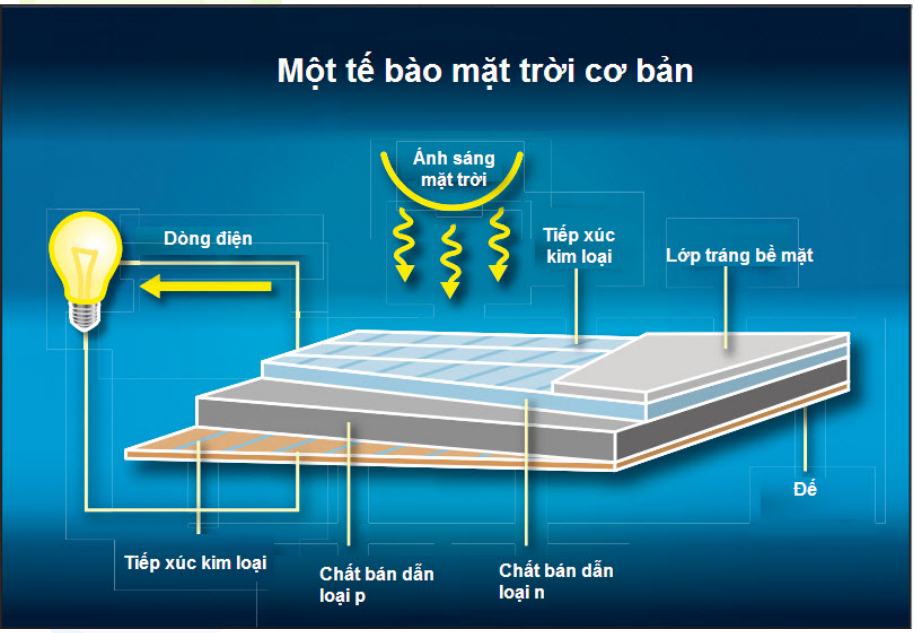
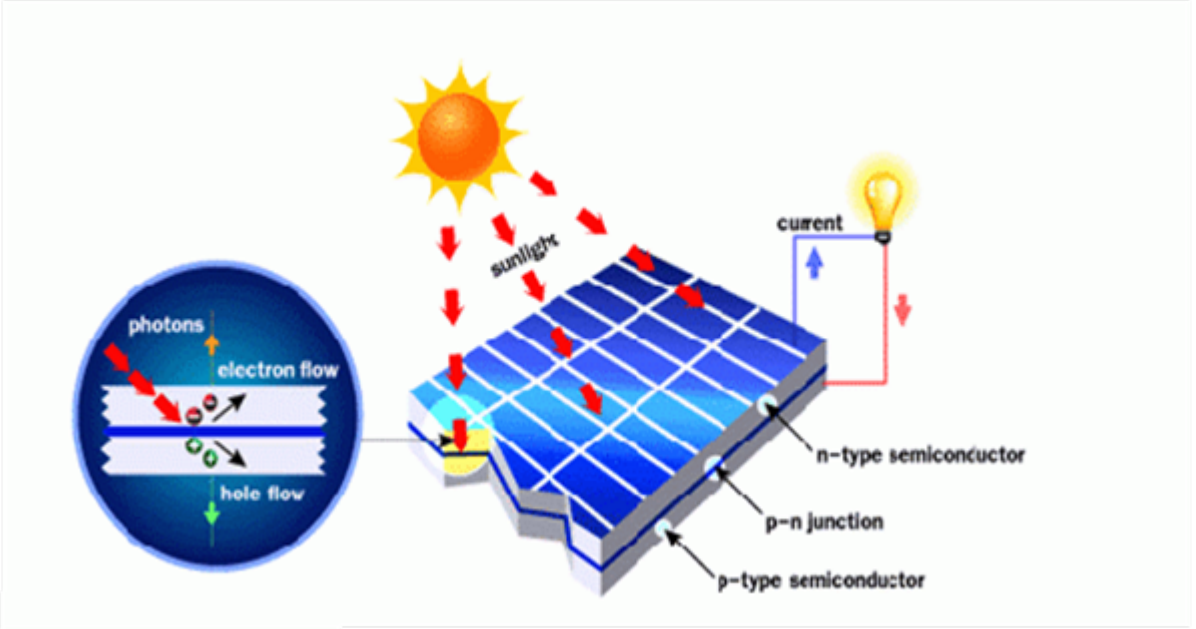
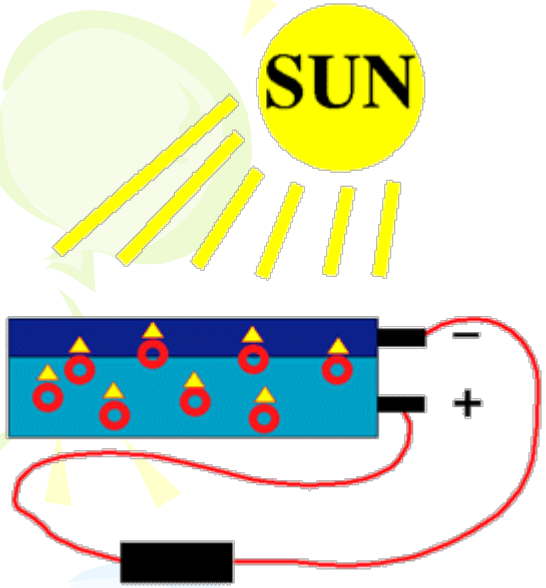
5.1.5.1. Basic Principle



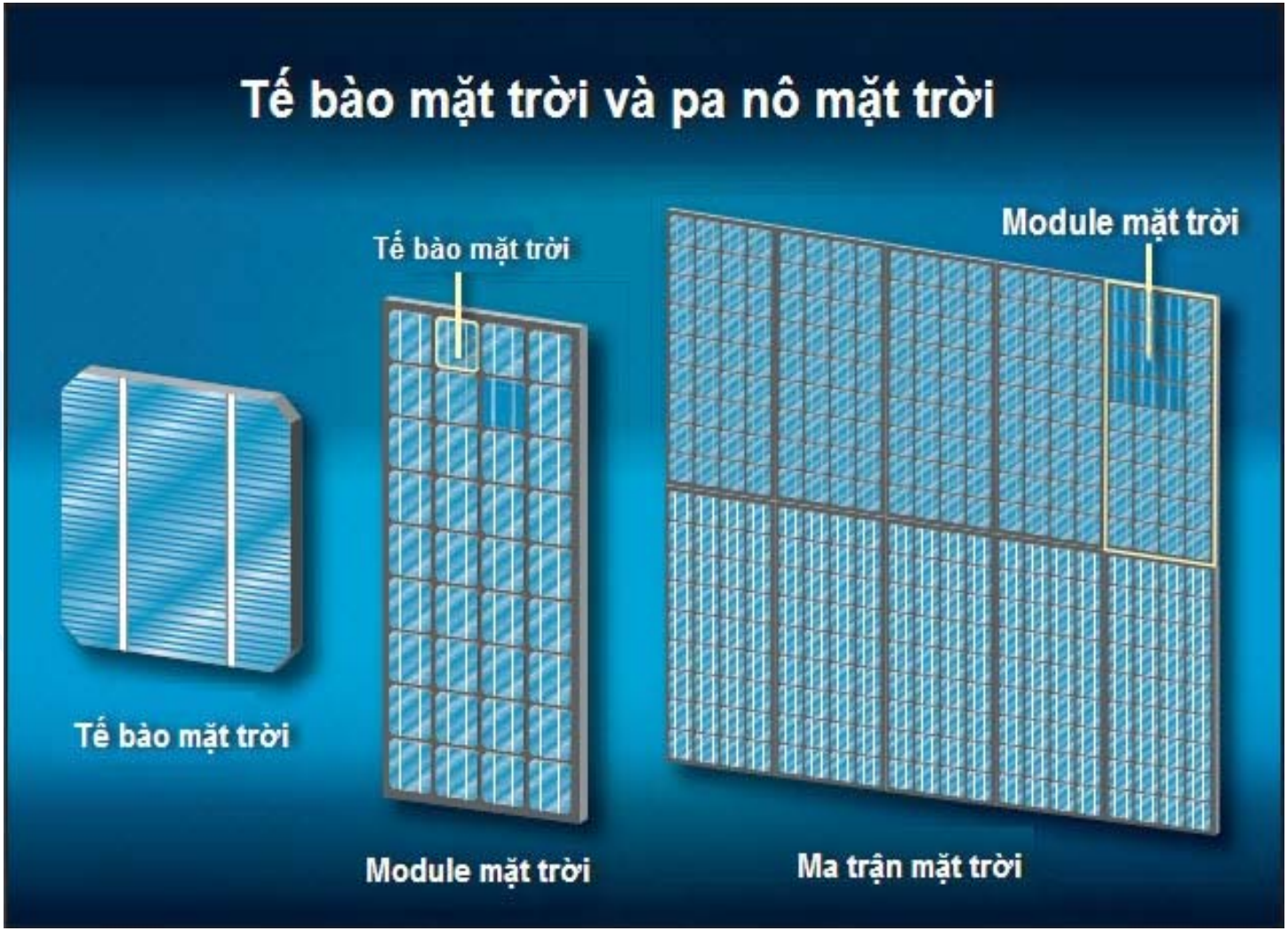




- Radiation rays from the sun to the earth are photons.

