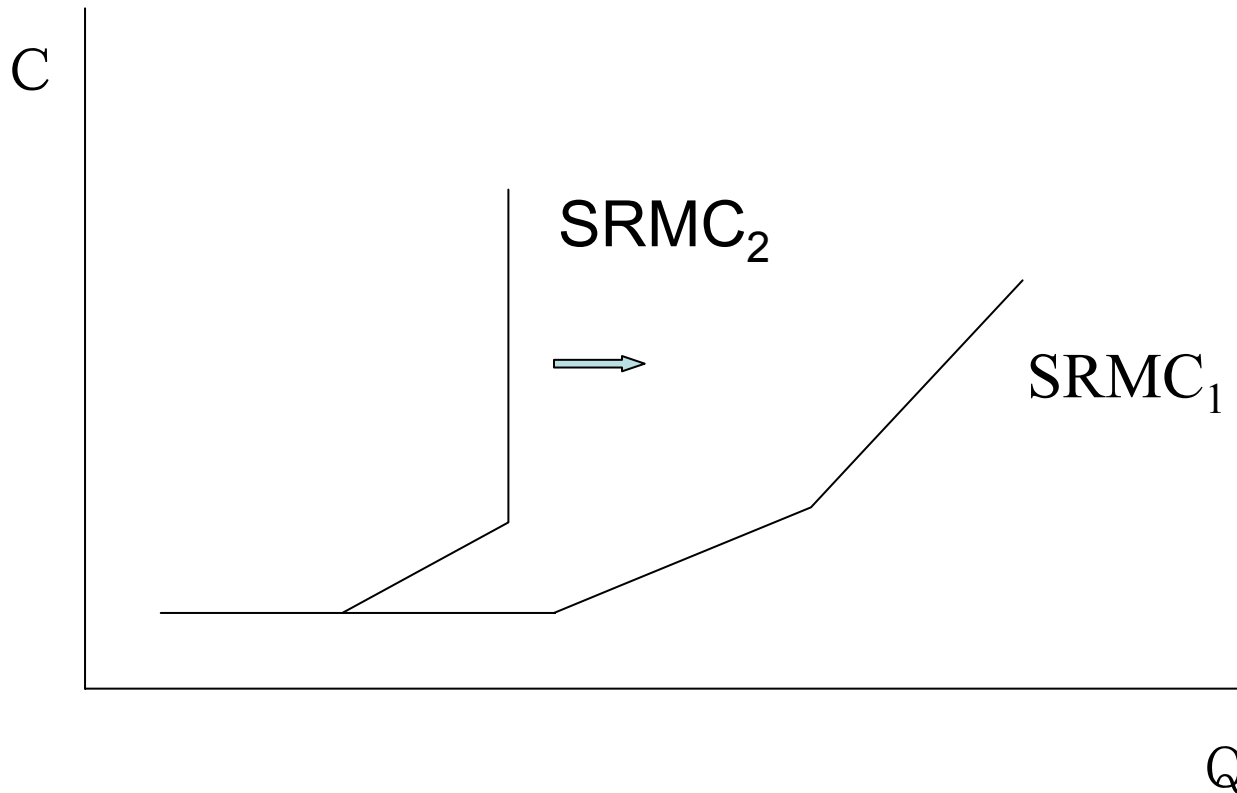
# 1-2c Source Structure of Rural Electricity

- A rural electricity source structure made up of national grids, rural small hydropower, small thermal power, and renewable energy
- The Installed Generating Capacity and Electricity Output Structure of China

| Year | Installed Generating Capacity (GW) |               |            |               | Electricity Output (TW·h) |               |            |               |
|------|------------------------------------|---------------|------------|---------------|---------------------------|---------------|------------|---------------|
|      | Total                              | Thermal power | Hydropower | Nuclear power | Total                     | Thermal power | Hydropower | Nuclear power |
| 1980 | 65.9                               | 45.6          | 20.3       |               | 301                       | 243           | 58         |               |
| 1985 | 87.0                               | 60.6          | 26.4       |               | 411                       | 318           | 92         |               |
| 1990 | 137.9                              | 101.8         | 36.0       |               | 621                       | 495           | 126        |               |
| 1995 | 217.2                              | 162.9         | 52.2       | 2.1           | 1007                      | 807           | 187        | 13            |
| 2000 | 319.3                              | 237.5         | 79.4       | 2.1           | 1369                      | 1108          | 243        | 17            |
| 2001 | 338.5                              | 253.0         | 83.0       | 2.1           | 1484                      | 1205          | 261        | 18            |
| 2002 | 356.6                              | 265.6         | 86.0       | 4.5           | 1654                      | 1352          | 275        | 27            |
| 2003 |                                    |               |            |               | 1911                      |               |            |               |

