

# Renewable Energy Development Status in Taiwan

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# 台灣再生能源發展現況

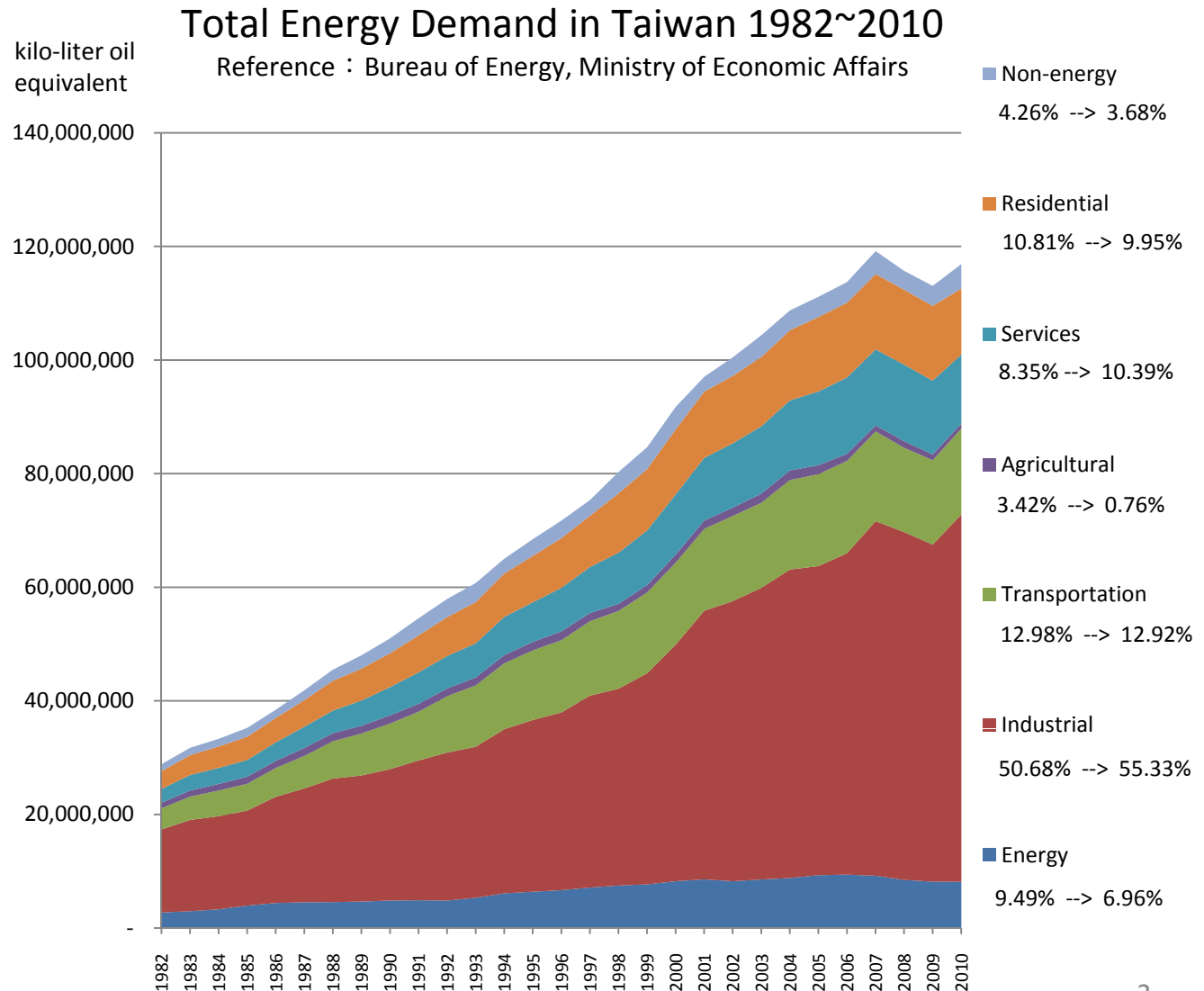
吳明全

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2010/09/18

# Energy Demand in Taiwan

- Energy consumption in Taiwan growth 4 times over the past 29 years.
- Industrial sector consumes more than half of the energy in Taiwan.