- Energy from photons is transferred to the surface of solar PV by which electrons (red circles) are separated from atoms and then, they mass together at the top surface. Thus, the balance of electrons between the top surface and bottom surface is not maintained

- When connecting two surfaces by a electrical conductor, there will has a stream of electrons from the top surface to the bottom surface


Tế bào mặt trời và pa nô mặt trời
Tế bào mặt trời
Module mặt trời
Tế bào mặt trời
Module mặt trời
Ma trận mặt trời

5.1.5.2. Examples

KANSAI Electric power company, Japan (10/2011)

Discussions

- Actual State of solar PV in? advantages/disadvantages
- Updated information of solar PV in Vietnam?
- Solutions to promote more solar PV applications in Vietnam?

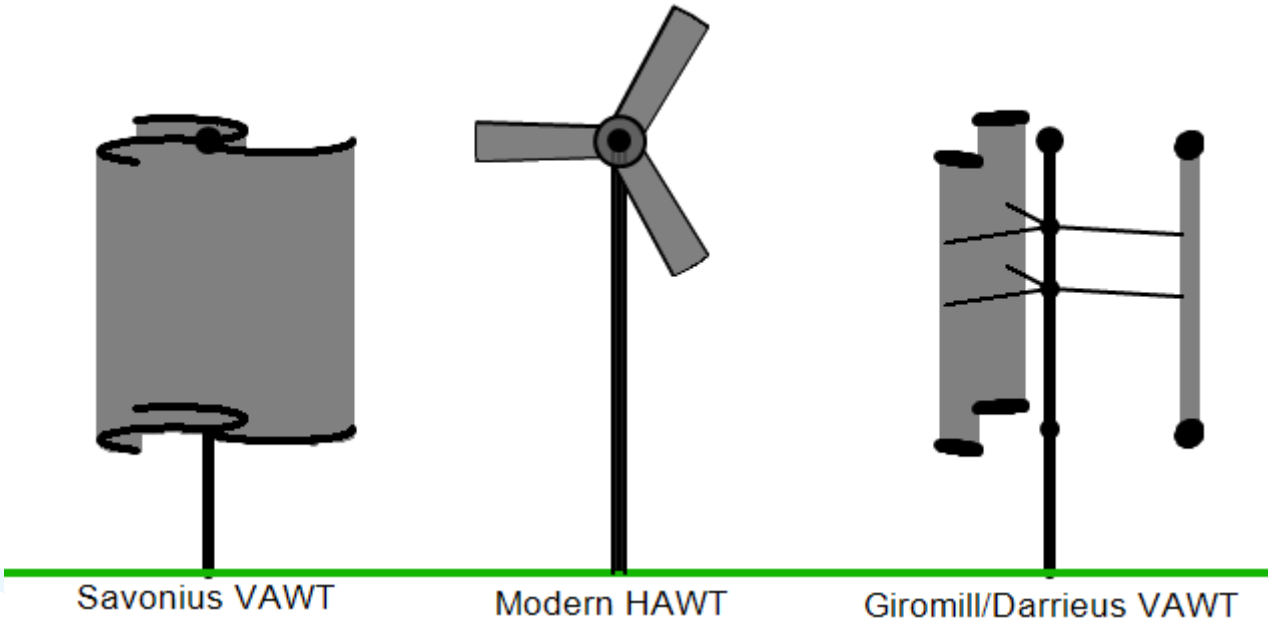
5.2. Wind Energy

Classification

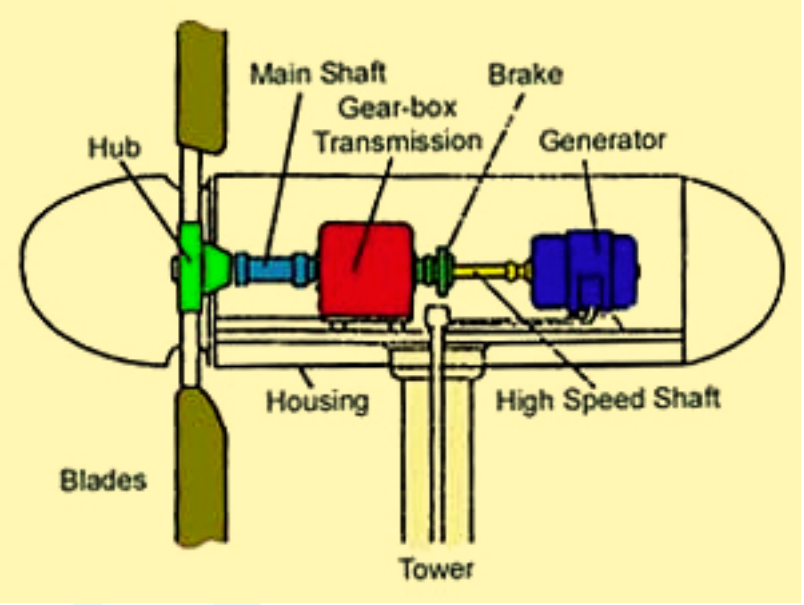
- Horizontal-axis wind turbines
- Vertical-axis wind turbines
  - Darrieus
  - Savonius

- Darrieus wind turbine

- Savonius wind turbine


Savonius VAWT
Modern HAWT
Giromill/Darrieus VAWT


AGRIBANK



- Use wind to create work → for different purposes: generator, water pump,…

Determine P_W (W)

- Consider total wind power flowing through an imaginary area A :

$$P_W = \frac{1}{2}\dot{m}u^2 = \frac{1}{2}\rho A u^3$$

- Where:

  u – wind speed, *m/s*

  ρ - the air density, kg/m^3

  $\dot{m} = \rho A u$ - the volume of air passing through A , kg/s

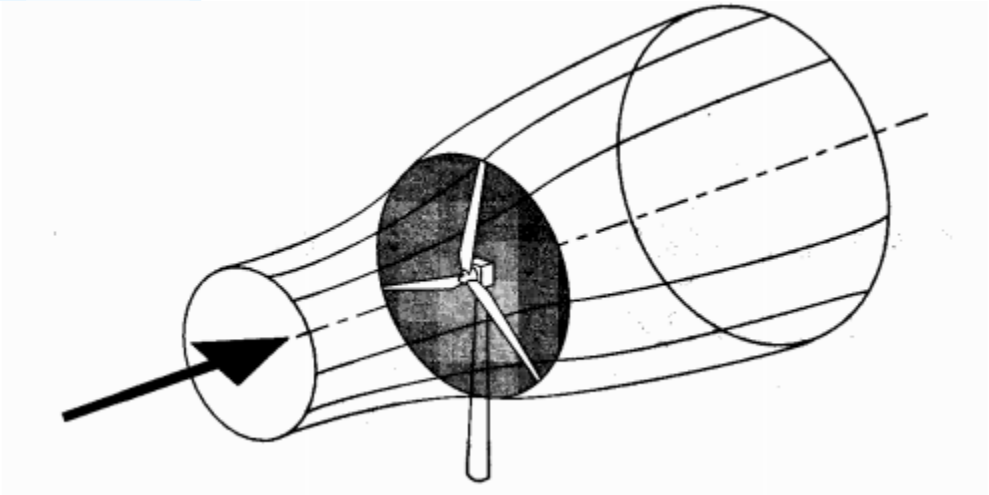
- ***Question***: Can the outcome power P_r obtained from wind turbines achieve P_W?

- ***Answer***: No. This only happens if no wind go through the rotor, which is impossible in practice

- Denoted by C_P the power coefficient, and by definition, C_P is determined by:

$$C_P = \frac{P_r}{P_W}$$

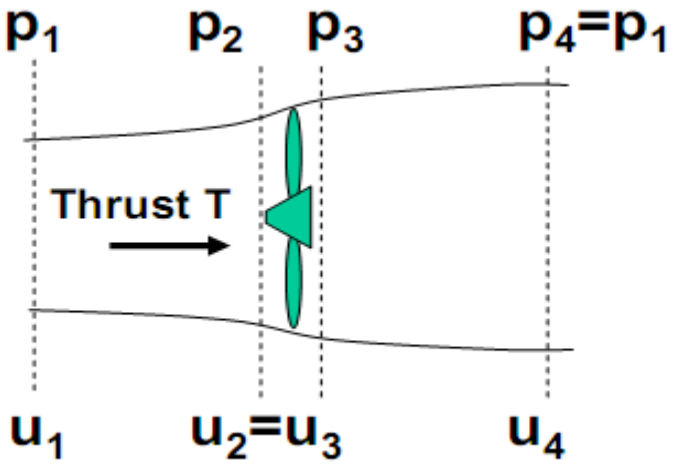
BETZ limit



- The wind will be diffused behind the rotor and thus, in practice, P_r must be smaller than P_W.
- BETZ shows that the maximum value of C_P is 0,593.