# 1-2d Rural Electricity Supply Curve

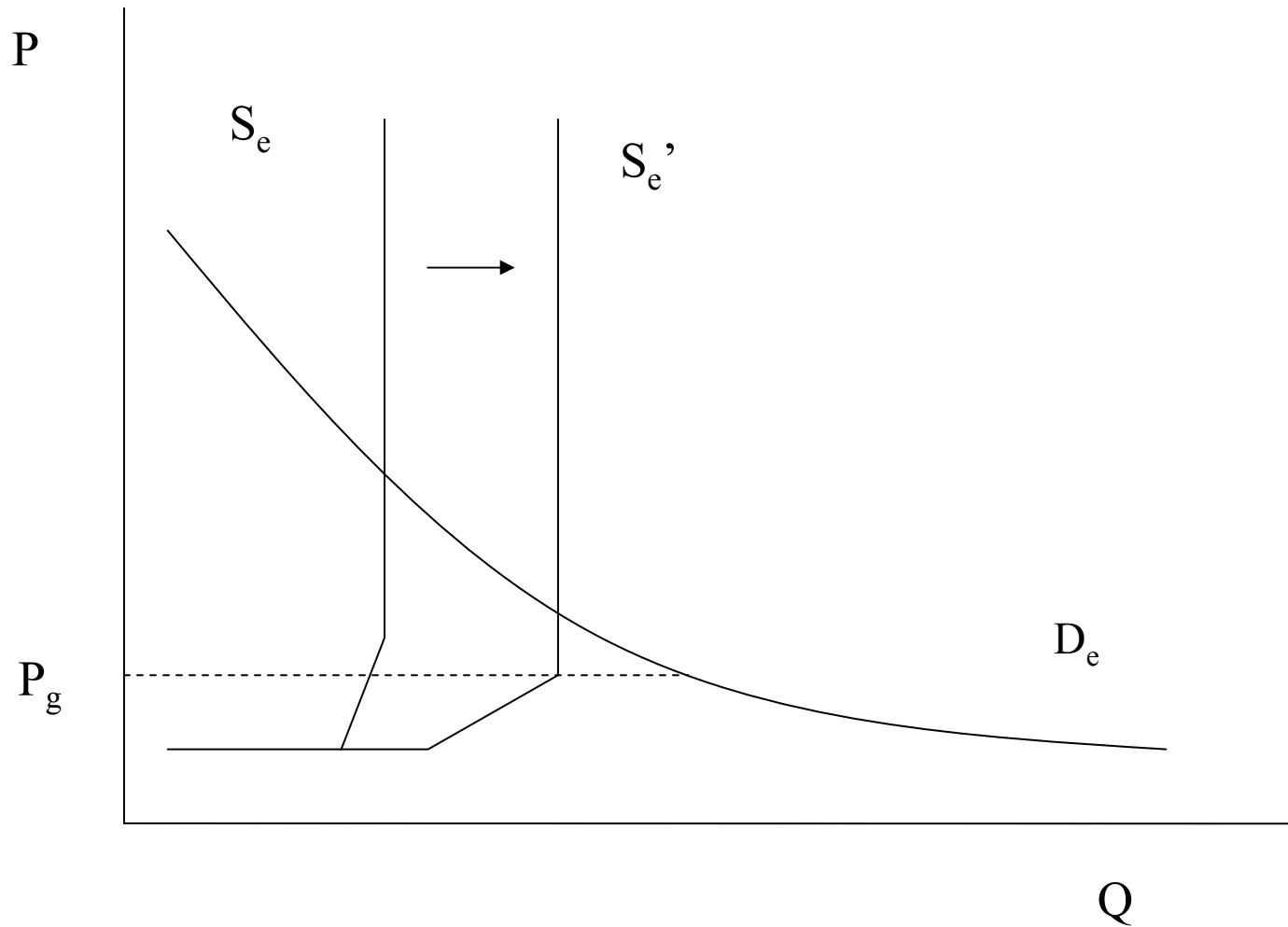
- Short-term marginal cost curve (subject to production capacity constraint)



## 1-2e Rural Electricity Supply Function

- Consider a simple situation. Assume  $AC=FC+MC_1Q_1+MC_2Q_2$
- $(FC+MC_1Q_1+MC_2Q_2)\cdot(1+r)= P\cdot(Q_1+Q_2)$   
where,  $r$  is return rate
- $Q=Q(P, R)$   
where  $R$  represents the quality of electricity supply;

## 2-1 Stage I (1949-1978): Increasing rural electricity supply



## 2-1a Electricity shortage and the planned economy

- Low rural electricity supply capacity and insufficient supply
- Because of the farmers' low income level, the rural electricity demand was low
- Under the planned economy, rural electricity was promoted to guarantee agricultural product supply and support industrialization

## 2-1b Developing Small Hydropower

- Increases in rural electricity supply mainly rely on developing one single type of technology, mainly small hydropower
- The Chinese government has established a series of supporting policies