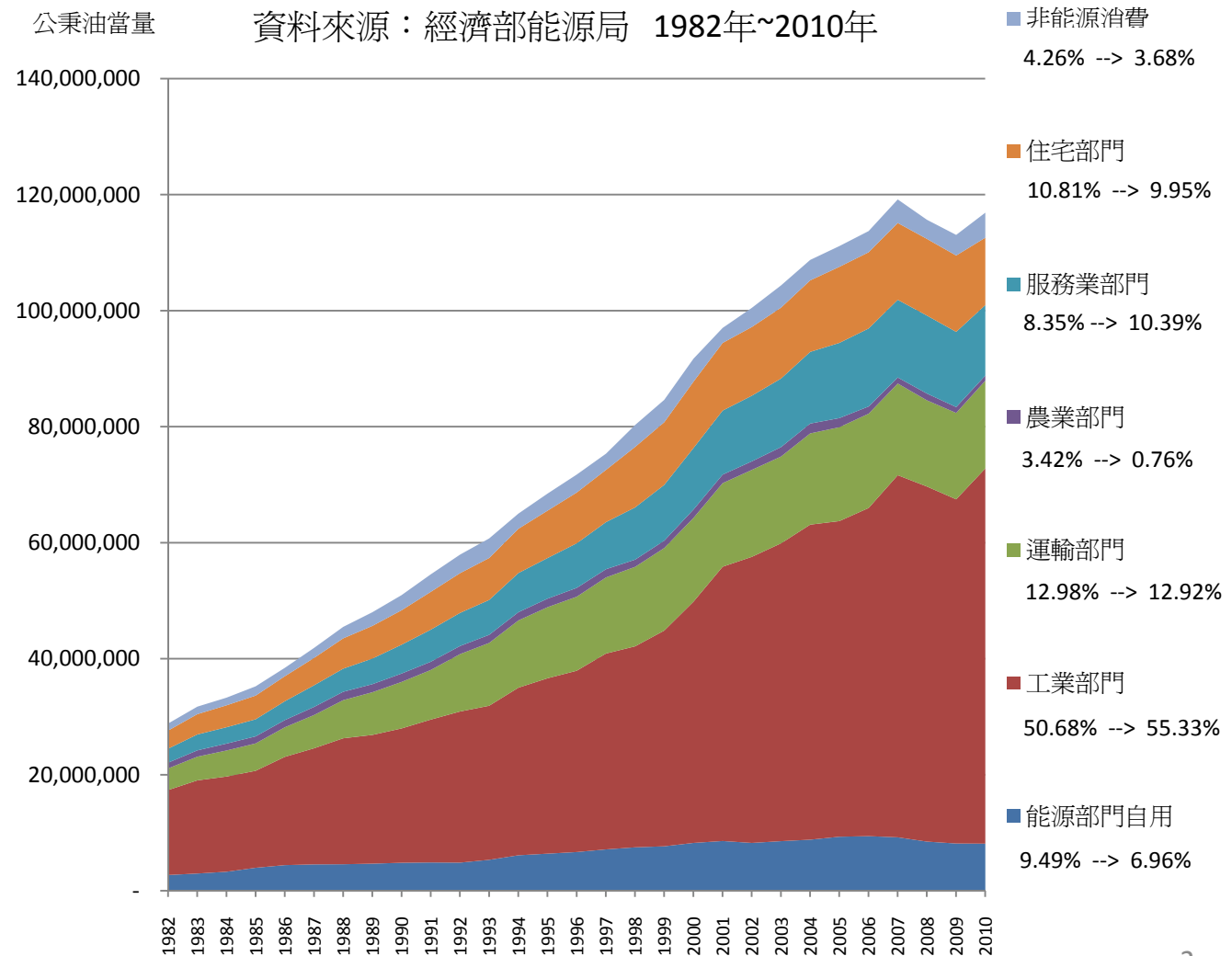


# 台灣能源需求

- 過去29年台灣能源消耗成長了4倍。
- 其中工業部門消耗了台灣一半以上的能源。

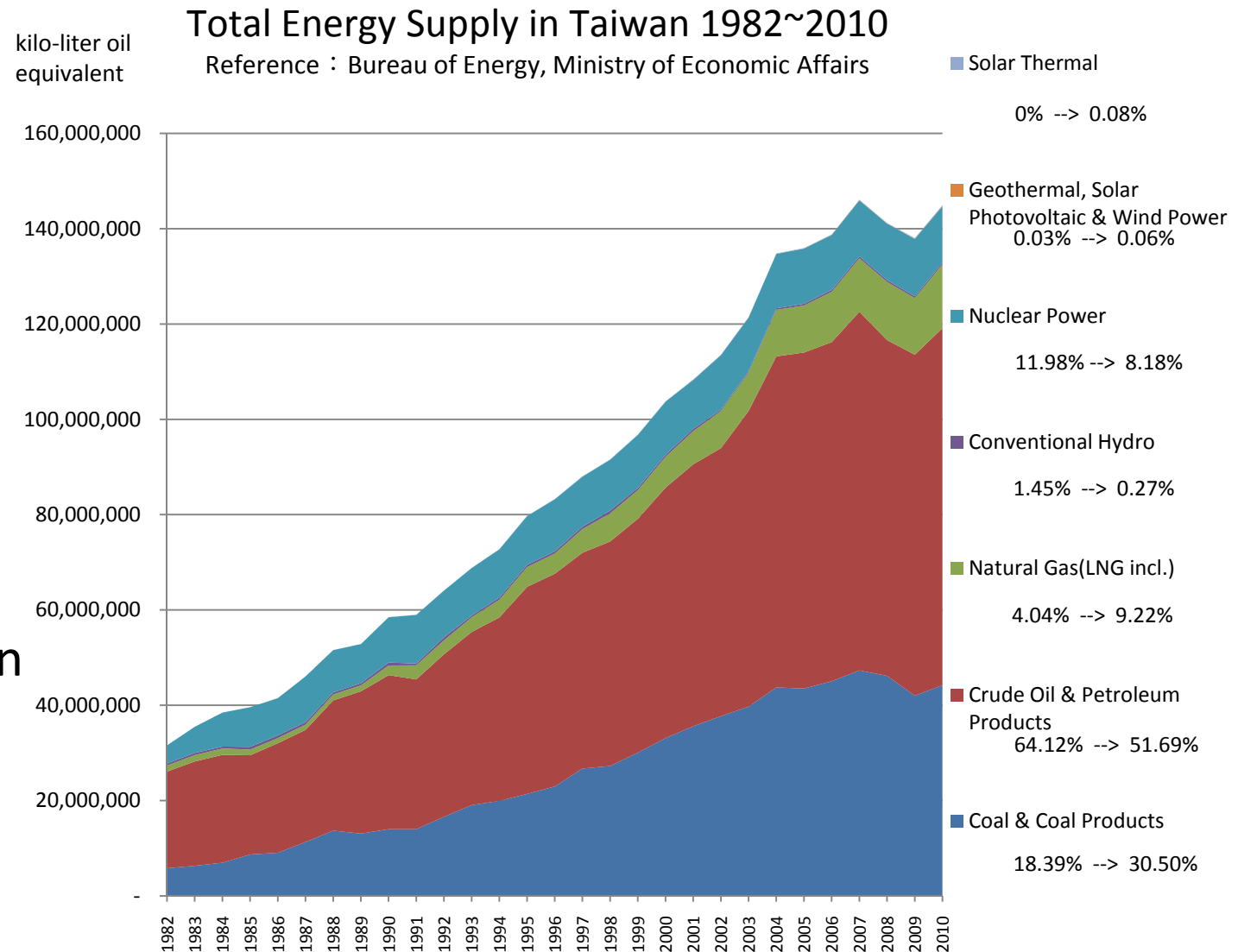
## 最近29年台灣能源總需求統計

資料來源：經濟部能源局 1982年~2010年



# Energy Supply in Taiwan

- Energy supply in Taiwan that depends on fossil fuels is still more than 90 %.
- Renewable energy in Taiwan is only less than 0.5% of total energy supply.