Assumptions in BETZ limit theory

- No friction
- The working fluid is not pressed, and it move stably
- The wind peed is only changed along the rotor's axis



- Bernoulli equation:

$$p_1 + \tfrac{1}{2}\rho u_1^2 = p_2 + \tfrac{1}{2}\rho u_2^2 \qquad p_3 + \tfrac{1}{2}\rho u_3^2 = p_4 + \tfrac{1}{2}\rho u_4^2$$

- Result:

$$p_2 - p_3 = \tfrac{1}{2}\rho(u_1^2 - u_4^2)$$

($p_1 = p_4$ and $u_2 = u_3$)

- Force and momentum balance:

$$T = A(p_2 - p_3) \quad \text{and} \quad T = \dot{m}(u_1 - u_4) = \rho u_2 A(u_1 - u_4)$$

- Therefore:

$$T = \tfrac{1}{2}\rho A(u_1^2 - u_4^2)$$

$$u_2 = \tfrac{1}{2}(u_1 + u_4)$$

- ***Conclusion***: the wind speed at the rotor's surface is the mean of incoming and outgoing wind speeds from the rotor

Vertical-axis decline coefficient

- Denoted by a the vertical-axis decline coefficient, which is defined as

$$u_2 = u_1(1 - a)$$

- We have:

$$u_4 = u_1(1 - 2a)$$

- So,

$$T = 2 \rho A u_1^2 a (1-a)$$

Results of BETZ limit

- Power obtained at the output of wind turbines:

$$P_r = T\,u_2 = \tfrac{1}{2}\,\rho A u_1^3\,4a\,(1-a)^2$$

- Power coefficient:

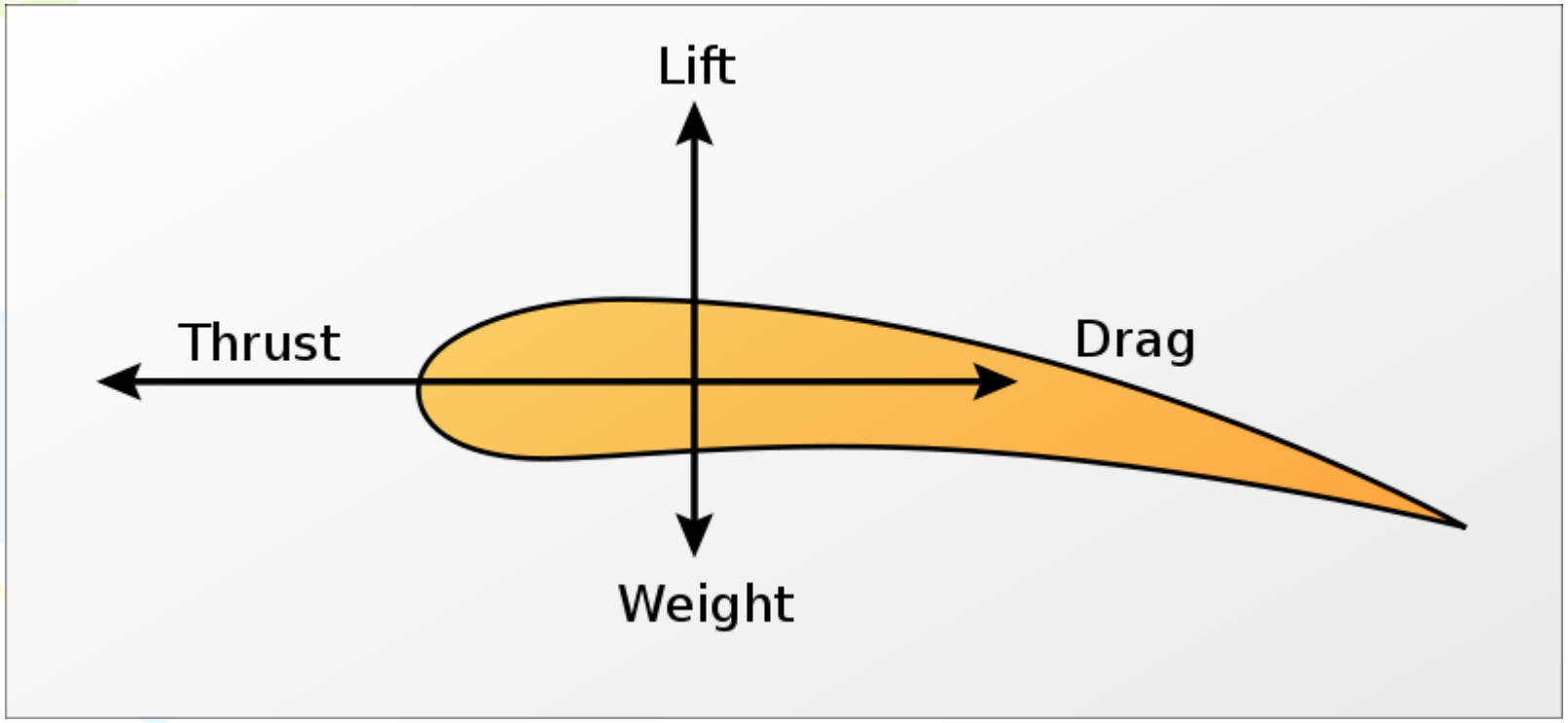
$$C_p = 4a(1-a)^2$$

- When a = 1/3, C_P is maximum, which is called BETZ limit:

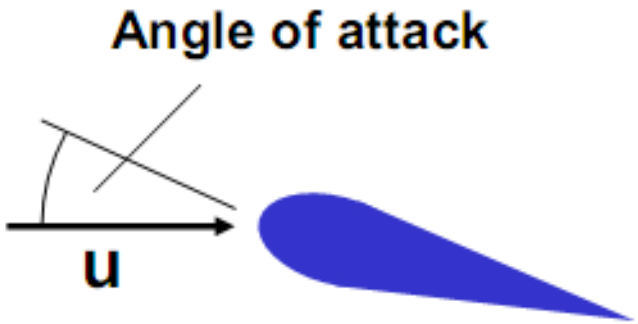
$$C_p = 16/27 = 0.593$$

- The corresponding value of T is:

$$T = (4/9)\,\rho A u_1^2$$

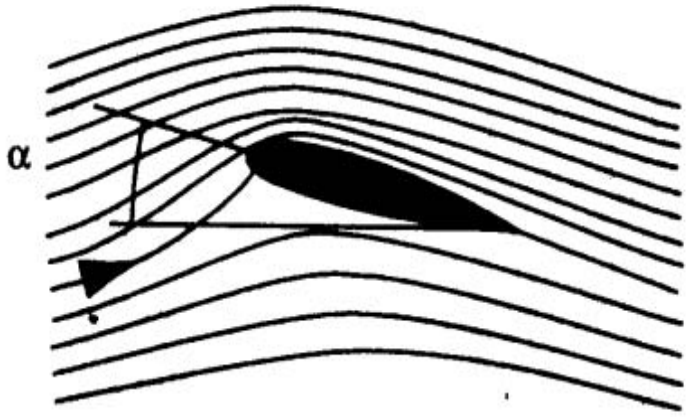


Lift is several times larger than Drag



- When angle of attack α gets larger, lift is higher until stall happens

No stall

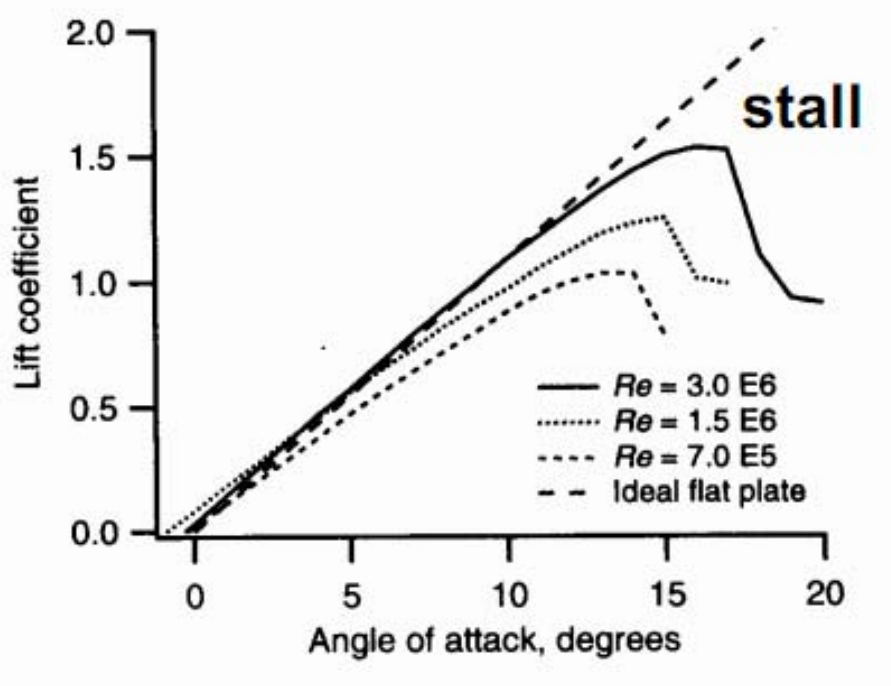


Stall

- We have:

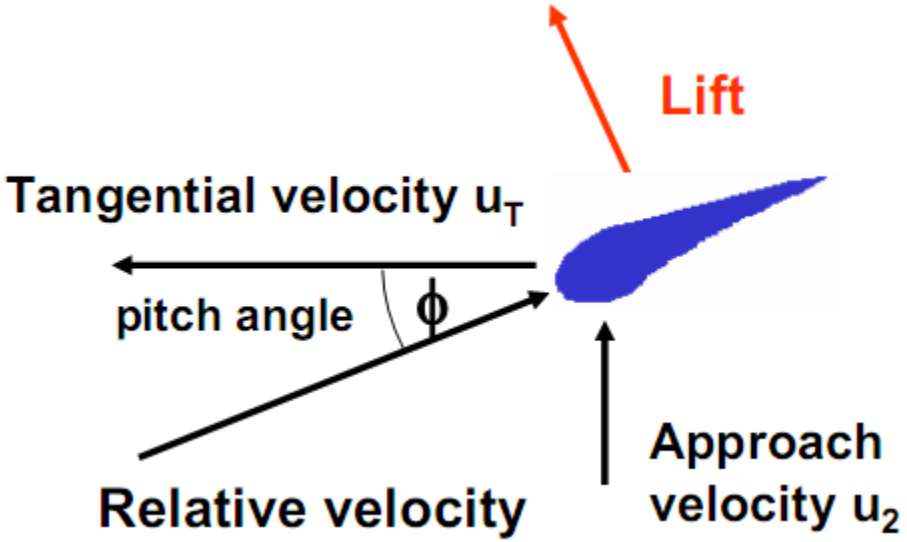
Lift $= \frac{1}{2} \rho u^2 C_L A$

Where, C_L is the Lift coefficient and A is aerofoil area.



- Based on BETZ's law and the aerodynamics theory, we can determine the theoretical shape of the rotor's propellers
- Consider a propeller as a lots of short sections, length δr
- The working state at some points on the propeller depends on their position.

Relative velocity



* Note: Tangential velocity is much higher than the wind speed

* Relative velocity u_{rel}:

$$u_{rel} = \sqrt{u^2_T + u^2_2}$$

Top-propeller velocity ratio

- Denoted by λ is Top-propeller velocity ratio, which is a ratio between the velocity at the top of the propeller u_{tip} and the wind speed u_1, ta có:

$$\lambda = u_{tip}/u_1$$

- Denoted by R the radius of the rotor, we can determine the Tangential velocity u_T at a position with radius r as follow:

$$u_T=(r/R)\ \lambda\ u_1$$

- when a = 1/3, C_P is maximum, and we have

$$u_2 = \frac{2}{3}u_1$$

- Denoted by ϕ Pitch angle, we have:

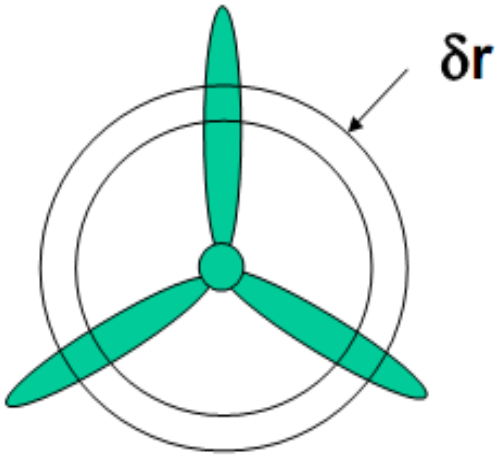
$$tg\phi = u_2/u_T$$

- So:

$$\phi = \arctan\left[\frac{2}{3(r/R)\lambda}\right]$$

- We have a force T:

$$\mathbf{T = (4/9)\ \rho A u_1^2}$$

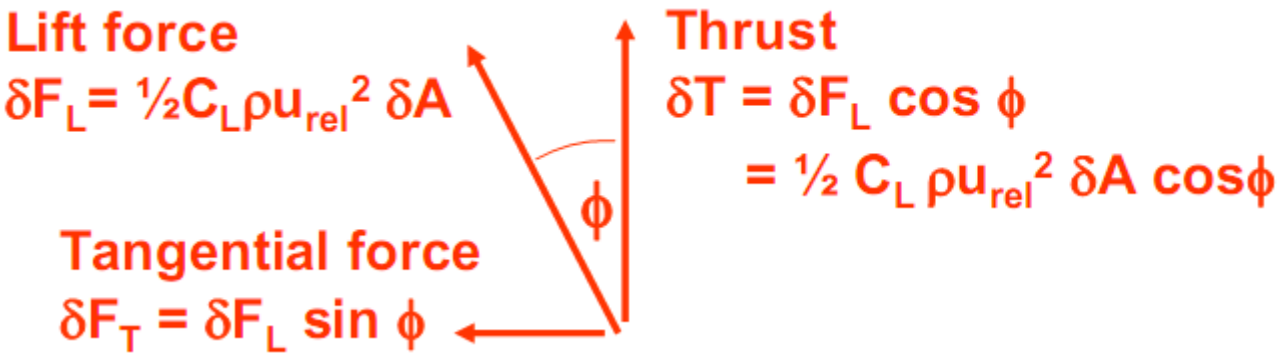


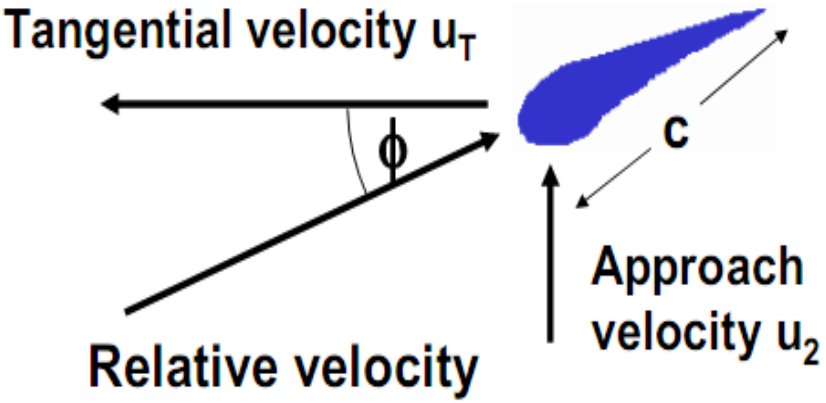
- Applying BETZ formula for this left hand size figure with thickness δr:

$$\delta T = (4/9)\,\rho\, 2\pi r\, \delta r\, u_1^2$$

- Consider an ideal rotor, we have:

Lift force $\delta F_L = \frac{1}{2} C_L \rho u_{rel}^2\, \delta A$





- Let $\delta A = B.\delta r.c$, where B is the number of propellers, and using the result $u_2 = 2/3u_1$ we have:

$$u_{rel} = \sqrt{u^2{}_T + u^2{}_2} = u_2/\mathrm{Sin}\phi$$

- So:

$$\tan \phi \sin \phi = C_L Bc/4\pi r$$

Results

- The propeller's width:

$$c = \frac{8\pi \sin\phi}{3BC_L\lambda_r}$$

- Fling angle:

$$\phi = \arctan\left[\frac{2}{3(r/R)\lambda}\right]$$

Example

- Consider a rotor with 3 propellers, radius R = 5*m*, Lift coefficient C_L is 1, and $\lambda = 7$. We have the following table in the ideal case

r/R	0,2	0,4	0,6	0,8	1,0
Propeller's width	0,86	0,46	0,31	0,24	0,19
Fling angle	27	15	11	8	7