## 2-1c The Distribution of Exploitable Small and Medium-sized Hydropower Resources in Different Chinese Regions

Unit: 10000 kW

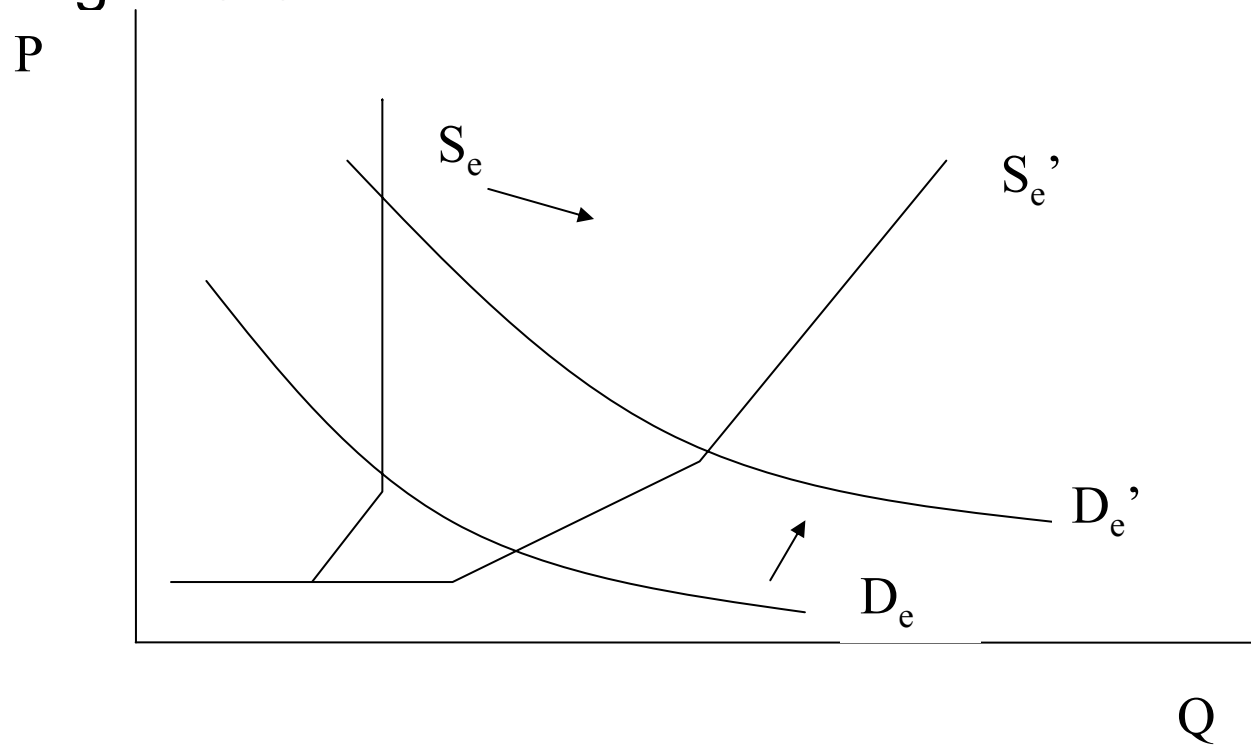
| Region         | Small Hydropower | Medium-sized hydropower | Total  | Region    | Small Hydropower | Medium-sized hydropower | Total   |
|----------------|------------------|-------------------------|--------|-----------|------------------|-------------------------|---------|
| Beijing        | 9.00             | 44.85                   | 53.85  | Hubei     | 403.60           | 159.1                   | 562.71  |
| Hebei          | 93.93            | 61.54                   | 155.47 | Hunan     | 414.60           | 279.82                  | 694.42  |
| Shanxi         | 58.10            | 34.60                   | 92.70  | Guangdong | 416.60           | 231.32                  | 647.92  |
| Inner Mongolia | 38.70            | 119.60                  | 158.30 | Guangxi   | 232.20           | 258.90                  | 491.10  |
| Liaoning       | 42.91            | 102.89                  | 145.30 | Hainan    | 39.74            | 28.63                   | 68.37   |
| Jilin          | 188.79           | 142.31                  | 331.10 | Sichuan   | 587.80           | 1278.63                 | 1866.43 |
| Heilongjiang   | 72.80            | 77.78                   | 150.58 | Guizhou   | 255.40           | 364.05                  | 619.45  |
| Jiangsu        | 11.20            |                         | 11.20  | Yunnan    | 1025.00          | 717.58                  | 1742.58 |
| Zhejiang       | 322.65           | 117.25                  | 439.90 | Tibet     | 1600.00          | 234.80                  | 1834.80 |
| Anhui          | 68.45            | 45.05                   | 113.50 | Shannxi   | 156.90           | 153.30                  | 310.2   |
| Fujian         | 359.40           | 272.49                  | 631.89 | Gansu     | 108.90           | 254.76                  | 363.66  |
| Jiangxi        | 308.33           | 230.89                  | 533.22 | Qinghai   | 200.00           | 321.46                  | 521.46  |
| Shandong       | 21.50            |                         | 21.50  | Ningxia   | 2.30             | 5.50                    | 7.80    |
| Henan          | 103.10           | 52.25                   | 155.35 | Xinjiang  | 397.90           | 728.77                  | 1126.67 |
| National total | 7539.8           | 6318.2                  | 13858  |           |                  |                         |         |

## 2-1d Structure of Rural Electricity Use for Production Purposes

- The structure of rural electricity use for production purpose has transformed

## 2-2 Stage II (1978-1997): Both Rural Electricity Demand and Supply Experienced Significant Increases

- Both the Supply Curve and the Demand Curve moved rightward



# 2-2a Background

- Severe energy shortage in rural areas. Rural energy shortage, poverty, and ecological degradation are interwove
- Farmers' income Increased
- Governing authorities of the rural electricity: from the Ministry of Water Resource and Power to the Ministry of Energy, then to the Ministry of Water Resource and the Ministry of Power