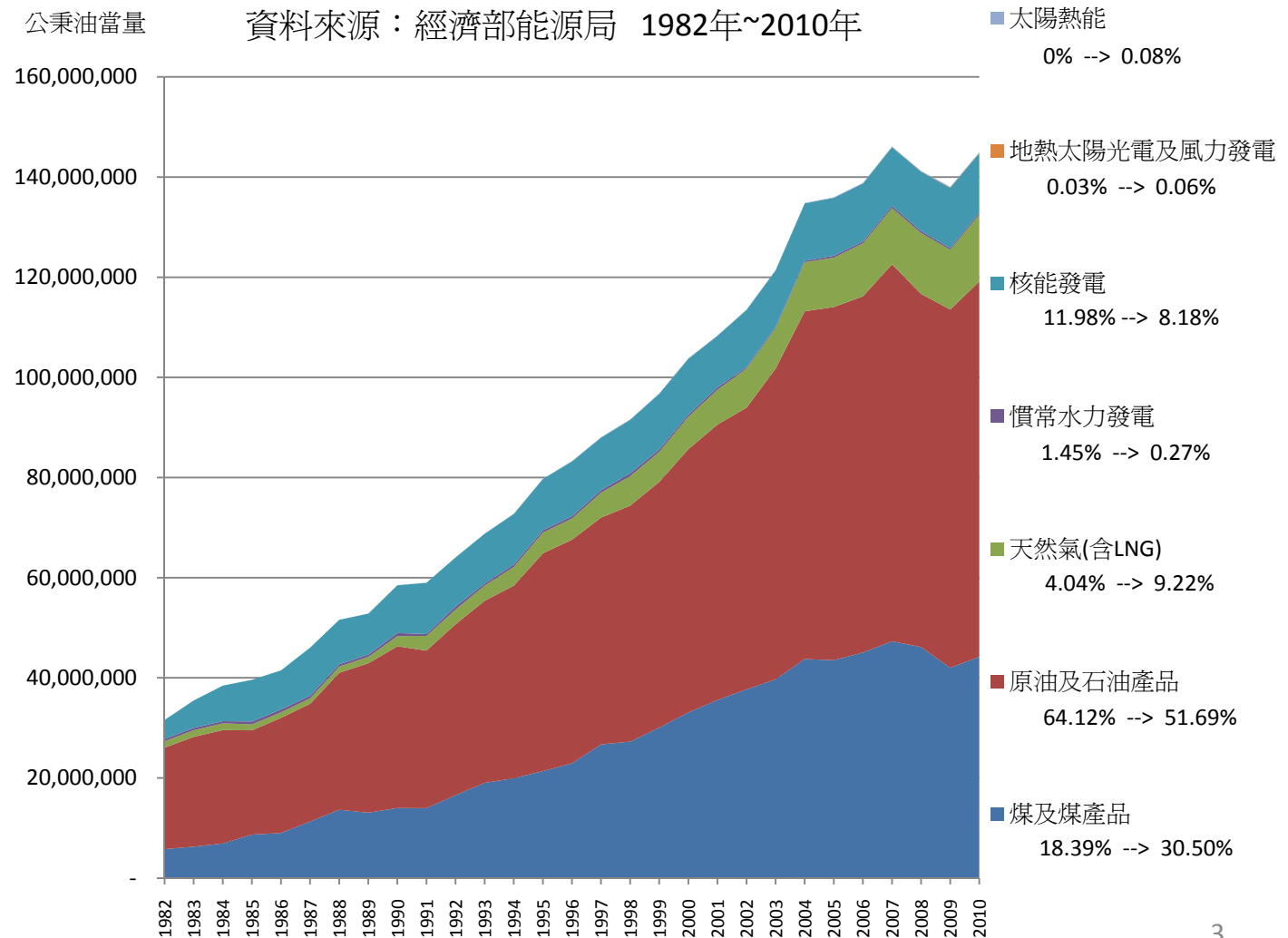


# 台灣能源供給

- 台灣能源供給仍有九成以上依賴化石燃料。
- 台灣再生能源僅佔能源總供給不到千分之五。

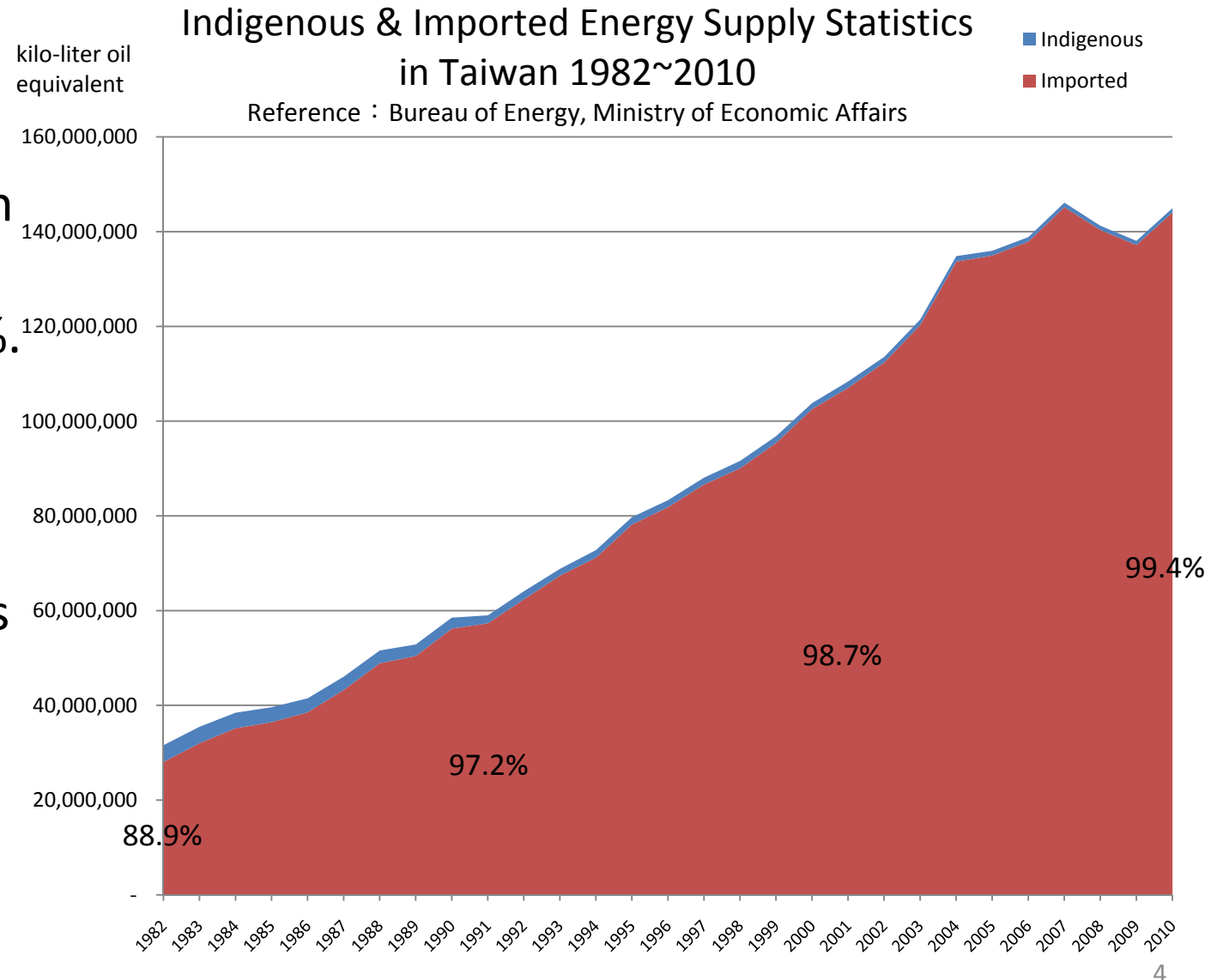
## 最近29年台灣能源總供給統計

資料來源：經濟部能源局 1982年~2010年



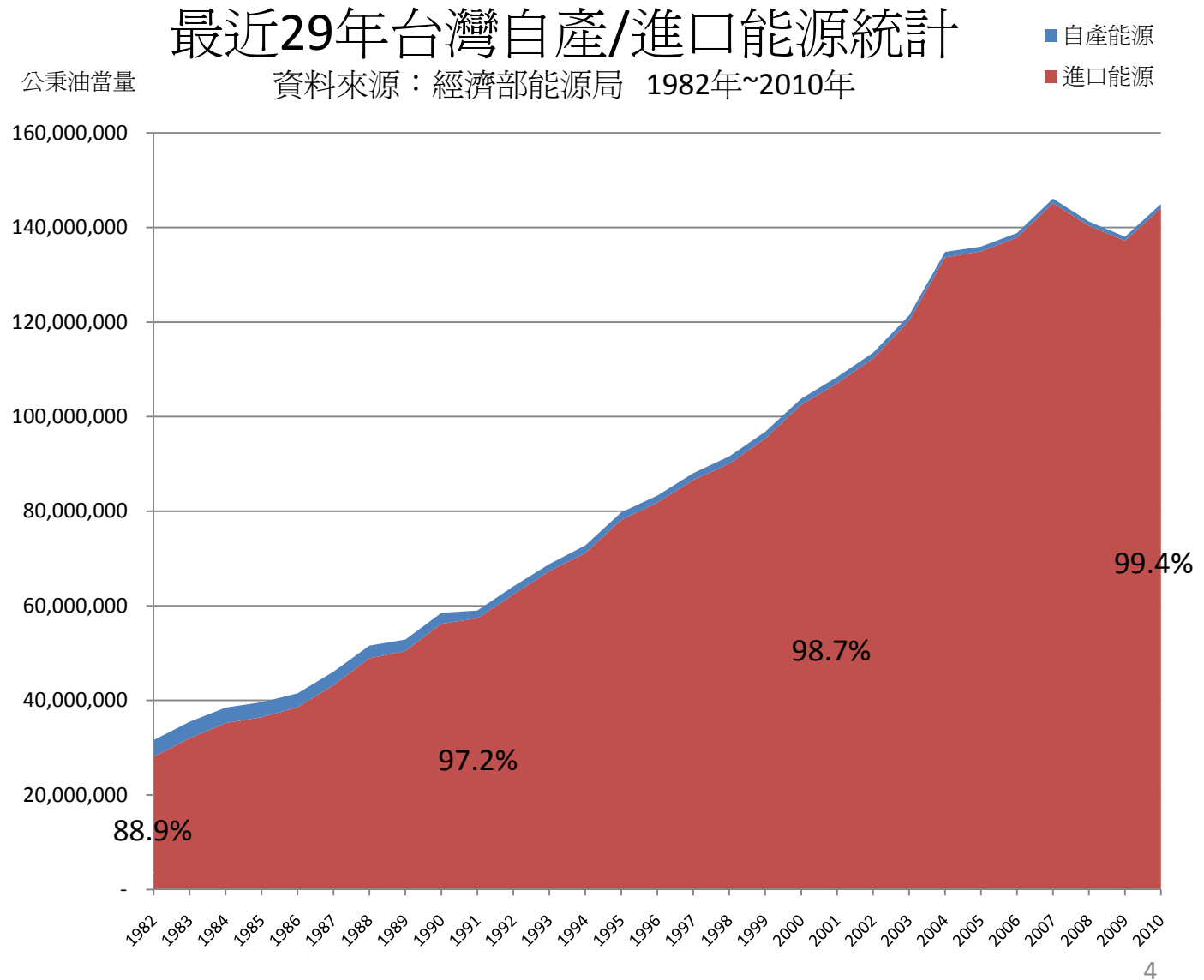
# Energy Dependency on Imports

- Energy Dependency on Imports in Taiwan is about 99.4 %.
- Value of Energy Imports / Total Imports is about 25.53%.



# 進口能源依存度

- 台灣進口能源依存度高達九成九四。
- 能源進口值佔總進口值超過四分之一。



# Controversial Nuclear Power Promote Renewable Energy Development (A)

- 1978, Tai-Power began to plan the 4<sup>th</sup> nuclear power plant.
- 1986, Chernobyl nuclear power plant occurred disaster.
- 1987, Legislative Yuan froze the nuclear project budget.
- 1992, Executive Yuan passed the 4<sup>th</sup> nuclear power plant plan.
- 1996, Abolition of the nuclear project budget by Legislative Yuan, but when Executive Yuan asked to reconsideration, the proposed budget had thawed.
- 1997, the 3<sup>rd</sup> Legislative Yuan draft 'The Statute For Promotion of Renewable Energy'.
- December 1997, sign the Kyoto Protocol.
- 1998, Civil Energy Conference and National Energy Conference.
- 2000, Stop to build the 4<sup>th</sup> nuclear power plant and constructed again in 2001.

# 核電爭議促進再生能源發展（一）

- 1978年台電開始籌建核四廠。
- 1986年車諾堡核電廠災變。
- 1987年立法院凍結核四預算。
- 1992年行政院通過核四興建計畫。
- 1996年立法院廢止核四預算，行政院提出覆議後立法院又解凍預算。
- 1997年立法院第三屆第三會期提出促進再生能源利用條例草案。
- 1997年12月簽署京都議定書。
- 1998年舉辦民間能源會議及全國能源會議。
- 2000年宣布停建核四廠。
- 2001年宣布核四廠復工。

# Controversial Nuclear Power Promote Renewable Energy Development (B)

- 2001 , the 4<sup>th</sup> Legislative Yuan draft 'The Statute For Reward Renewable Energy to Power'.
- July 2001, '2001 International Symposium on New Energy'.
- 2002~2004 , the 5<sup>th</sup> Legislative Yuan draft 7 versions of bill.
- 2005~2007 , the 6<sup>th</sup> Legislative Yuan draft 7 versions of bill and finished the First Reading procedure in December 2005.
- 2005, Civil Energy Conference and National Energy Conference.
- 2008~2009 , the 7<sup>th</sup> Legislative Yuan draft 8 versions of bill.
- September 2008, Public hearing on bill.
- December 2009, 8 versions of bill finished the First Reading procedure.
- 2009, Civil Energy Conference and National Energy Conference.

# 核電爭議促進再生能源發展（二）

- 2001年立法院第四屆第五會期提出獎勵再生能源發電條例草案。
- 2001年7月舉辦2001新能源國際研討會。
- 2002年~2004年立法院第五屆任期提出七個版本法案草案。
- 2005年~2007年立法院第六屆任期提出七個版本法案草案，於2005年12月完成一讀程序。
- 2005年舉辦民間能源會議及全國能源會議。
- 2008年~2009年立法院第七屆任期提出八個版本法案草案。
- 2008年9月舉辦再生能源發展條例草案公聽會。
- 2008年12月八個版本法案草案完成一讀程序。
- 2009年舉辦民間能源會議及全國能源會議。

# Renewable Energy Development Act

| The frame of 'The Statute For Renewable Energy Development' |                             |            |                                    |
|-------------------------------------------------------------|-----------------------------|------------|------------------------------------|
| Article 1                                                   | goals                       | Article 13 | exploitation of thermal energy     |
| Article 2                                                   | competent authorities       | Article 14 | related Electricity Law            |
| Article 3                                                   | defination                  | Article 15 | land needed                        |
| Article 4                                                   | power generation facilities | Article 16 | import tariff exemption            |
| Article 5                                                   | order and Electricity Law   | Article 17 | refrain from miscellaneous license |
| Article 6                                                   | principles for promoting    | Article 18 | provide the operation data         |
| Article 7                                                   | funding sources             | Article 19 | mediation                          |
| Article 8                                                   | in electricity net          | Article 20 | penalties for violations           |
| Article 9                                                   | wholesale rate and formula  | Article 21 | penalties for violations           |
| Article 10                                                  | subsidy                     | Article 22 | penalties for violations           |
| Article 11                                                  | rewarded demonstration      | Article 23 | implementation date                |
| Article 12                                                  | public works or buildings   |            |                                    |

- Renewable Energy Development related bills submitted since May 1997 took 12 years to complete the legislative process.
- 'The Statute For Renewable Energy Development' in Taiwan contains 23 articles and was promulgated by the President on 8 July 2009.

