# The Role of DC in Future Electricity Systems

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# Energy Quality- a Future Issue

Oil, natural gas, and coal are projected to supply almost 90 percent of the world's energy in 2015

(DOE/IEA 97).

We must improve conversion efficiency and increase use of local resources for generation of electricity for high quality uses as:

Cooling (medicines, food, space)

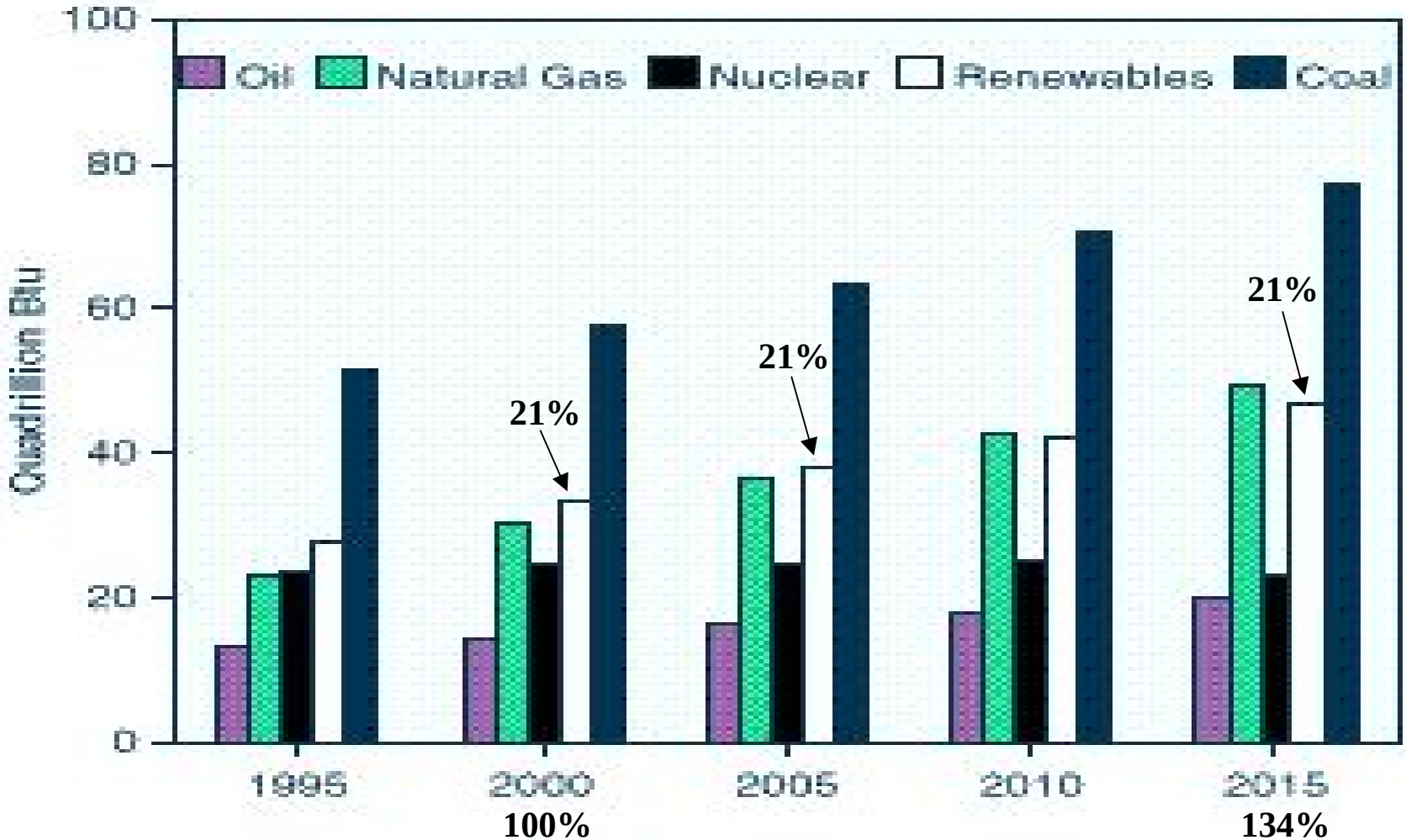
Light

Movement (water pumping, tools, transport)

Telecom

IT & automation

# Figure 22. World Energy Use for Electricity Generation by Fuel Type, 1995-2015




Sources: **History (1995):** Energy Information Administration, *International Energy Annual 1995*, DOE/ EIA-0219(95) (Washington, DC, December 1996). **Projections:** EIA, World Energy Projection System (1997).