## 2-2b The 123 Rural Hydropower Poverty Alleviation Program

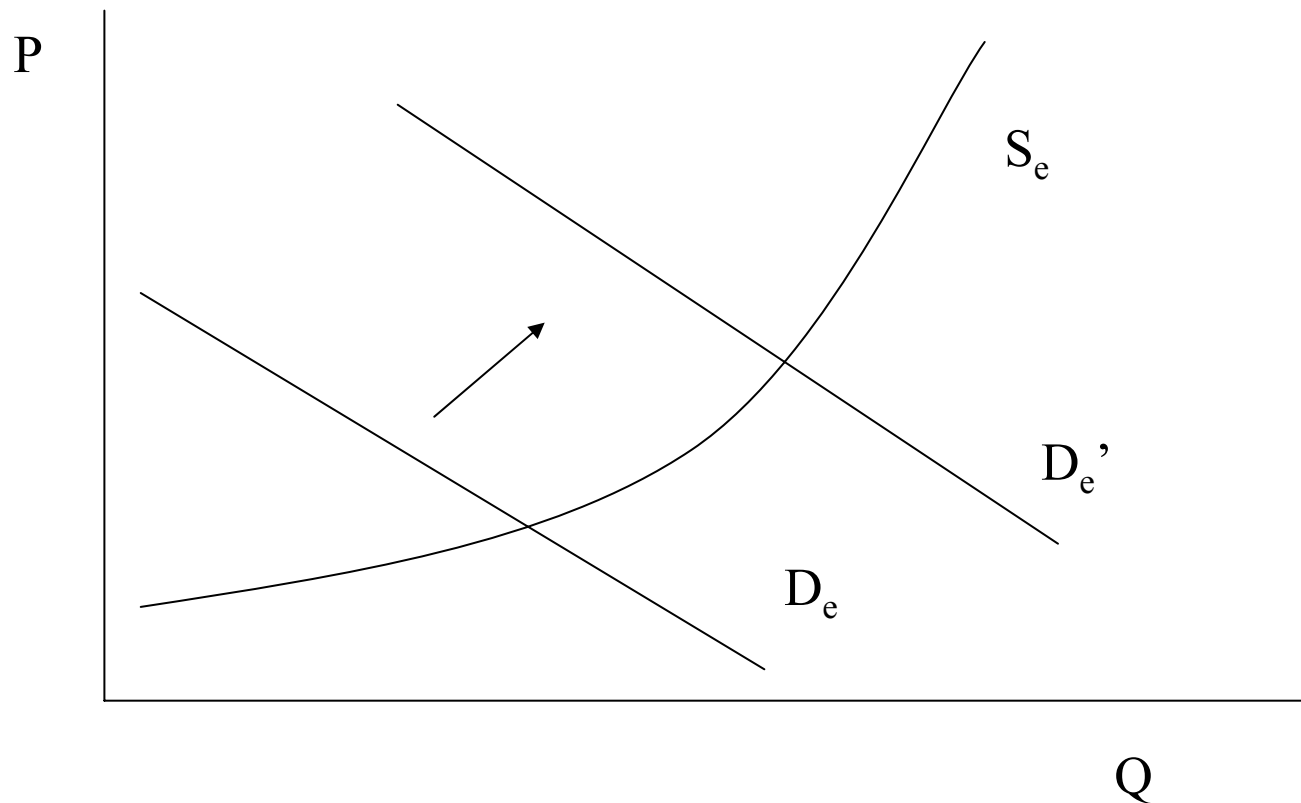
- Carry out preliminary electrification county construction on the basis of small hydropower supply:
  - built 109 rural hydropower preliminary electrification counties during 1986-1990;
  - built 208 such counties during 1990-1995;
  - planned to build 300 such counties during 1996-2000

## **2-2c Electricity Poverty Alleviation and the Construction of Rural Electrification Counties**

- The “Electricity Poverty Alleviation and Joint Better-off Seeking Program”
- Rural electrification county construction
- In 1993, national tax and local tax system were separated

## 2-3 Stage III (1998 hitherto) Enhancing the Rural Electricity Market through Institutional Instruments

- The Chinese government boosts rural market demand



# 2-3a Background 1

- After the 1997 Asian financial crisis, China increased infrastructure construction and investment to stimulate domestic demand and maintain an annual GDP growth goal of 8%
- Electricity oversupply: the average utilization hours