# 再生能源發展條例

| 再生能源發展條例條文架構 |         |       |        |
|--------------|---------|-------|--------|
| 第一條          | 立法目的    | 第十三條  | 熱利用    |
| 第二條          | 主管機關    | 第十四條  | 準用電業法  |
| 第三條          | 定義      | 第十五條  | 設置土地   |
| 第四條          | 發電設備規範  | 第十六條  | 進口關稅豁免 |
| 第五條          | 規模與電業法  | 第十七條  | 免請雜項執照 |
| 第六條          | 推廣目標    | 第十八條  | 運轉報告   |
| 第七條          | 基金      | 第十九條  | 調解     |
| 第八條          | 電網並聯    | 第二十條  | 罰則     |
| 第九條          | 躉購費率及審議 | 第二十一條 | 罰則     |
| 第十條          | 補貼費用    | 第二十二條 | 罰則     |
| 第十一條         | 示範補助    | 第二十三條 | 實施日    |
| 第十二條         | 公共工程設置  |       |        |

- 自從**1997**年起提出再生能源發展相關法案花了**12**年才完成立法程序。
- 台灣的再生能源發展條例包含**23**條條文於**2009**年**7**月**8**日由總統公告。

# 2010 Renewable Energy Wholesale Rate in Taiwan

| Renewable energy category                                                       | Power wholesale rate (NT/ kW-hr) |
|---------------------------------------------------------------------------------|----------------------------------|
| 1 kW ~ 10 kW Solar Photovoltaic*                                                | 11.1883                          |
| 10 kW ~ 500 kW Solar Photovoltaic                                               | 12.9722                          |
| >500 kW Solar Photovoltaic                                                      | 11.119                           |
| 1 kW ~ 10 kW Wind Power                                                         | 7.2714                           |
| >10 kW Wind Power                                                               | 2.3834                           |
| Offshore Wind Power                                                             | 4.1982                           |
| Run of River Hydro Power                                                        | 2.0615                           |
| Geothermal Power                                                                | 5.1838                           |
| Biomass Power                                                                   | 2.0615                           |
| Waste Power                                                                     | 2.0879                           |
| Else                                                                            | 2.0615                           |
| *1 kW ~ 10 kW Solar Photovoltaic has additional 50,000 NT / kW equipment grant. |                                  |

# 2010年台灣再生能源躉購費率

| 再生能源類別                            | 電能躉購費率(元/度) |
|-----------------------------------|-------------|
| 1 瓩以上至10 瓩太陽光電*                   | 11.1883     |
| 10 瓩以上至500 瓩太陽光電                  | 12.9722     |
| 500 瓩以上太陽光電                       | 11.119      |
| 1 瓩以上至10 瓩風力                      | 7.2714      |
| 10 瓩以上風力                          | 2.3834      |
| 風力發電離岸系統                          | 4.1982      |
| 川流式水力                             | 2.0615      |
| 地熱能                               | 5.1838      |
| 生質能                               | 2.0615      |
| 廢棄物                               | 2.0879      |
| 其他                                | 2.0615      |
| *1 瓩以上至10 瓩太陽光電設置案另外提供5 萬元/瓩設備補助。 |             |

# Regulations for Renewable Energy Power Generation Equipment Identified

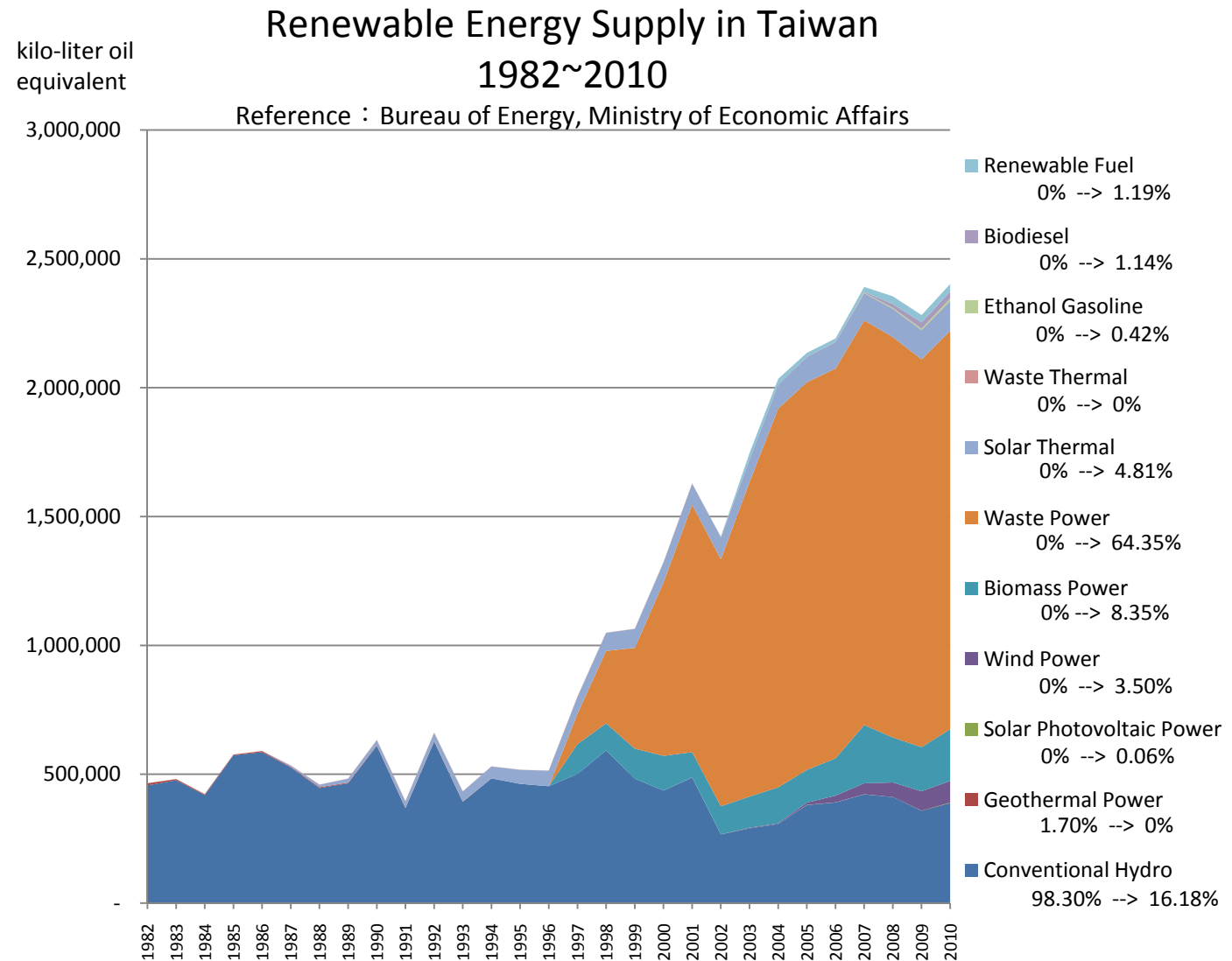
- According to Article 4 of 'The Statute For Renewable Energy Development', Ministry of Economic Affairs had formulated a 'Regulations for Renewable Energy Power Generation Equipment Identified'.
- Since April 30, 2010 the regulation was promulgated, Ministry of Economic Affairs accepts 336 cases of application power equipment identified, installed capacity more than 260MW.
- which Solar Photovoltaic Power generation equipment 322 cases, with a total installed capacity of up to 52.227MW.
- Wind Power 12 cases, with a total installed capacity of up to 211.305MW.
- Run of River Hydro Power 1 case, installed capacity 0.225MW.
- Geothermal Power 1 case, installed capacity 0.496MW.

# 再生能源發電設備認定辦法

- 依「再生能源發展條例」第4條規定，經濟部訂定了「再生能源發電設備認定辦法」。
- 自2010年4月30日再生能源發電設備認定辦法施行以來，經濟部受理申請發電設備認定案件合計336件，裝置容量超過26萬瓩。
- 其中太陽光電發電設備計322件，總裝置容量達5萬2,227瓩。
- 風力發電計12件，總裝置容量達21萬1,305瓩。
- 川流式水力發電設備1件，裝置容量為225瓩。
- 地熱發電設備1件，裝置容量496瓩。

# Renewable Energy Supply in Taiwan

- Classified statistics based on the definition of Renewable Energy Development Act, waste power accounted for 64% of renewable energy supply in Taiwan.