# Electricity Generation from Renewables

Renewables are frequently found in quantities large enough to supply the local population.

Renewables are distributed and often found where people like to live. Keywords: reduced transport, scarce, self supply.

Renewables appear in many kinds, shapes and qualities. They may be difficult and costly to convert.

We need:

Decentralized multifuel electricity systems

to convert local fuels efficiently.

# Generating Electricity[1]

Most electricity is generated by generators propelled by thermodynamic prime movers.

To save fuel and emissions, electricity generation *and* use must fit demand.

Hence:

- Prime movers need to be controlled to maximum efficiency at any allowed output.

- Variable load generators need to operate efficiently over a wide power range.

# Generating Electricity$_2$

All prime movers have performance maps.

For any power output, at least one optimal speed exists.

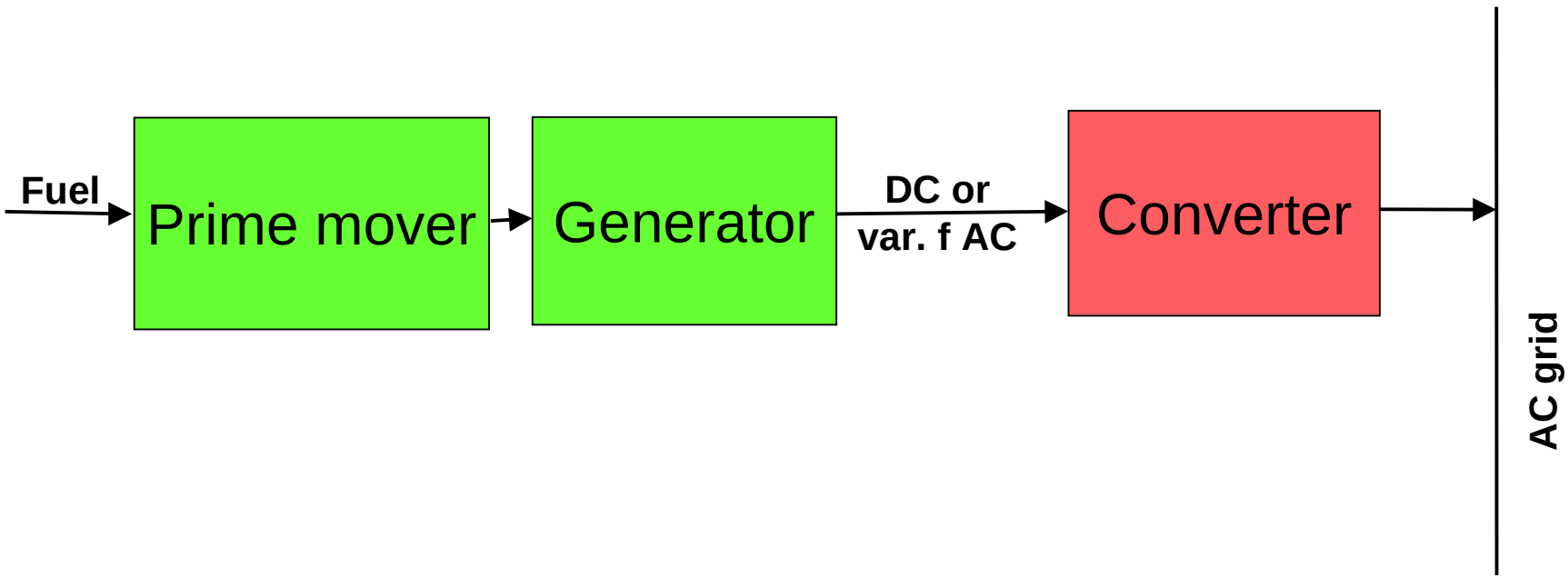
To achieve optimal performance over a wide power range, the speed should be controlled with respect to power output.