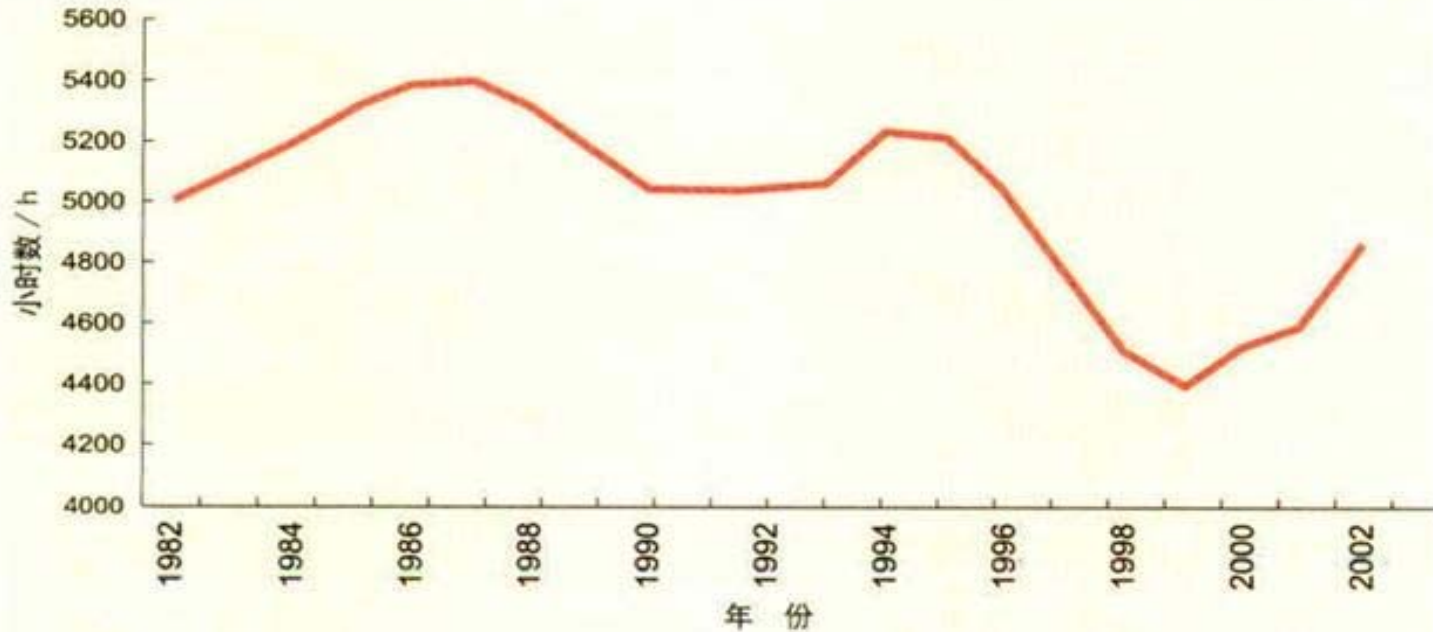
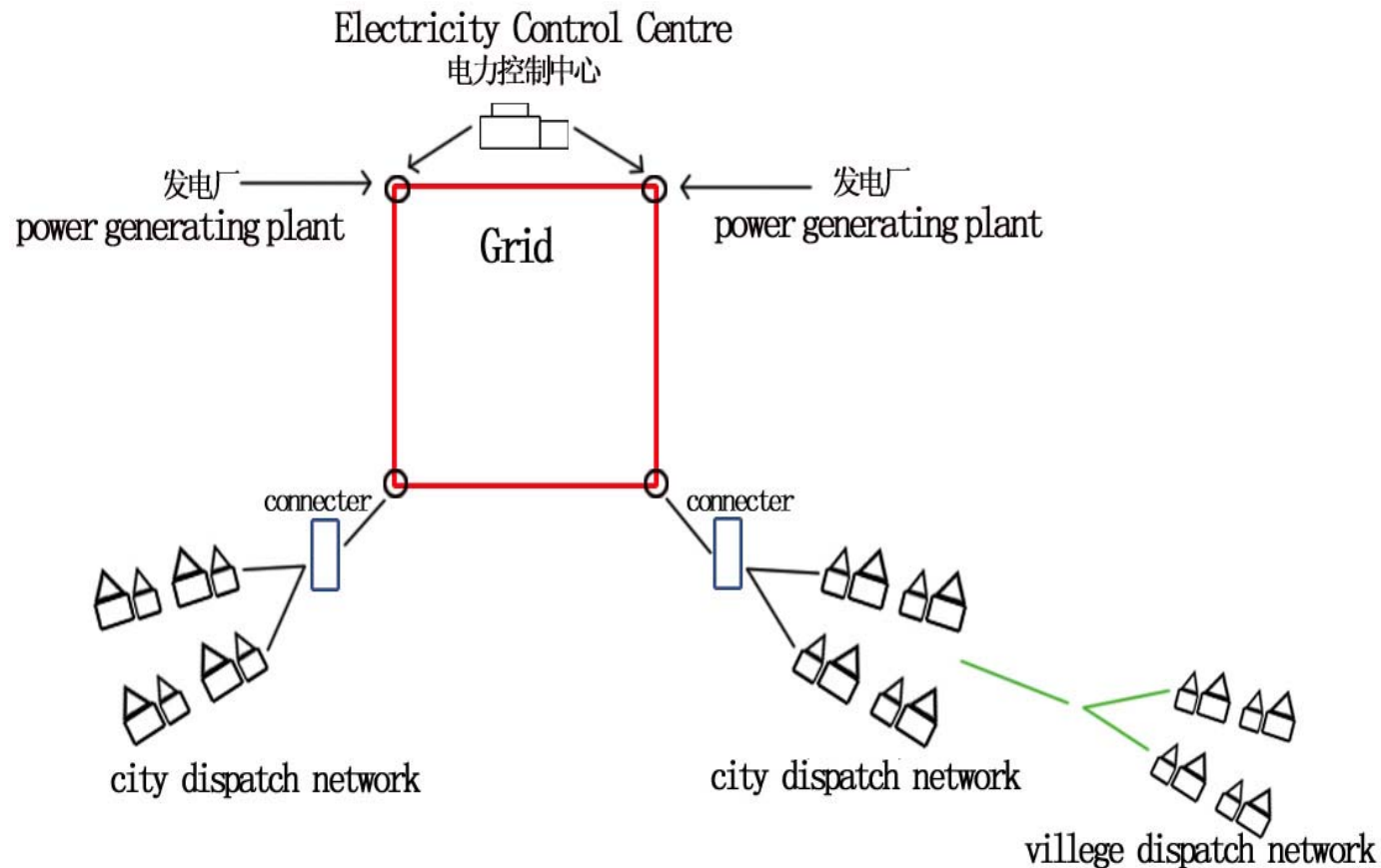