Wind turbine efficiency

- We had

$$P_W = \frac{1}{2}\dot{m}u^2 = \frac{1}{2}\rho A u^3$$

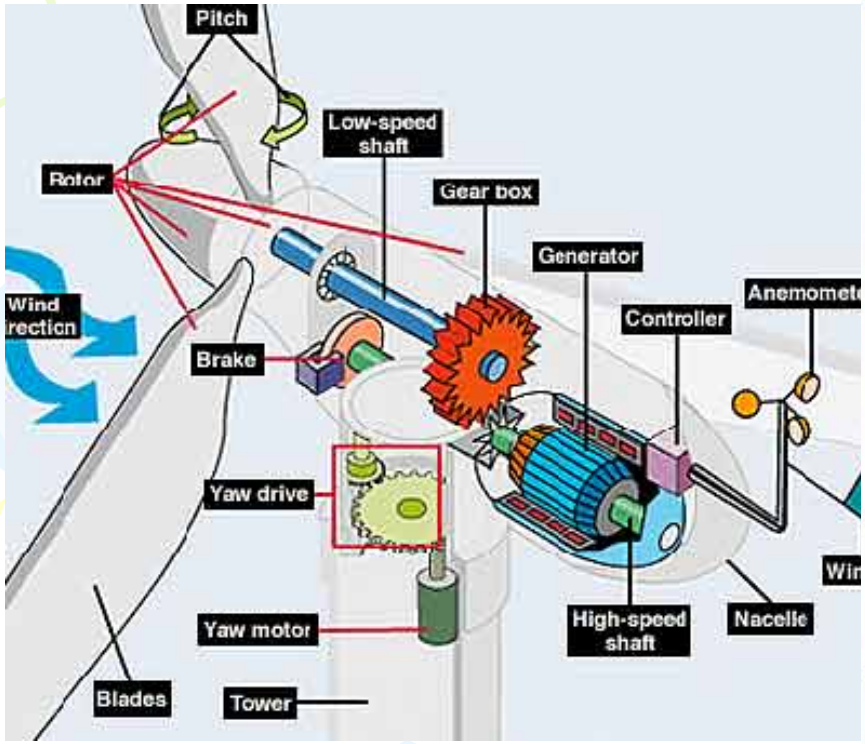
- Denoted by η the wind turbine efficiency and D the diameter of the rotor, we have:

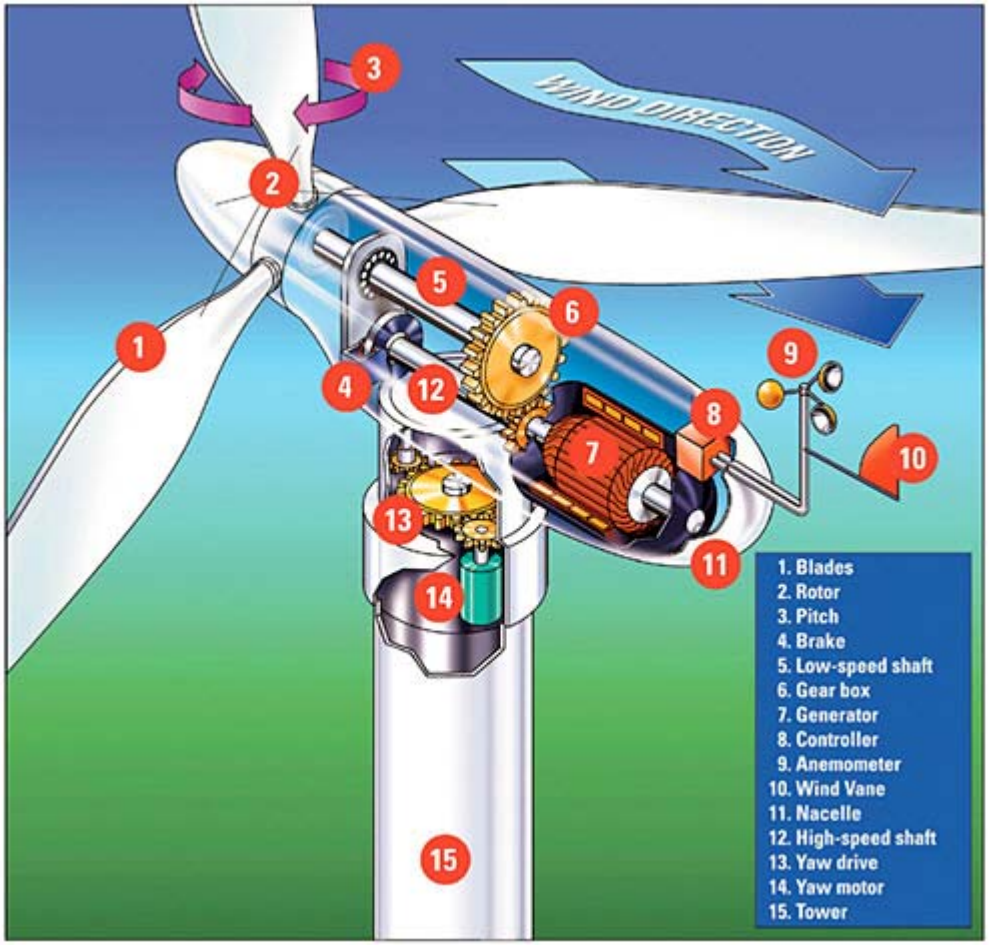
$$P_r = \eta\frac{1}{2}\rho A u^3 = \frac{1}{8}\eta\rho u^3\pi D^2$$

Notes

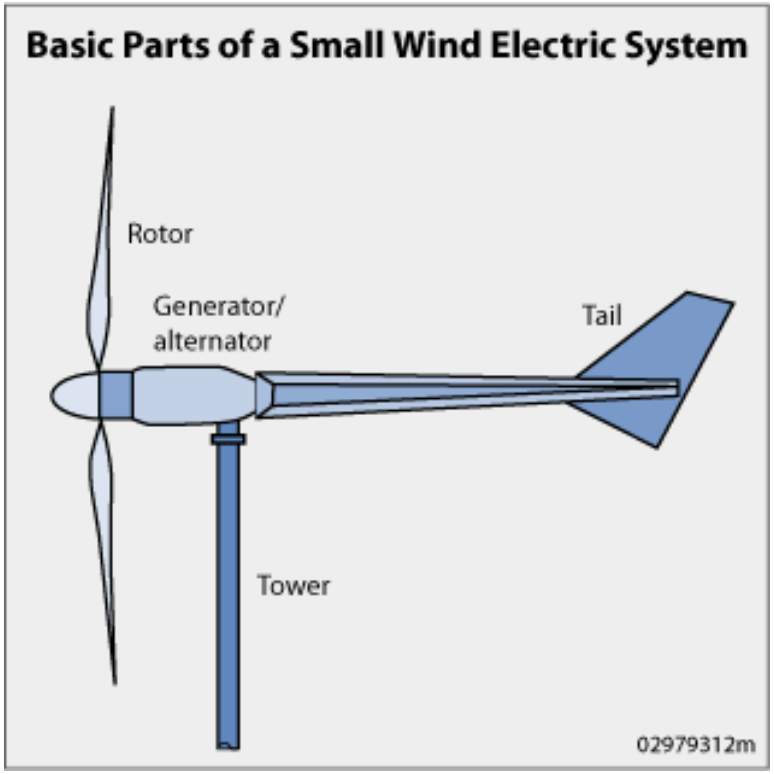
- The wind speeds in a direction should be considered to be the same
- Do not install the wind turbines in areas that are not even and flat. The turbines needs to be far from house and trees also
- The average wind speed should be *7m/s* at *25m height* from the ground.
- Make sure that the minimum distance between the turbines is 10R