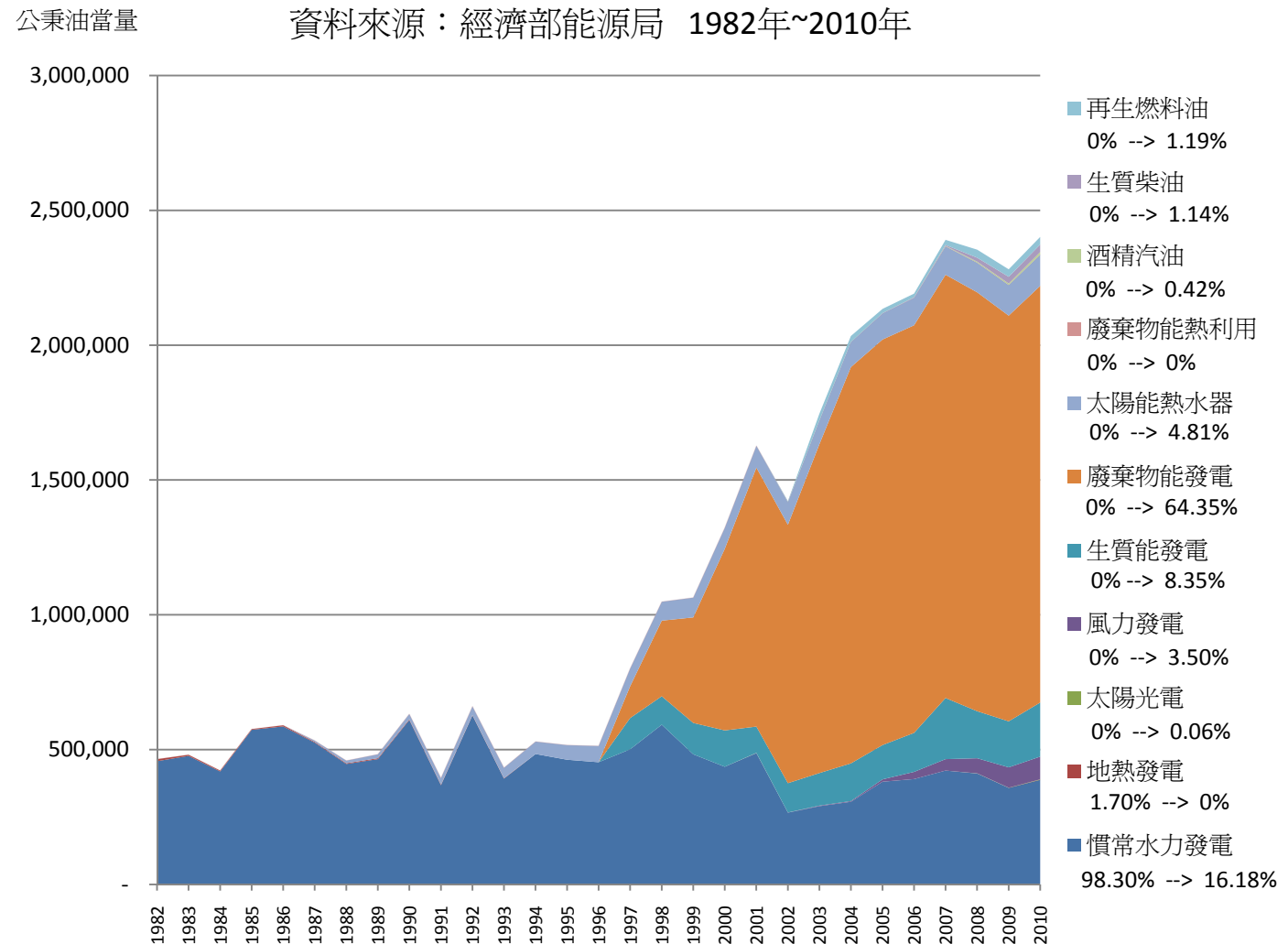


# 台灣再生能源供給

- 依據再生能源發展條例的定義進行分類統計，廢棄物能發電佔台灣再生能源供給的六成四。

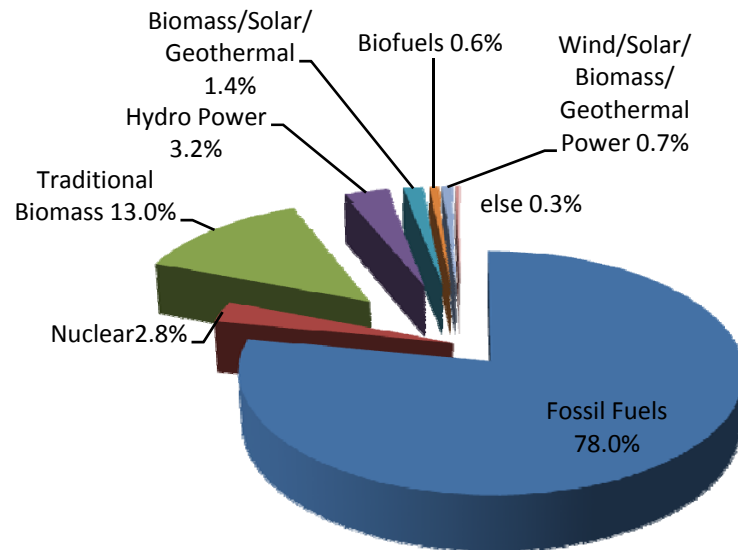
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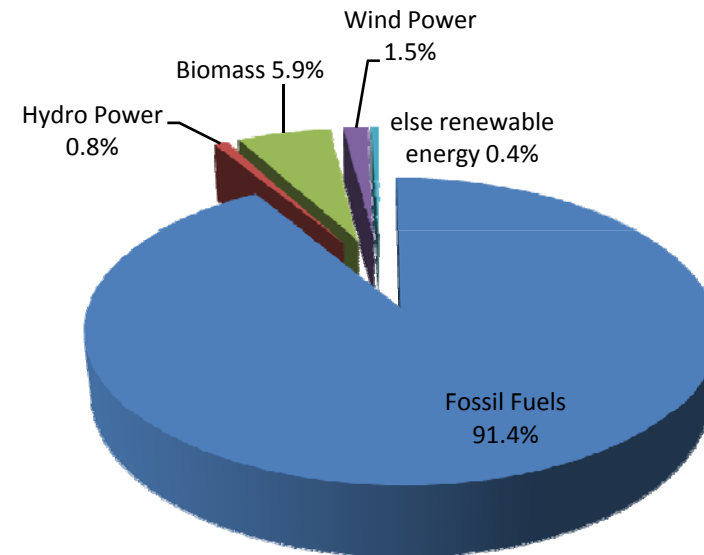
# Biomass

- Biomass is the first priority of alternative energy.
- Biofuels can replace coal fuel.
- Cellulosic biomass has no competing with food.
- The efficiency of gasification Synthesis is far better than of fermentation.
- It's necessary to gradually promote mandatory E10 Ethanol Gasoline.



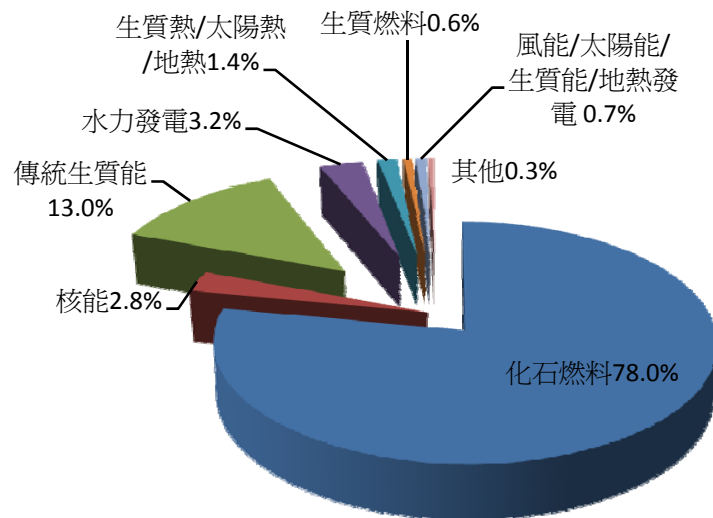
2009 Global Energy Consumption

2007 Germany Energy Consumption



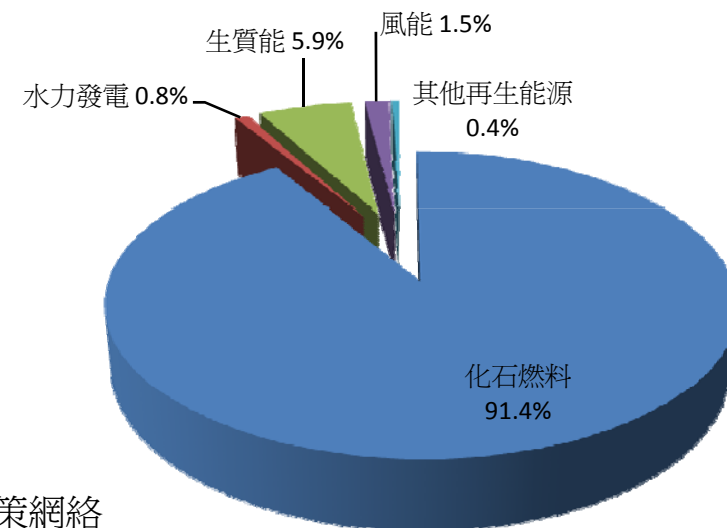
# 生質能

- 生質能是替代能源第一順位。
- 生質燃料可替代煤燃料。
- 纖維素生質能沒有與食物競合困擾。
- 第二代生質能汽化合成法效率遠勝於發酵法。
- 應逐步推動強制E10酒精汽油。