图 2.1 发电设备平均利用小时数<sup>①</sup>



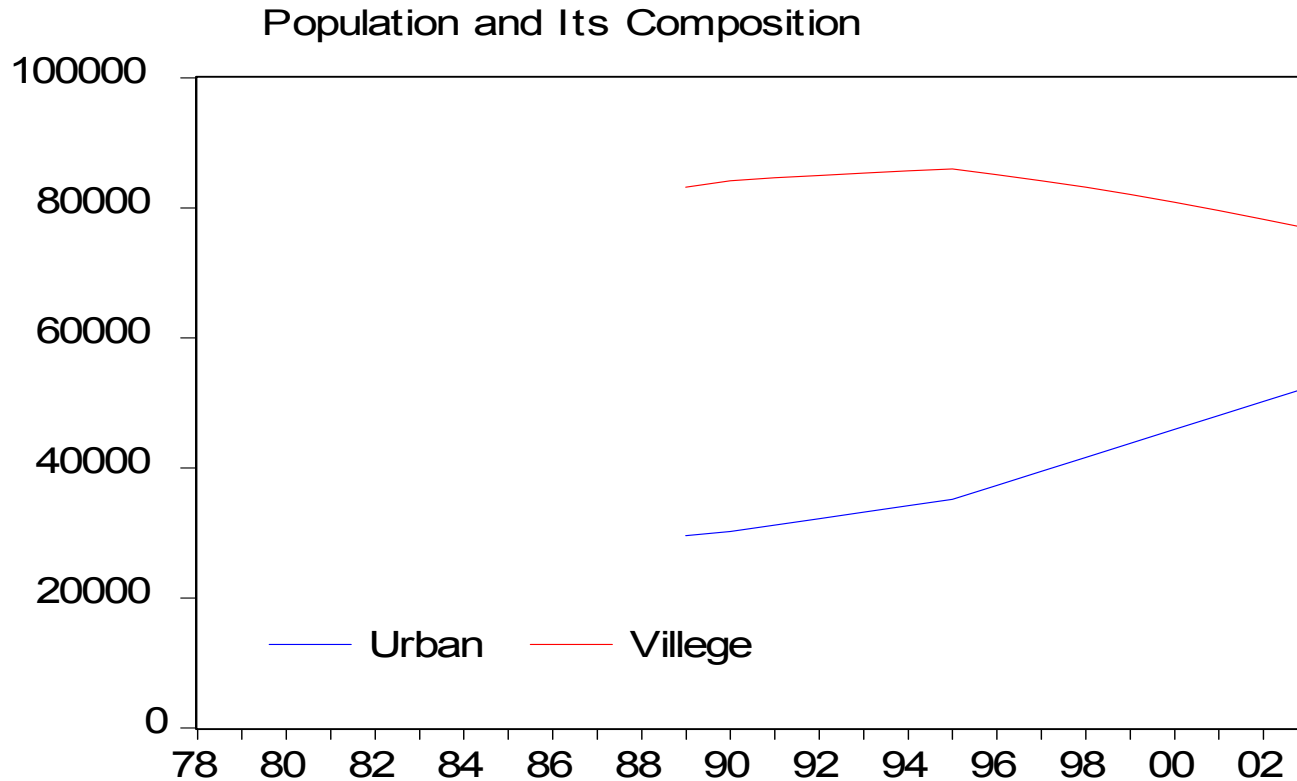
# 2-3a Background 2

- Rural electricity supply chains and price formation mechanism



# 2-3a Background 3

- Urbanization and urban-rural population composition changes (including ecological migrants)



## 2-3b Enhancing the Rural Electricity Market

- The State Council issued the “Notice of the State Council’s Approval and Transmission to the State Economic and Trade Commission’s Proposal for Accelerating Rural Electricity System Reform and Strengthening Rural Electricity Administration (SC[1999] No. 2)
- “Two Reform and One Price Unification”: reform rural electricity administration regime, renovate rural electricity grid, and unify the urban and rural electricity price of a same grid

## 2-3c Reform the rural electricity administration regime

- Set up electricity operating entities at national, provincial (power companies) and county (power supply enterprises) levels
- Reform the management regime of township electricity management stations.

# 2-3d Rural Grid Renovation

- After the long era of no regular investment in rural electricity grid, the central government uniformly plans for rural grid construction and renovation
- The state decided to investment RMB 290 billion from 1998 and spend 5 years to finish rural grid renovation

## 2-3e Unify the Rural and Urban Electricity Price of Each Grid

- Carry out uniform costing on urban and rural low-voltage electricity distribution network and charge uniform price on urban and rural users
- The operation and maintenance costs of rural low-voltage grids, which were burdened by farmers, are now included in the national catalog electricity price and burdened grid-wide (cross compensation?).

## 2-3f Rural Electricity Grid Renovation by the Water Resource Ministry

- By 2002, the water resource ministry finished Phase I of its rural electricity grid renovation project, phase II of the project is developed smoothly, Phase I and II covering 7 provinces.

## 3-1a Electricity Access and No-access at County and Lower Level in China

| Year | Electricity Access |         |                   | Without Electricity Access |      |         |                            |                    |
|------|--------------------|---------|-------------------|----------------------------|------|---------|----------------------------|--------------------|
|      | Town               | Village | Farmer households | County                     | Town | Village | Farmer households (10,000) | Population (10000) |
| 1993 | 97.4%              | 93%     | 89.6%             | 26                         | 1269 | 54858   | 2501                       |                    |
| 1994 | 97.8%              | 95%     | 91.3%             | 16                         | 1071 | 37151   | 2214                       |                    |
| 1995 | 98.25%             | 96.06%  | 93.3%             | 16                         | 828  | 29783   | 1731                       |                    |
| 1996 | 98.60%             | 96.72%  | 94.67%            | 11                         | 649  | 24818   | 1404                       | 7200               |
| 1997 | 99.03%             | 97.66%  | 95.86%            | 10                         | 442  | 17462   | 1107                       |                    |
| 1998 | 99.20%             | 98.10%  | 96.87%            | 8                          | 364  | 14042   | 881                        | 5000               |
| 1999 | 98.31%             | 97.77%  | 97.43%            | 7                          | 766  | 16509   | 706                        |                    |
| 2000 | 98.45%             | 98.23%  | 98.03%            |                            |      |         |                            |                    |
| 2001 | 98.56%             | 98.53%  | 98.40%            | 3                          | 629  | 10952   | 478                        |                    |
| 2002 | 98.54%             | 98.71%  | 98.48%            | 3                          | 608  | 9303    | 458                        |                    |