Wind electric systems

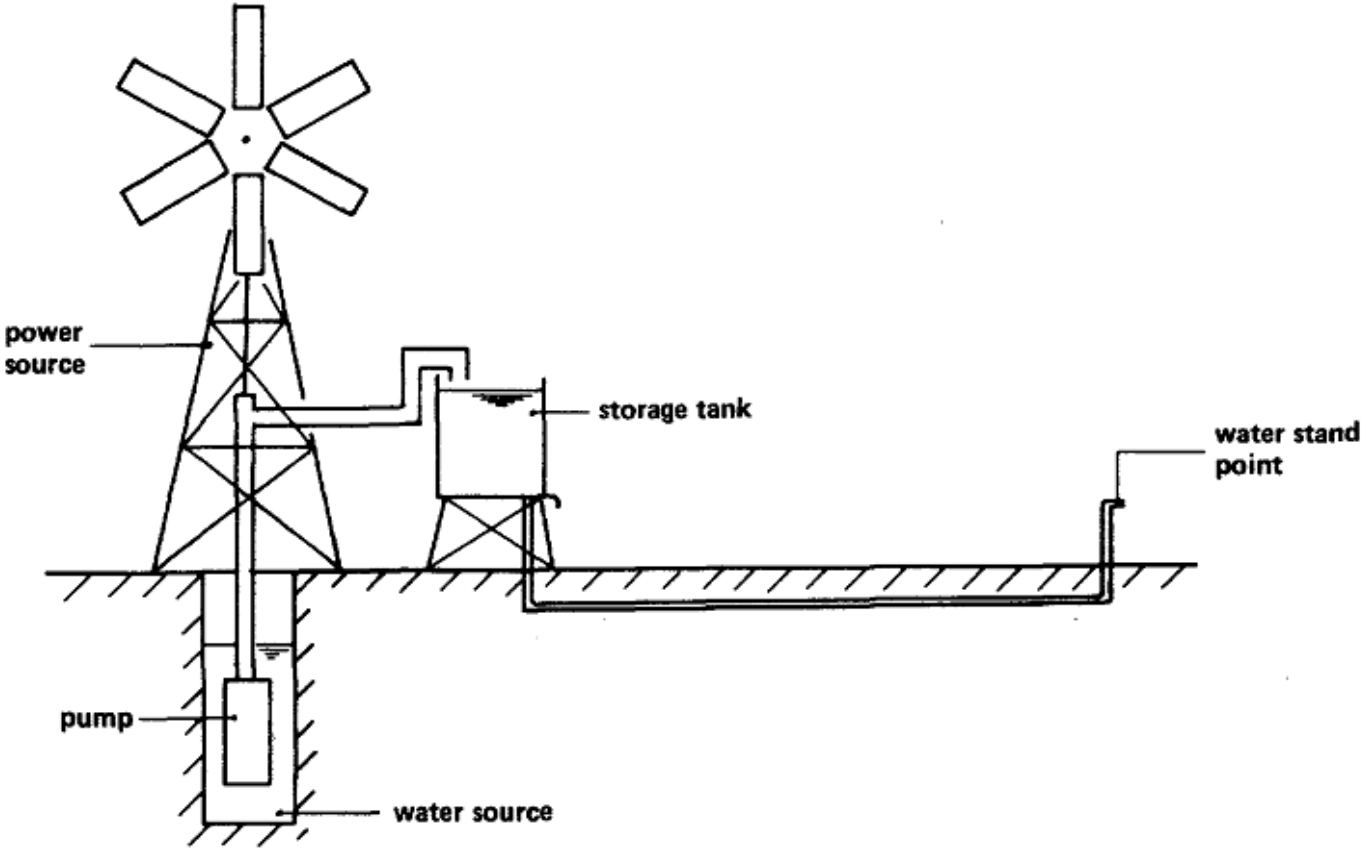


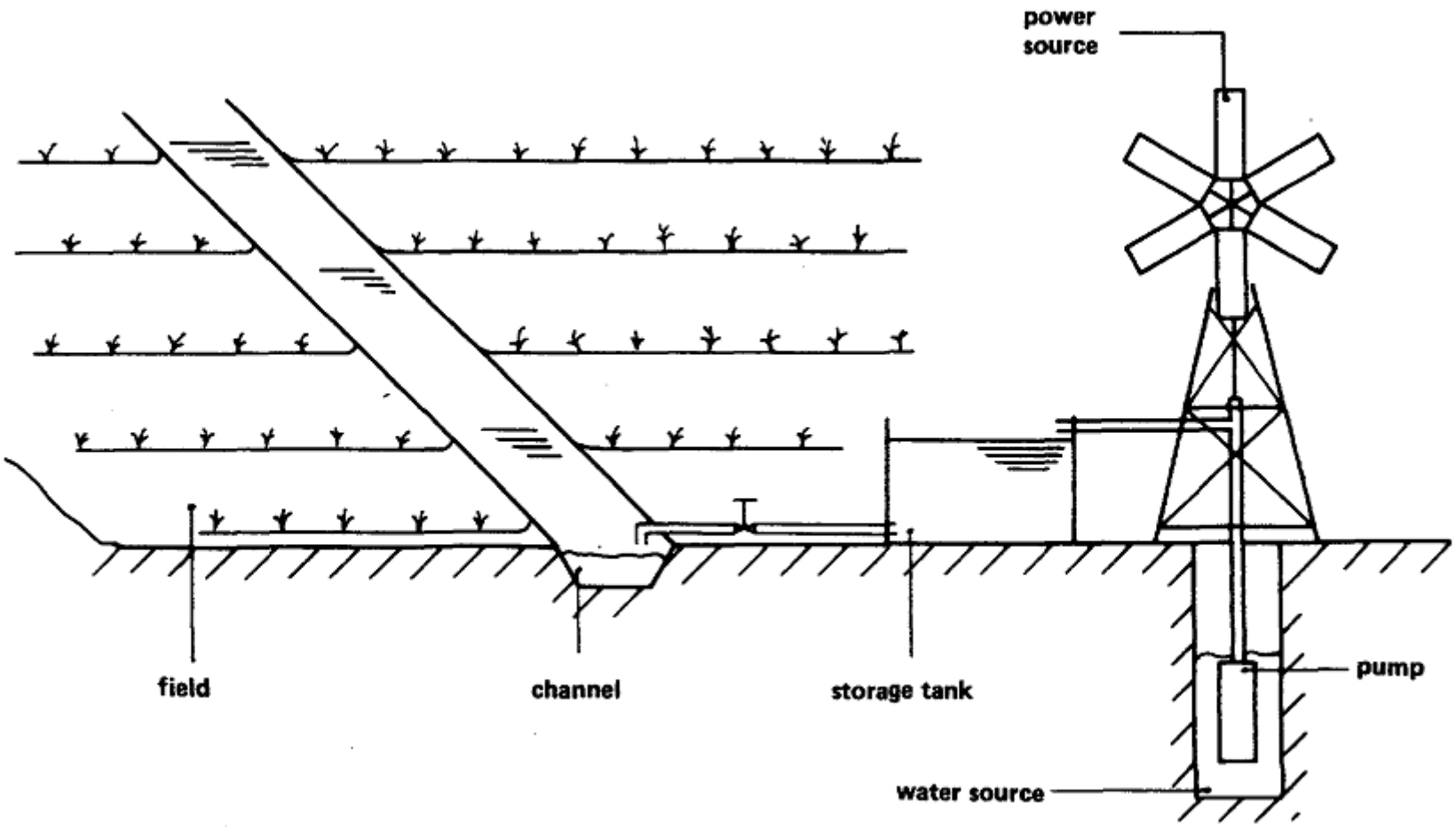


Small-power Wind electric systems



Water-pump wind turbines




power source
field
channel
storage tank
pump
water source

Discussions

- Potentiality of wind energy in Vietnam and possible applications
- Current situation and trends for future?
- Classify wind turbines? Present properties of horizontal-axis and vertical-axis wind turbines.
- Mechanism protecting the turbines in storms?

5.3. Biofuels, Biomass energy & Biogas

BioFuels

- Bioenergy is renewable energy made available from materials derived from biological sources. In its most narrow sense it is a synonym to biofuel, which is fuel derived from biological sources

- Biofuel classification
  - Liquid: Biodiesel and Bioethanol
  - Gas
  - Solid.

BIODIESEL

- Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long chain alkyl (methyl, propyl or ethyl) esters
- Biodiesel is typically made by chemically reacting lipids(e.g., vegetable oil, animal fat (tallow) with an alcohol.