2009年世界能源總供給

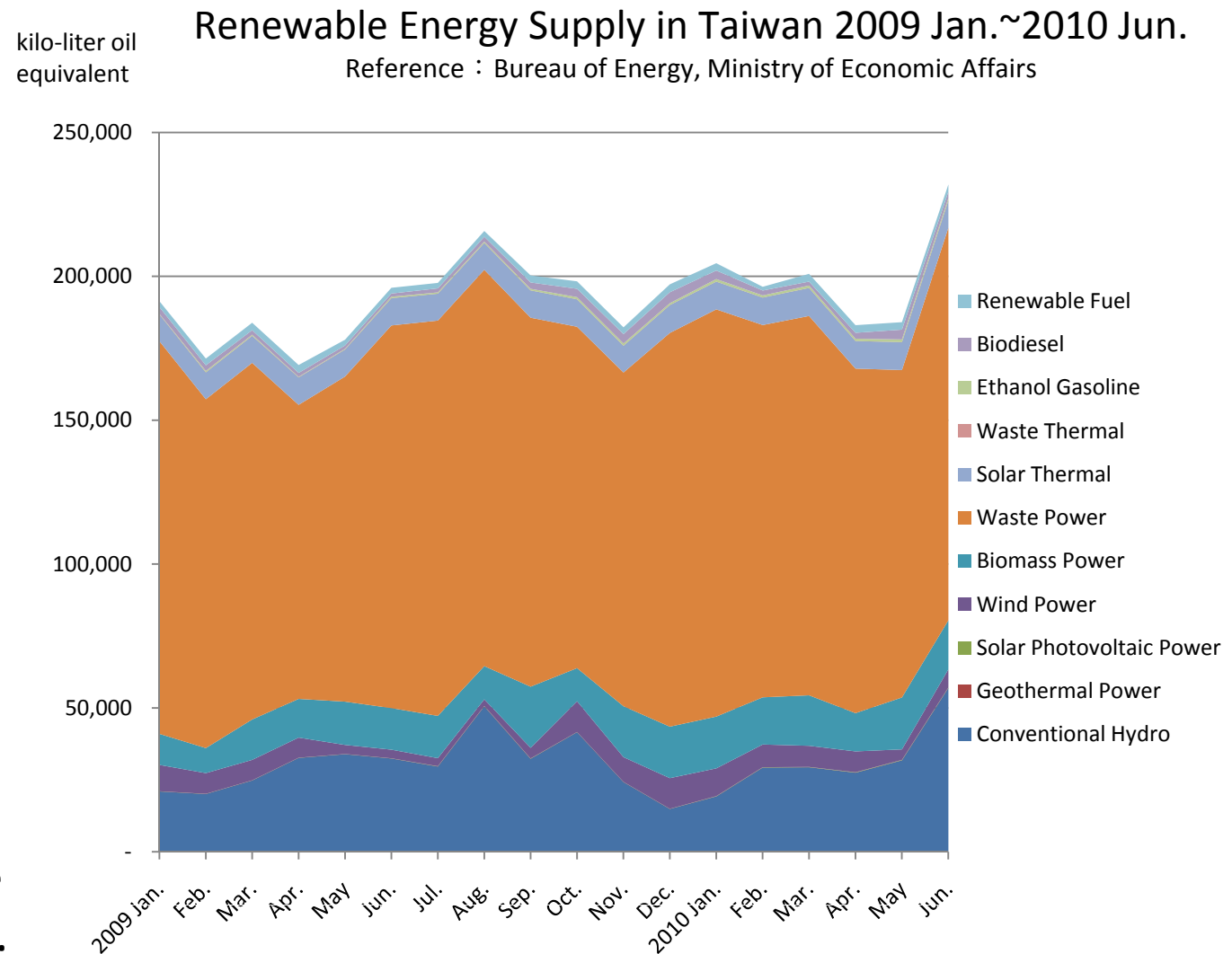
2007年德國能源總供給



資料來源：2010可再生全球狀況報告，21世紀再生能源政策網絡

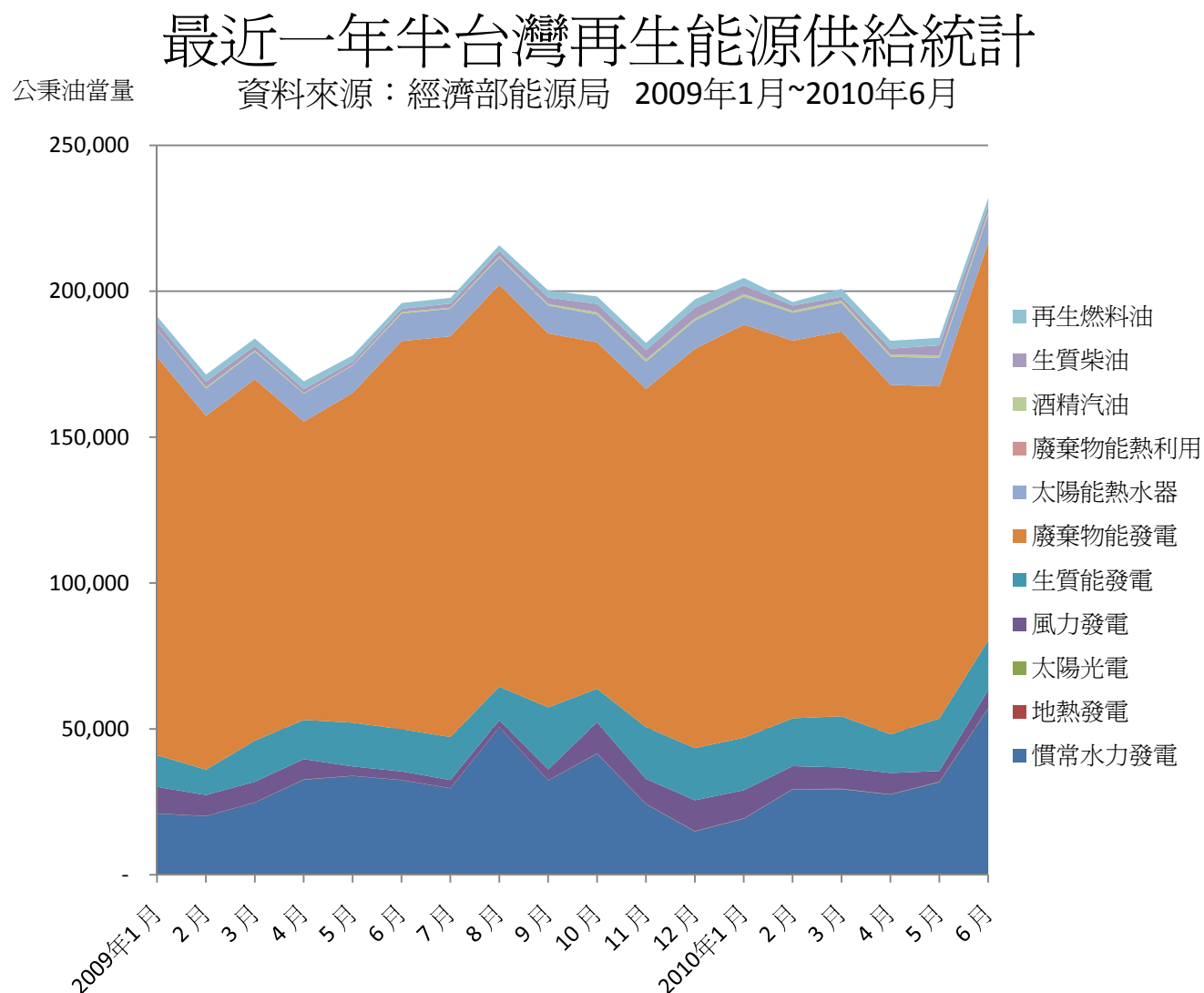
# Renewable Energy Supply in Annual cycle

- Conventional Hydro Power Supply is maximum in August to October.
- Wind Power Supply is minimum in May to September.
- Solar Photovoltaic Power and Wind Power are complementary.



# 再生能源供給的年度週期變化

- 慣常水力發電在八到十月為最大值。
- 風力發電在五到九月為最小值。
- 太陽光電發電與風力發電為互補的。



# How much energy can be extracted from wind

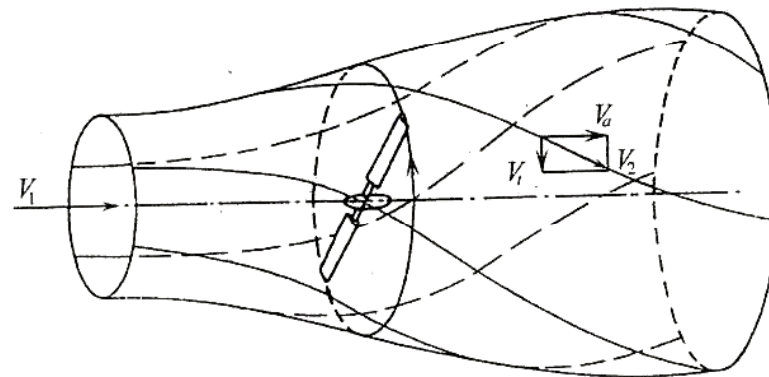
## — Batz limit

- Wind turbine can use the energy of nature wind by energy conversion. Wind turbine changes kinetic energy of wind into mechanical energy and then changes into electrical energy.
- So wind turbine can generate electricity. The greater energy of wind, the more electricity that wind turbine can generate.
- However, energy conversion by wind turbine must satisfy the laws of fluid dynamics, according to the theoretical analysis of German physicist Albert Batz in 1919, the power coefficient of wind turbine is less than 0.593.

$$P_O = \frac{1}{2} \rho A V^3 C_p \eta_m \eta_G \eta_I$$

$$C_p = \frac{8\lambda^2}{R^4} \int_0^R \frac{\omega}{2\Omega} (1-k) r^3 dr \quad \lambda = \frac{\Omega R}{V_1}$$

$$\text{Max } C_p = 4 \left( \frac{2}{3} \right)^2 \left( 1 - \frac{2}{3} \right) = 0.59259...$$



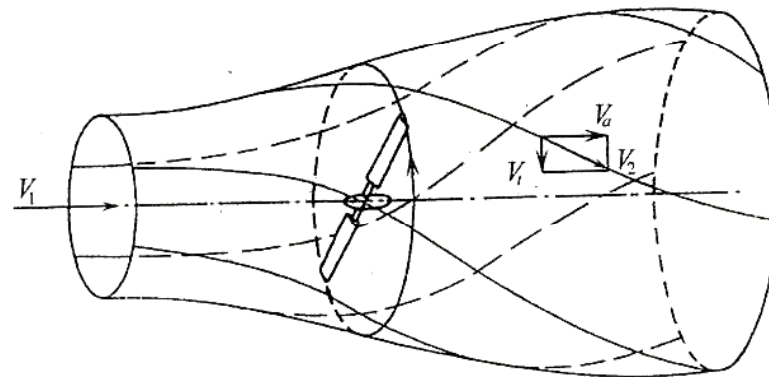
# 從風中可以提取多少能量－貝茲定律

- 風力機是藉由能量轉換將自然界風的能量拿來利用，風力機將風的動能轉化成機械能再轉化成電能，所以風力機能發電。
- 風的能量越大，則風力機發的電就越多。
- 風力機轉換能量還必須滿足流體動力學的定律，依據德國物理學家貝茲**1919**年的理論推導，風力機的功率係數不可能大於**0.593**。

$$C_p = \frac{8\lambda^2}{R^4} \int_0^R \frac{\omega}{2\Omega} (1-k) r^3 dr \quad \lambda = \frac{\Omega R}{V_1}$$