Source: China Electricity Yearbook



# 3-1b The Quality of Rural Electricity Supply

| Year | Voltage qualification rate at rural household end | Electricity supply reliability rate (share of villages with farmers' living electricity needs guarantee rate at 80% or above among villages with electricity access) | Wire loss rate |
|------|---|--|----------------|
| 1993 |   |  | >20%           |
| 1994 |   | 75%  | >20%           |
| 1995 |   | 80%  | >20%           |
| 1996 |   | 85%  | >20%           |
| 1997 |   | 92%  | >20%           |
| 1998 |   |  | <12%           |
| 1999 |   |  | <12%           |
| 2000 |   |  | <12%           |
| 2001 | 90.03%  | 99.12%   | <12%           |
| 2002 | 91.21%  | 99.16%   | <12%           |

Source: China Electricity Yearbook

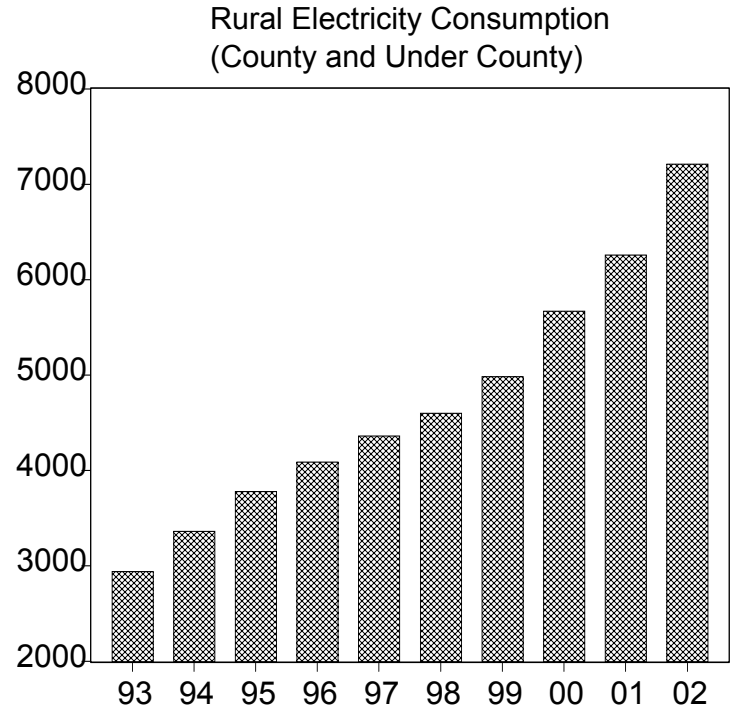
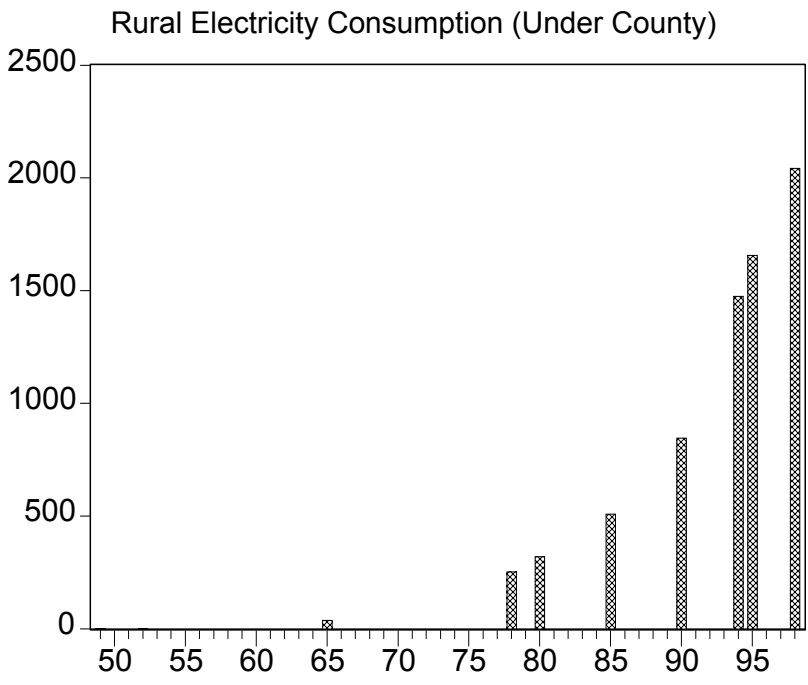
# 3-1c The Rural Electricity Supply Price of China

## The Doorstep Electricity Price for Rural Farmers

| Year | Share of Villages with rational electricity price | Counties with same electricity price in urban and rural areas | Electricity Price RMB/KWh. |
|------|---|---|----------------------------|
| 1992 |   |   |                            |
| 1993 | 75%   |   | 0.85                       |
| 1994 | 80%   |   | 0.84                       |
| 1995 |   |   | 0.84                       |
| 1996 |   |   | 0.83                       |
| 1997 | 85%   |   | 0.81                       |
| 1998 |   |   | 0.71*                      |
| 1999 |   |   | 0.655*                     |
| 2000 |   |   | 0.62                       |
| 2001 |   | 200   | 0.59                       |
| 2002 |   | 934   | 0.56                       |
| 2003 |   |   |                            |