We need:

Variable speed generators.

# AC or DC for Local Electrical Systems? 1

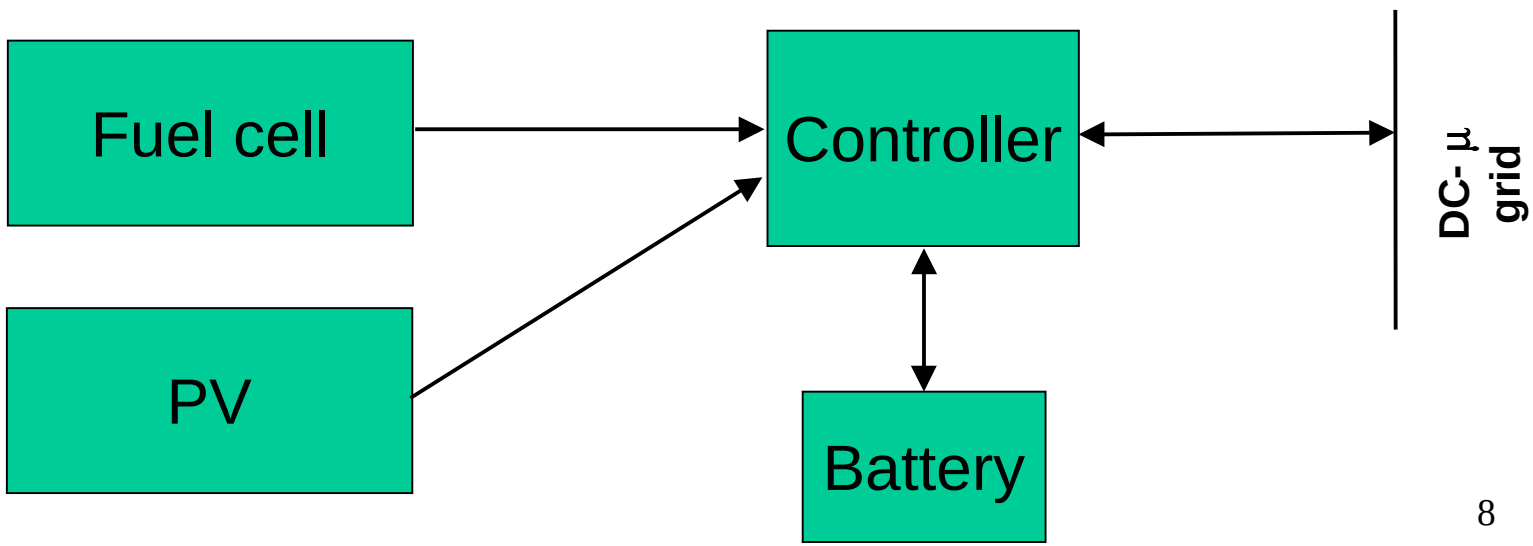
- Variable speed generators generate DC or variable frequency AC. To be hooked on to a fixed frequency grid, both need complicated converters.
Efficiency and reliability are reduced. Price is increased.



# AC or DC for Local Electrical Systems? 2

- Generators as PV, fuel cells and thermo-voltaic cells generate DC as an intrinsic property.
They are easily hooked up to DC-network.

- In a DC-network, batteries act as a short term storage and maintain stable supply while switching between sources.



# AC or DC for Local Electrical Systems? 3

- More DC systems are easily interconnected. Power flow is controlled by voltage, no frequency or phase problems.

- Small DC-motors have higher efficiency than small AC-motors.

- The power factor in a DC-system is 100%. IR-losses are minimized.

- AC can be transformed reliable and easily. Great advantage in high power and long distance applications!