+ Note: Ethanol is rarely used because of high cost

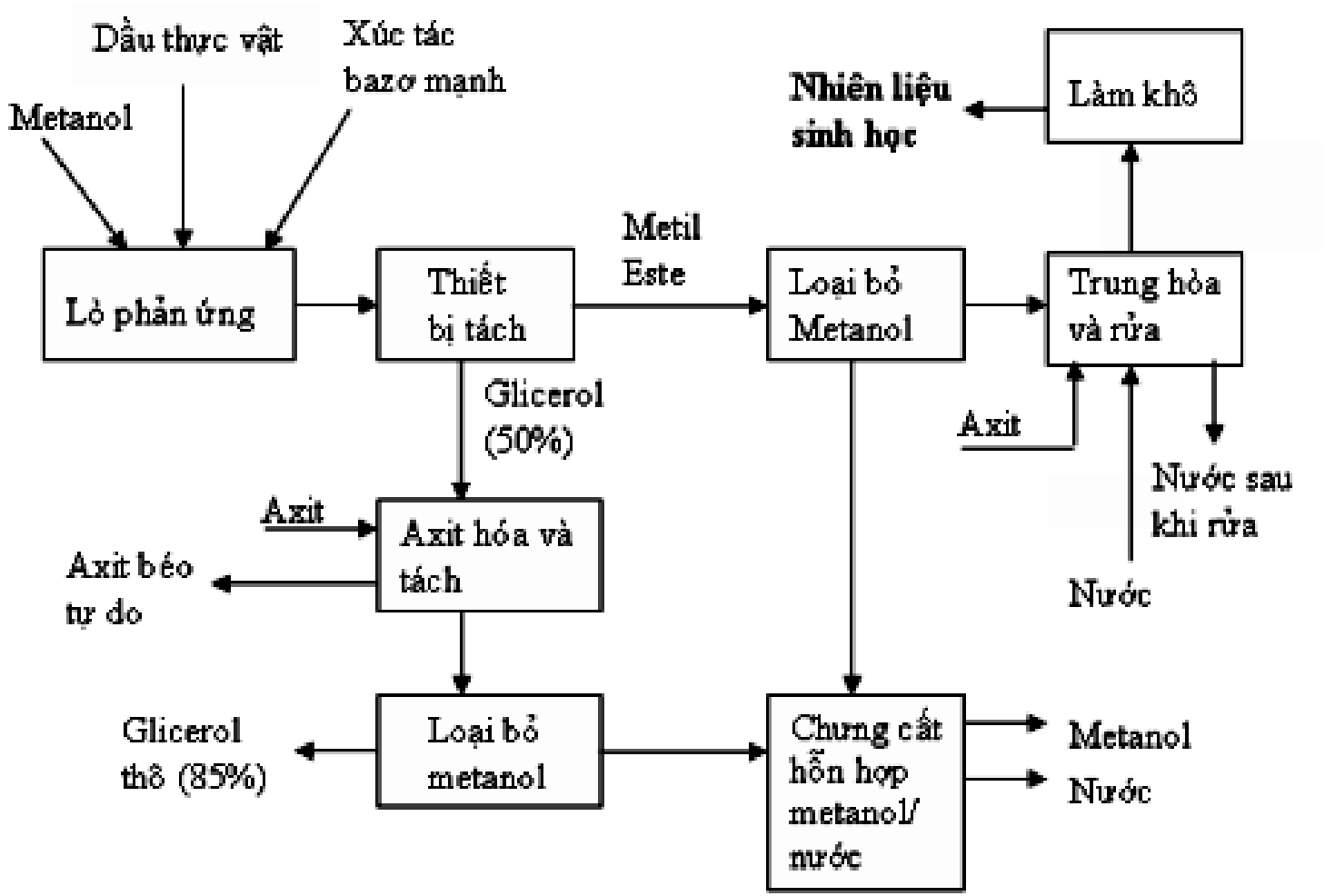
- Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix. For example, B20 refers to 20% biodiesel, 80% petrodiesel

Biodiesel synthesizing method

- Before synthesizing biodiesel:

  + Change grease/vegetable oil into fatty acid
  + Esterification of grease/vegetable oil with acid catalyst
  + Esterification of grease/vegetable oil with base catalyst

- Now, the third method is usually used for economic purpose


Dầu thực vật
Xúc tác
bazơ mạnh
Metanol
Nhiên liệu
sinh học
Làm khô
Lò phản ứng
Thiết
bị tách
Metil
Este
Loại bỏ
Metanol
Trung hòa
và rửa
Glicerol
(50%)
Axit
Nước sau
khi rửa
Axit
Axit hóa và
tách
Axit béo
tự do
Nước
Glicerol
thô (85%)
Loại bỏ
metanol
Chưng cất
hỗn hợp
metanol/
nước
Metanol
Nước

- Process of synthesizing biodiesel in the third method includes following stages:

+ Esterification in order to generate metil este: Put methanol and base (NaOH and KOH) into furnace first, and then put also grease/vegetable oil

+ Separate metil este from glicerol.

+ Remove redundant methanol

+ Neutralize and clean metil este.

+ Drying

The removed methanol can be reused

Biodiesel fuel blend stock (B100) specifications in Vietnam *(TCVN 7717 : 2007)*

	Standard	**units**	**limits**	Measuring method
1	Este content	% khối lượng	> 96,5	EN 14103
2	Density at 15oC	kg/m^3	860 - 900	TCVN 6594 (ASTM D 1298)
3	Flashing point	oC	130	TCVN 2693 (ASTM D 93)
4	Water and dreg	% volume	< 0,050	TCVN 7757 (ASTM D 445)
5	Kinetic viscosity at 40oC	mm^2/s	1,9 – 6,0A	TCVN 3171 (ASTM 445)
6	sulfate ash	% mass	< 0,020	TCVN 2689 (ASTM D 874)

7	sulfur	% mass (ppm)	< 0,05 (< 500)	ASTM D 5453/ TCVN 6701 (ASTM D 2622)
8	Copper erode	type	No1	TCVN 2694 (ASTM D 130)
9	Xêtan numeric value		> 47	TCVN 7630 (ASTM D 613)
10	Turbid point	^{o}C	Báo cáoC	ASTM D 2500
11	Carbon dreg	% mass	<0,050	ASTM D 4530
12	Acid numeric value	mg KOH/g	< 0,05	TCVN 6325 (ASTM D 664)
13	Iodine index	g iodine/100 g	< 120	EN 14111/ TCVN 6122 (ISO 3961)

14	Oxygenating stability at 110°C	hour	> 6	EN 14112
15	Glycerin	% mass	< 0,020	ASTM D 6584
16	Total Glycerin	% mass	< 0,240	ASTM D 6584
17	Phosphorus	% mass	< 0,001	ASTM D 4951
18	Distil temperature, 90% recover	°C	< 360	ASTM D 1160
19	Na and Ka	mg/kg	< 5,0	EN 14108 và EN 14109
20	Observation		No dreg, no impurities	Observed by eyes

Exhaust fumes from biodiesel

- Sulfur is not available in biofuels so that it reduces acid rain risk
- Does not contain aromatic hydrocarbon so that it reduces affect of benzen, xeton,…in the air.
- CO, CO_2, NOx are reduced significantly comparing to traditional fuels
- Significantly reduce hydrocarbon.
- Reduce smoke

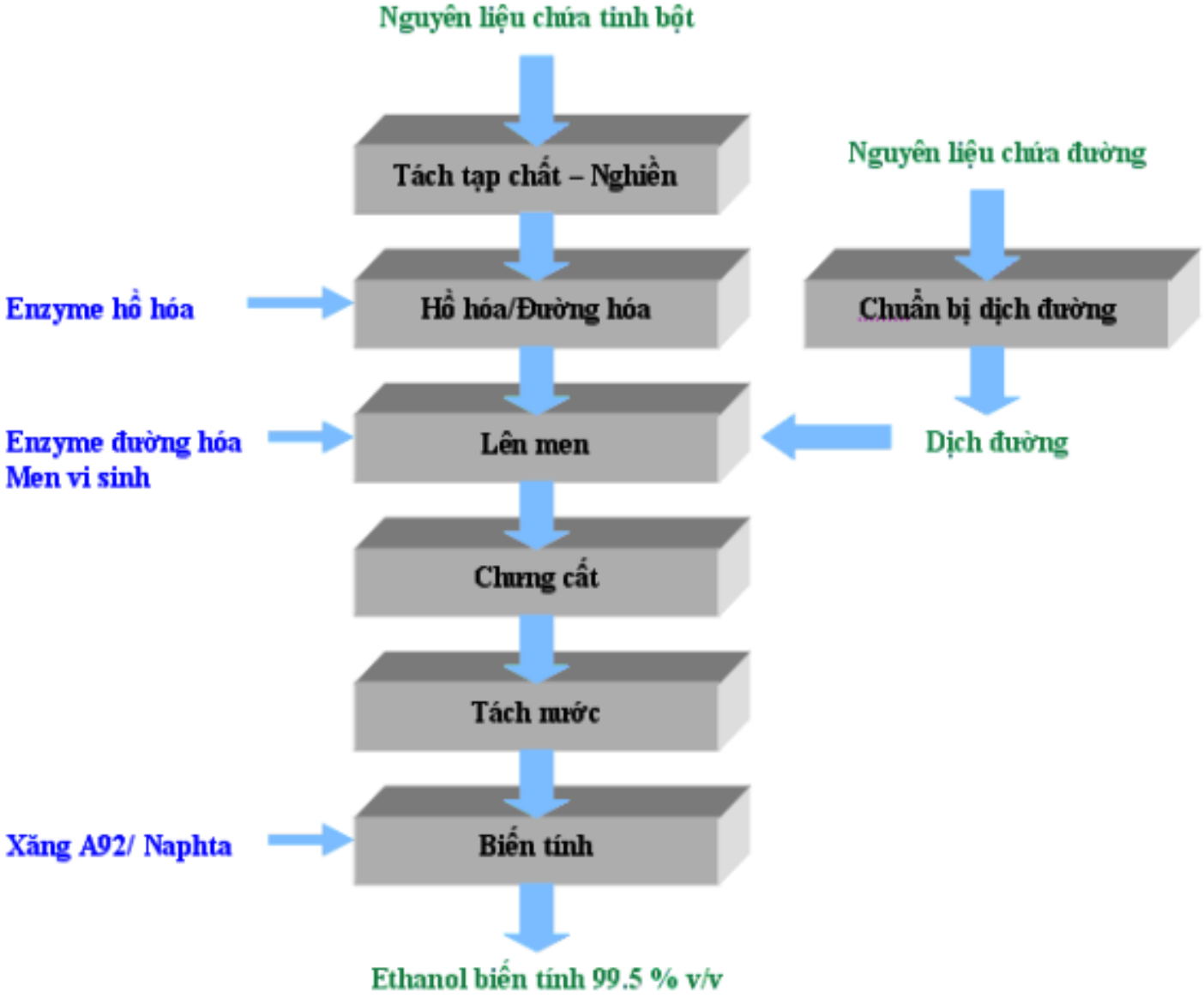
Applications

- B100 or mixture of biodiesel and petroldiesel with under any ratios can be used for diesel motor.