(\* Data from China Electricity Yearbook, the rest are calculated by the author)

# 3-1d Rural Electricity Consumption



Unit: 100mkwh

# 3-1e Rural Electrification County Construction

- By 1997, the State Power Corporation had completed the construction of 500 rural electrification counties
- The Ministry of Water Resource plans to build 400 rural hydropower electrification counties during 2001 to 2005

## 3-2 Problem of Rural Electrification

- Demand side:

Per capita electricity consumption in rural China is very low

- Supply side:

China faces increasing energy pressure and electricity shortage

Renewable energy is difficult to realize wide commercialization in the near future

Electricity industrial organization: market monopoly

China faces ever increasing GHG emission reduction pressure

# 4-1a Central Government

- Boost rural hydropower development mainly via administrative power
- Direct national subsidy
- Favorable taxes
- Lower rural electricity cost

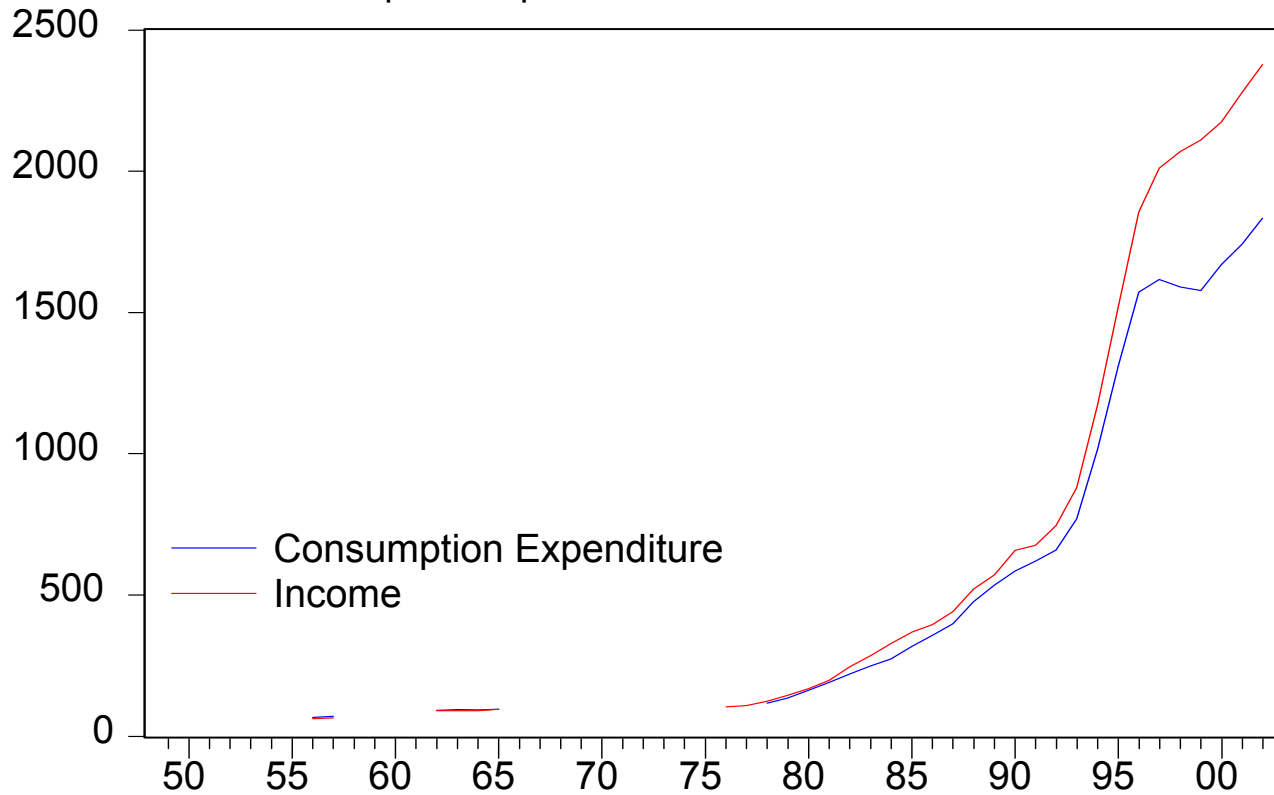
# 4-1b Local Government

- Local governments stimulated by developing local economy
- Provincial governments: enhance regulatory system and direct subsidy
- County governments: carry out county-wide rural electrification construction
- Township governments raise fund for electrification

# 4-2 Market Force

## Increases in farmer income level

China Rural Residents' Income (excluding transfer)  
and Consumption Expenditure





## 4-3 Interest Groups

- 1998: a period of promoting rural electricity market system, competition between the State Electricity Corp. and the Ministry of Water Resource

# 5-1 Main Conclusion

1. Since 1949, the driving forces behind China rural electrification mainly come from the administrative power and the local governments' motivation for developing local economy
2. The development history of China rural electrification indicates that government promotion alone can not guarantee the steady and effective implementation of rural electrification
3. The government should shift from mainly relying on administrative intervention to depending the functioning of market mechanisms
4. Vigorously promoting renewable energy is the inevitable way for China rural electrification

## 5-2 Further Work

- Quantitative analysis: co-efficiencies in the electricity demand model must be estimated; based on the above work, forecast future rural electricity demand
- Field survey: further investigate the driving forces behind China rural electrification
- The prospects of commercializing renewable energy resources in rural China, their GHG emission mitigation potential scenarios, and corresponding cost analysis