# AC or DC for Local Electrical Systems? 4

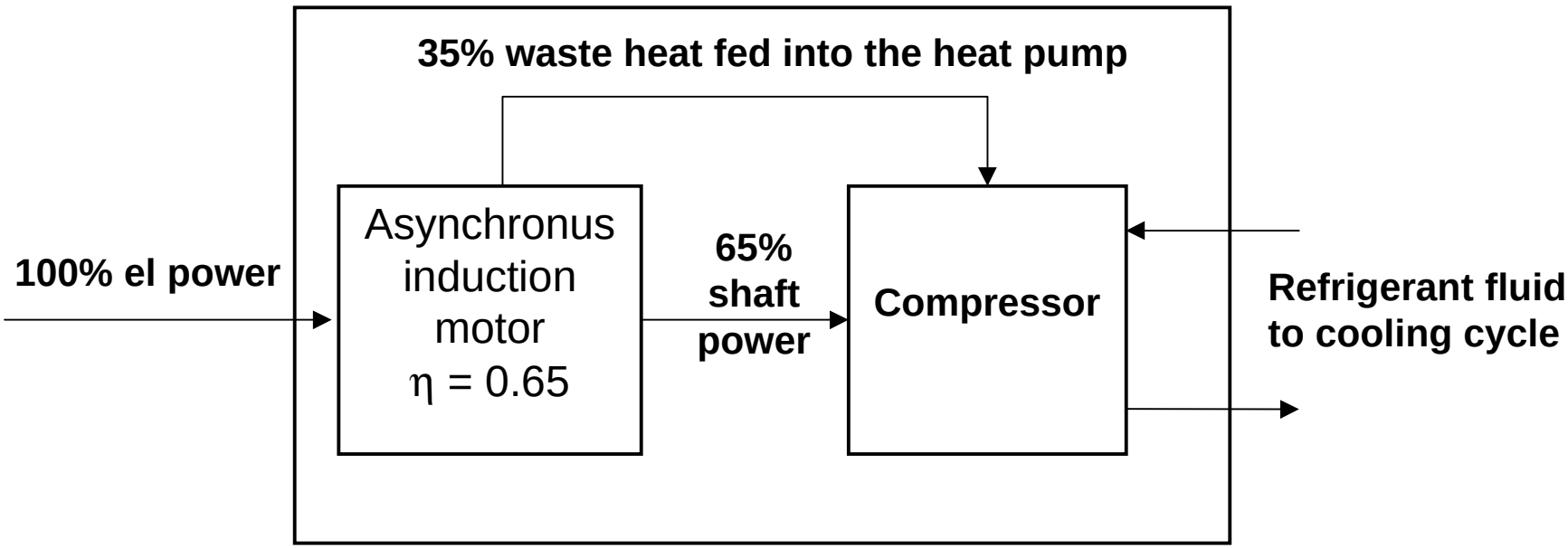
- Bigger AC motors and generators are simple, efficient and reliable.
- Audio, IT and telecom equipment are basically powered by DC. Hooked to AC-networks, poor efficiency adapters are needed.

Statement:

DC seems to be a good choice for low and medium local power applications.