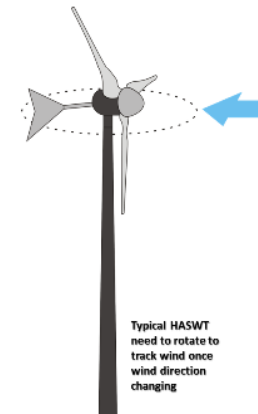
$$\text{Max } C_p = 4 \left( \frac{2}{3} \right)^2 \left( 1 - \frac{2}{3} \right) = 0.59259...$$

$$P_O = \frac{1}{2} \rho A V^3 C_p \eta_m \eta_G \eta_I$$



# Different Types of Wind Turbine

- In general, vertical-axis wind turbine is slower-rotation, lower noise and the power coefficient is smaller, the range of value is about 0.25 to 0.3.
- Horizontal-axis wind turbine is faster-rotation, higher noise and the power coefficient is larger, the range of value is about 0.3 to 0.35.
- Hi-VAWT wind turbines are highly efficient types of wind turbine in VAWT, their power coefficient are about 0.3. Hi-VAWT wind turbines have double advantages of high efficiency and low noise.

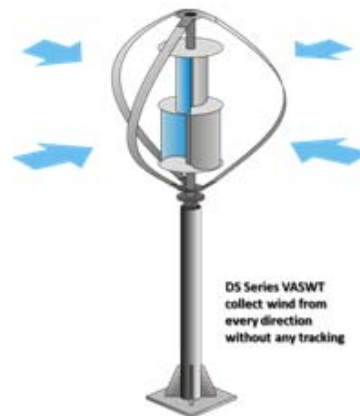


Reference : <http://www.hi-vawt.com.tw/>

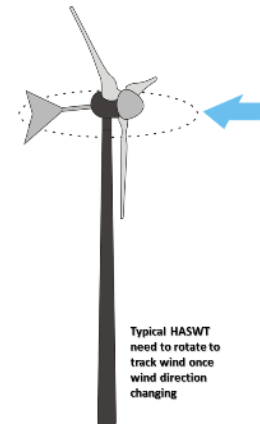
# 不同型式的風力機

- 一般而言，垂直軸式風力機轉速慢，噪音小，但功率係數較小，值約0.25~0.3。
- 水平軸式風力機轉速快，噪音大，但功率係數較大，值約0.3~0.35。
- 新高風力機屬於垂直軸式風力機中高效率機種，功率係數值約0.3，兼具高效率、噪音小雙重優勢。