Gasohol

- Gasohol includes Biomethanol, bioethanol, biobuthanol,…
- The most common gasohol is bioethanol, which is made from materials such as sugar-cane, sugar-beet, mía, củ cải đường, cassava, grain,…
- Octane numeric value of Ethanol petrol is higher than usual so that the machine gets hot more quickly than usual also
- Ethanol petrol storage has to be made from special iron, and ethanol transportation is also more difficult

Productivity process



Applications

- E100 or a mixture of ethanol and mineral-oil petrol under any ratios can be used for petrol motor

Physical/chemical properties of ethanol (TCVN 7716 : 2007)

	Standards	**units**	limits	**Measuring method**
1	Ethanol content	% volume	>92,1	ASTM D 5501
2	Methanol content	% volume	< 0,5	
3	Content of Plastic cleaned by solvent	mg/100 Ml	< 5,0	TCVN 6593 (ASTM D 381)
4	Water content	% volume	<1,0 (1)	ASTM E 203 hoặc ASTM E 1064
5	Property-modified material content	% volume		
a		% volume	> 1,96	
b		% volume	< 5,0	

6	inorganic clorua content	mg/L (ppm mass)	< 32 (40)	ASTM D 512-81
7	Copper content	mg/kg	<0,1	ASTM D 1688
8	Acid content (as CH_3COOH)	% mass (mg/L)	< 0,007 (56) (3)	ASTM D 1613
9	pH		6,5 - 9,0	ASTM D 6423
10	Sulfur	Pp mass	< 30	TCVN 6701 (ASTM D 2622)

11	Sulfate	mg/kg (ppm mass)	<4	
12	Density at 15^{o}C	kg/m^{3}	report	ASTM D 891 hoặc ASTM D 4052
13	Observation		Do not see any impurities Or Precipitate	

Dung Quat Bio Ethanol production plant

- Is constructed in Dung Quat
- Biggest plant in central area of Vietnam using cassava as input materials. The expected power is 100 million lit ethanol/year, which satisfies 25% Bio ethanol E5 needs in Vietnam
- Input materials 240.000 *tons/year*.

Plans for development of biofuels

- 2015: 250.000 *tons/year*
- 2025: 1.800.000 tons/*year*, satisfy 5% total fuels

NEWs

- Russian scientists (Siberia) confirm that we could get biodiesel from mud by a simple method with low cost

Bio Gas

- As mentioned earlier, Bio Gas can be considered as a part of Bio fuel.

- Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen **, where the main content is methane (CH_4)**

- The input materials are mainly from animal feces, and partly from water-fern, grass, straw, rice stubble…

- Bio gas devices must be ensured that the air can not get inside

- There are two ways of feeding input materials into the devices:

  + ***Discontinuous feeding***: materials will be full fed into the devices in one time. These materials are gradually disintegrated in 3-5 months, and after that, they are substituted by others

  + ***Continuous feeding***: Materials are first full fed into the devices also, and then, after a period of time, we substitute material parts that are disintegrated by others

Bio Gas information in Vietnam

- From 1995 to 2006, we built 100.000 constructions in different types.
- Constructions with volume larger than $10m^3$ are 80% in the south area and 60%-70% in the north area.
- Bio gas is now used for cooking and lighting. Only 2% used for hot water and 1% for production.

Bio gas device with cupola structure

- Construction materials are brick, cement, sand,…workman under 1 week training can be build this device
- Easy to construct, operate, low cost.
- Under the ground, high durability, stable and high efficiency

Data of development of cattle and animal in 2000-2005

units millions

Loại vật nuôi		2001	2002	2003	2004	2005
Pig	Số lượng	21.8	23.1	24.9	26.1	27.4
	Tỷ lệ tăng trưởng (%)	0	6.0	7.8	4.8	5.0
cow	Số lượng	3.89	4.06	4.39	4.91	5.54
	Tỷ lệ tăng trưởng (%)	0	4.4	8.1	11.8	12.8
buffalo	Số lượng	2.81	2.81	2.83	2.87	2.29
	Tỷ lệ tăng trưởng (%)	0	0.0	0.7	1.4	-20.2

quantity
increased

Nguồn : Báo cáo tổng kết Chăn nuôi toàn quốc, Cục Chăn nuôi, 2006

TT	animal	feces tons/unit/year	efficiency m3/ton	quantity million	bio gas million m3/year
1	buffalo	4,6	30	2,92	402,96
2	cow	4,0	30	5,40	648,0
3	milk cow	7,0	35	0,104	25,48
4	pig	1	50	27,40	1370,0
	Tổng cộng				**2446,44**
	Quy dầu tương đương (triệu toe)				**1,224**

Electric generator using bio gas

- Motor 1HP – 0,45m^3 /hour

- Motor 1kW – 0,62-0,7m^3 /hour

- **Ghi chú**:

  + The motor should be internal combustion, 4th generation.

  + Electric generator is not popular, only applied to cases with at least 15 pigs

STT	size (m3)	required quantity (con)	possible power (kW)	operation time hours/day
1	12	20 -30	1-1,5	4 -5
2	15	30 -40	2,5	6-7
3	20	45 – 50	3,0	5–6-7
4	25	50 - 60	3,5	6-7
5	30	60-70	5,0	6-7
6	35	>70	7,0	6-7

Notes

- The devices, constructions should be closed completely
- The best temperature is from 30^oC to 40^oC.
- Avoid affect of insecticides, pesticides, soap, lubricant

solid bio fuel

- Some solid bio fuels that several developing countries are now using in cooking or warming are woods, coal and dried feces

Biofuel production technology

First generation:

- First (1st)-generation biofuels are biofuels which are produced from food crops (sugar or oil crops) and other food based feedstock (e.g. food waste). These biofuels are on the market in considerable amounts today and their production technologies are well established. The most important biofuels of the 1st-generation are bioethanol, biodiesel, and biogas.

- Bioethanol is produced by fermenting sugars from starch and sugar biomass (e.g. cereal crops such as corn or maize and sugarcane).

Second generation:

- Different from the 1st generation the so called second (2nd) or ‘next’ generation of future biofuels can be produced from wider range of feed stocks, which are represented mainly by non-food crops.
- The whole plant biomass can be used or waste streams that are rich in lignin and cellulose, such as wheat straw, grass, or wood.

Third generation:

- Third generation biofuels rely on biotechnological interventions in the feedstocks themselves. Plants are engineered in such a way that the structural building blocks of their cells (lignin, cellulose, hemicellulose), can be managed according to a specific task they are required to perform.

Biomass energy

- Biomass refers to material of biological origin excluding material embedded in geological formations and transformed to fossil.
- Biomass can directly or indirectly be converted to biofuels which can be of solid, liquid or gaseous forms.
- ***Using:*** thermal enrgy, electric generator, work generated.

- ***Process:*** biomass sources → Pyrolysis → intermediate materials

- Potentiality: 30 – 50 *million tons/year, where:*
  + rice husk: 6 *million tons/year*
  + bagasse: 5 *million tons/year*

Discussions

- Current situation of using biofuels, biomass energy and bio gas in Vietnam?
- Updated information and related policies?
- Road to deploying biofuels, biomass energy and bio gas in Vietnam?
- Advantages/Disadvantages?

5.4. Small-scale Hydroelectric

- Average annual precipitation: 1860mm
- More than 2200 rivers + streams

- In standard: less than 30*MW*, the area is smaller than 10*hectares*.

- Potentiality: (less than 30*MW*): 4000*MW*.

Loại, *MW*	**0,1 - 1**	**1 - 5**	**5 - 10**	**10 - 15**	**15 - 20**
Tiềm năng, *MW*	126,8	1030	1048	648	563
Loại, *MW*	**20 - 25**	**25 - 30**	**30 - 35**	**35 - 40**	**40 - 50**
Tiềm năng, *MW*	309	290	135	175	144

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