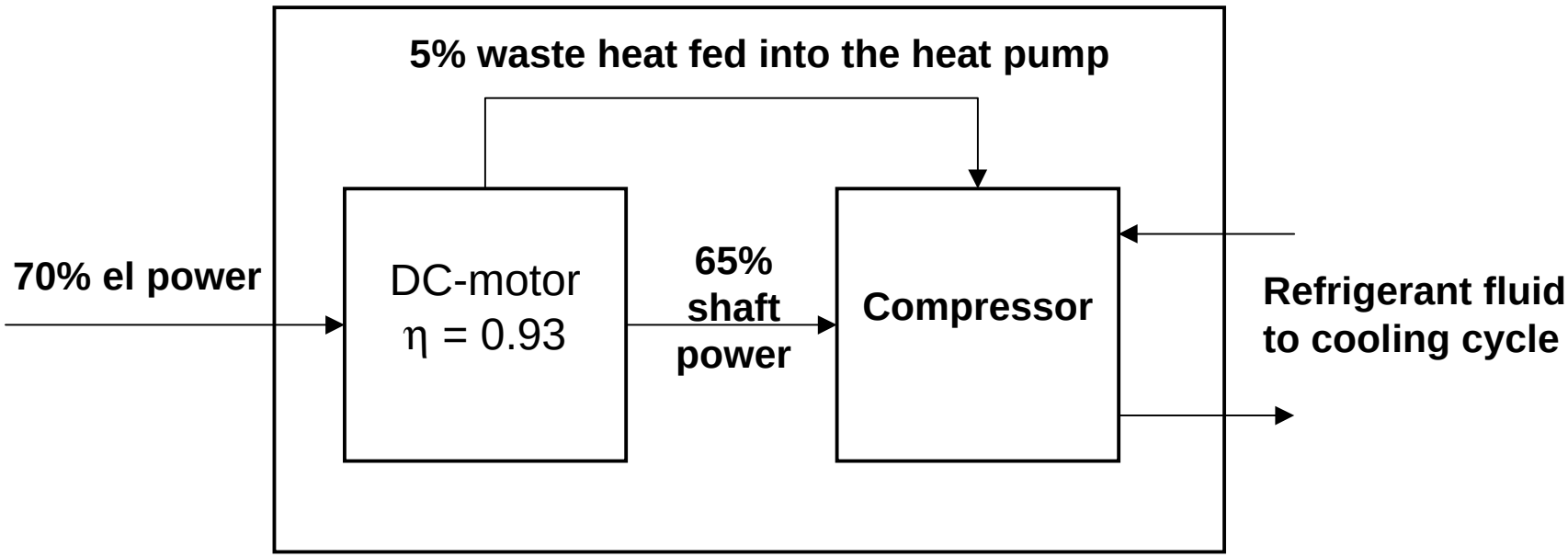
AC may be a better choice if high power or long distance is involved.

# AC Refrigerator Example




Refrigerator compressor propelled by induction AC-motor

# DC Refrigerator Example




As 30% less heat is fed into the compressor, the over all heat pump efficiency may be increased to 40%.

A modern refrigerator consumes about 500kWh/year.

Propelled by DC-motor, 40% = 200kWh/year is saved.

# Refrigerator Example, Scaled

Assume $2 \cdot 10^9$ refrigerators in the world. Replace interval 20 years.

(Including freezers and air condition, probably more units)

In year 2020, assume $3 \cdot 10^9$ refrigerators in the world.

If 1/3 are propelled by DC, the yearly

energy saved is: $10^9$ units $\cdot$ 200kWh/unit = 200TWh.

To generate this amount of energy, a power plant of 33% overall efficiency must burn 60 million tons of oil.

This amount of oil allows 50 million cars to run 12.000 km/year.

**(10km/ liter)** .

# What Voltage for Local DC-Networks?

- Voltage should be kept low to be safe: Less than 60V.

- High, to keep losses and use of conductor material low.

A compromise suggests voltages around 50V.

If high efficiency multifuel converters and DC appliances are made available, new big markets are created, but
no vendors take the risk to develop equipment with the wrong voltage.

We need:

A common voltage standard.

# 850 Million Local DC-systems in Operation Today

Every car has a complete power plant and a DC network.

When the car was born, the voltage was 6VDC.

During the 1950’s the voltage changed to 12VDC.

Today, a 42VDC standard is agreed by default.

Daimler Chrysler • Renault / Nissan • General Motors • Peugeot / Citroën
Ford • Fiat • BMW • Toyota • VW / Audi • Honda

In 2002, the first 42VDC cars will be launched.

# The Car Is the Key

Today: 57 million cars are manufactured yearly.

Fuel consumption is an issue:
Electrical car quipment will be made energy efficient.

The car industry's well organized distribution networks secure supply of equipment, spare parts, service and knowledge almost all over the world.

**Transferred also to serve stationary energy systems, efficient car technology for electricity generation *and* use can be made available for many new users .**

# Conclusions

- DC may be better suited than AC to provide efficient multiple source small scale electricity generation.
- Many household appliances will be more energy efficient powered by DC.
- A common DC standard may make electricity generation and appliances available for many people and open new markets for DC equipment.
- The new automobile 42VDC standard is probably nearly ideal also for local energy systems.
- 42V may stay for a long time. We should make it a standard for local electrical networks now!