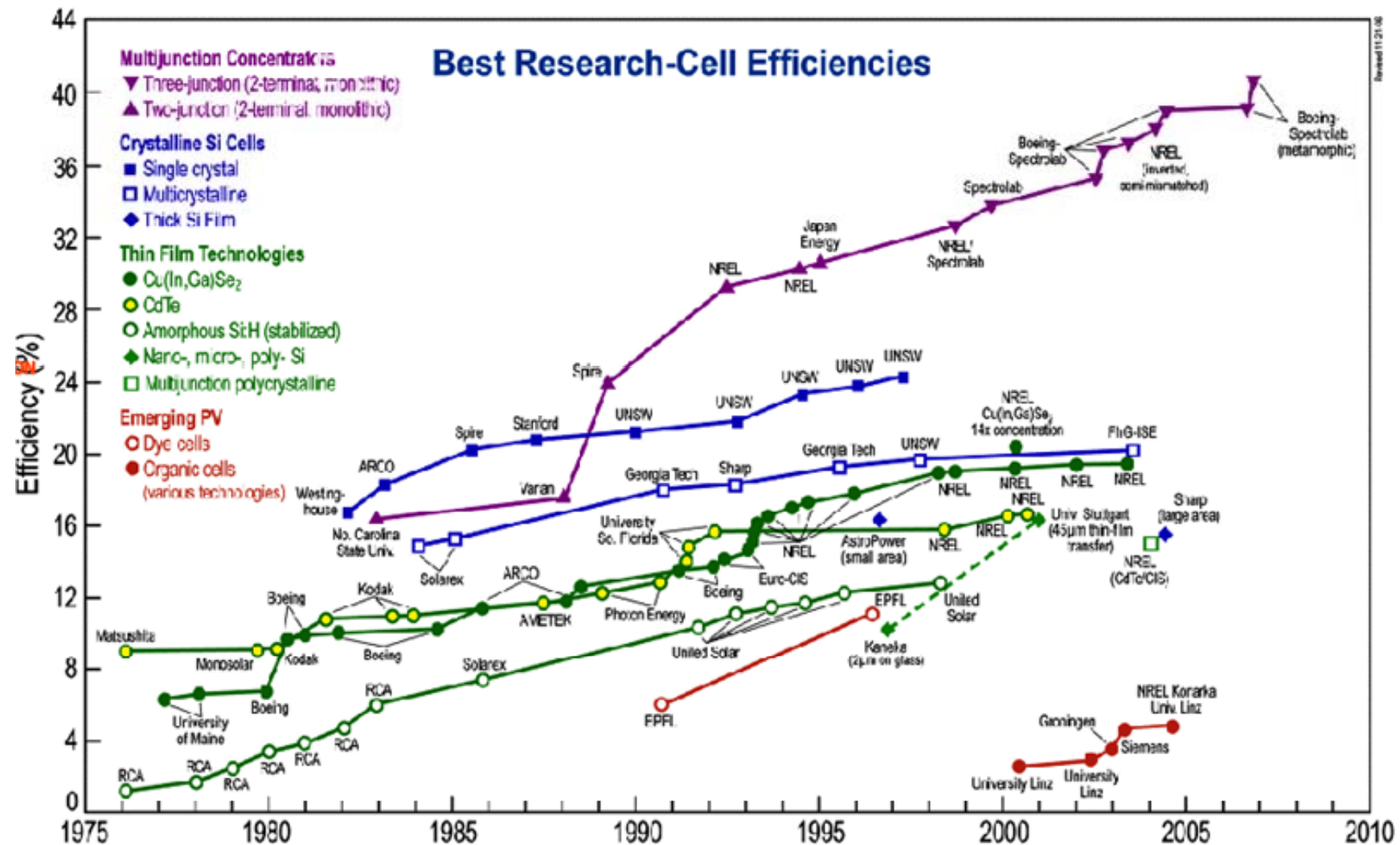
垂直軸式風力機



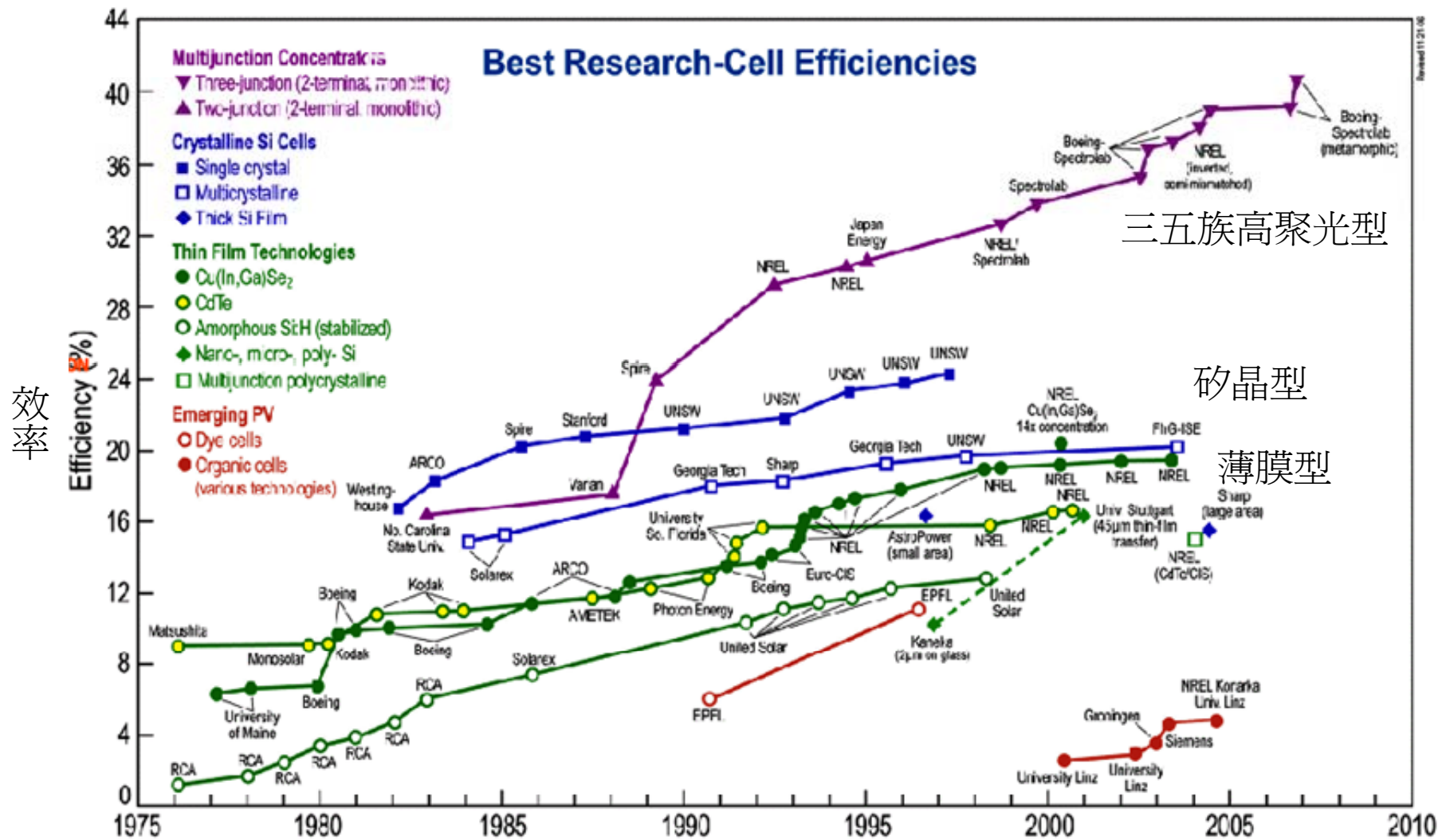
水平軸式風力機



# Different Types of Solar Photovoltaic Cell



# 不同型式的太陽光電晶片

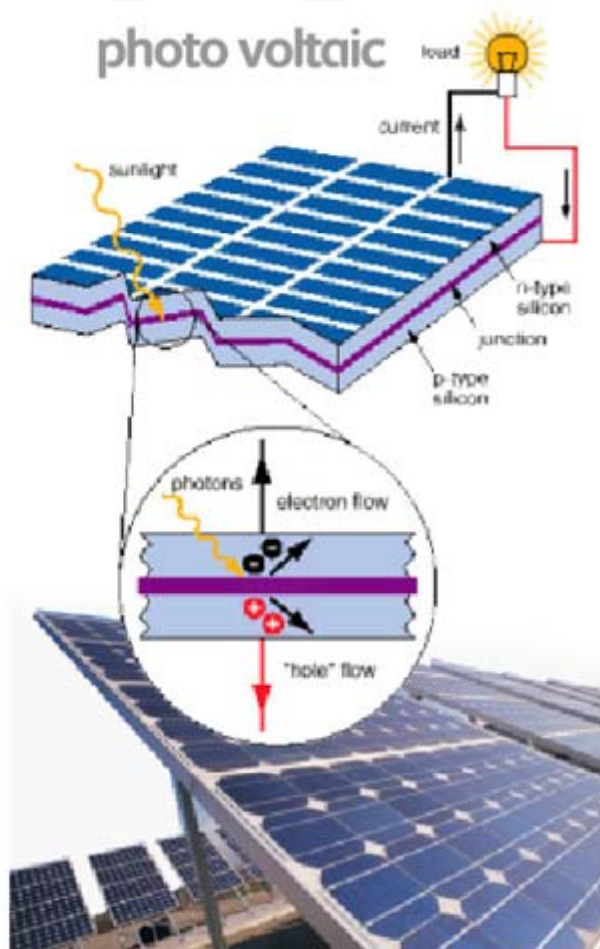


# SOLAR POWER GENERATOR TYPE

Typical silicon cell  
  
 0.071 W/in<sup>2</sup>  
 Conversion efficiency 11~20%

PV

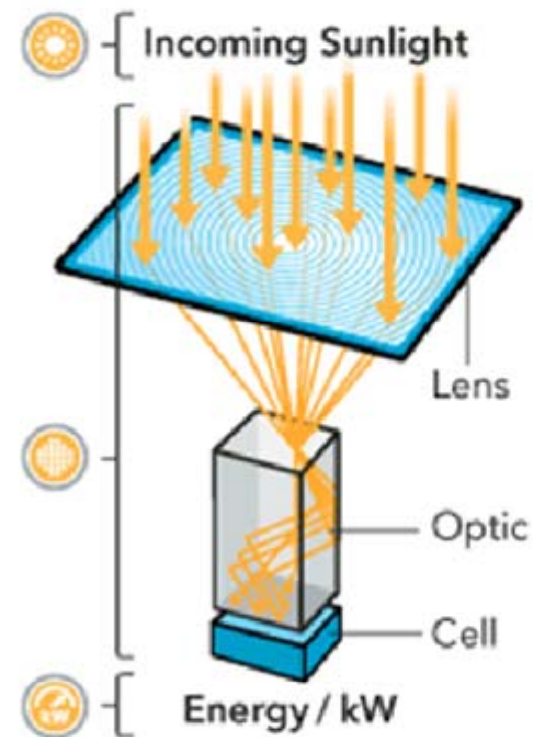
photo voltaic



Spectrolab cell  
 56.8 W/in<sup>2</sup>  
  
 Conversion efficiency > 36%

CV

constant voltage



HE Optics System

# SOLAR POWER GENERATOR TYPE

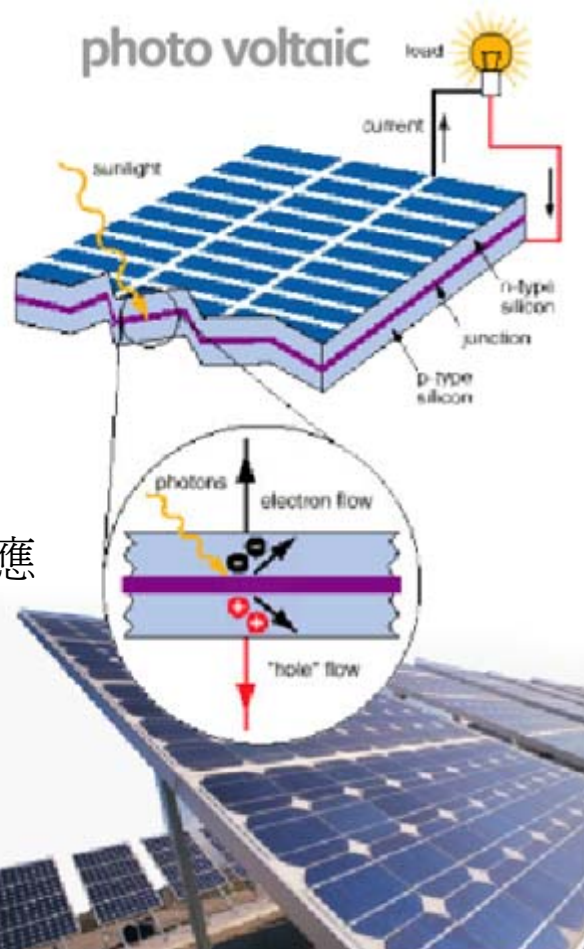
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太陽  
光電  
發電

光電效應

PV

photo voltaic

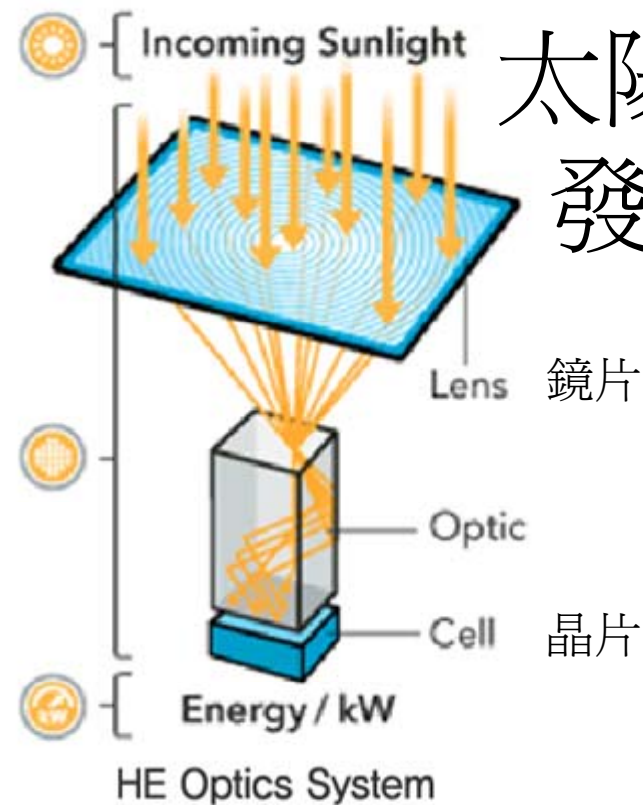


Spectrolab cell  
 56.8 W/in<sup>2</sup>  
  
 Conversion efficiency > 36%

CV

constant voltage

高聚光  
太陽能  
發電



# Conclusion

- Current energy consumption is very large, renewable energy replace fossil energy is necessary.
- Controversial Nuclear Power Promote Renewable Energy Development.
- Renewable energy in Taiwan, according to their demand for, the first priority is Biomass, followed by Wind Power and Solar Photovoltaic.
- Other types of renewable energy sources should also be developed, including : Hydrogen Energy, Run of River Hydro Power, Geothermal, Ocean Energy, etc.
- In addition to provide renewable energy as alternative energy, it still need to adjust the industrial structure, eliminating the high energy-consuming industries.

# 結論

- 目前能源消耗相當大，急需以再生能源取代化石能源。
- 核電爭議促進再生能源發展。
- 適合台灣的再生能源，依其需求量第一順位為生質能，其次為風能、太陽能。
- 其他類型的再生能源也應該開發，包含：氫能、川流式水力、地熱、海洋能等。
- 提供再生能源做為替代能源之餘，仍須調整產業結構，淘汰高耗能產業。