

Energy Challenges in Oman
ICE Local Branch, Oman

Conventional and Renewable Energy Resources in Oman

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The Presenter:

TARIQ UMAR



Total Experience (Post Master Degree): 6 years (2 years field and 4 years teaching and research)

Current Role: Program Leader and Lecturer in Civil Engineering; College of Engineering, A'Sharqiyah University Oman (2013 - Now)

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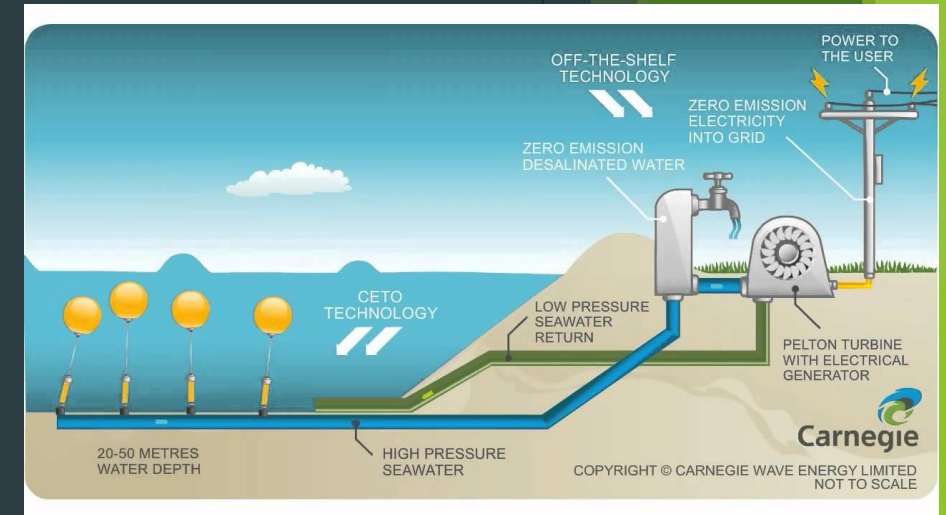
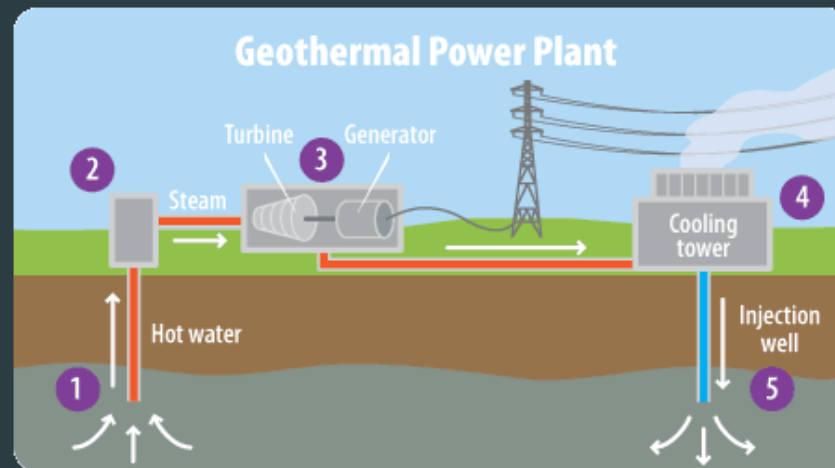
ICE Graduate Member: Since 2010

Career Appraisal Completion: 2014

Professional review Plan: 2016

Agenda:

- Introduction
- Climate Change
- Oman Oil and Gas Sector
- Renewable Energy Resources in Oman
- wind energy
- solar energy
- Bio Gas
- Wave Energy
- Geothermal Energy
- Way Forward
- UN Sustainable Goals
- Questions



➤ Introduction:

- Energy is essential to economic and social development and improved quality of life
- Much of the world's energy is currently produced and consumed in ways that could not be sustained
- The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption in the country
- Climate change is one of the most difficult challenges facing the world today
Burning fossil fuels such as coal, oil and gas provides about three quarters of the world's energy
- Oman, like other Arab gulf countries, depends on oil and gas to produce Energy

➤ Introduction:

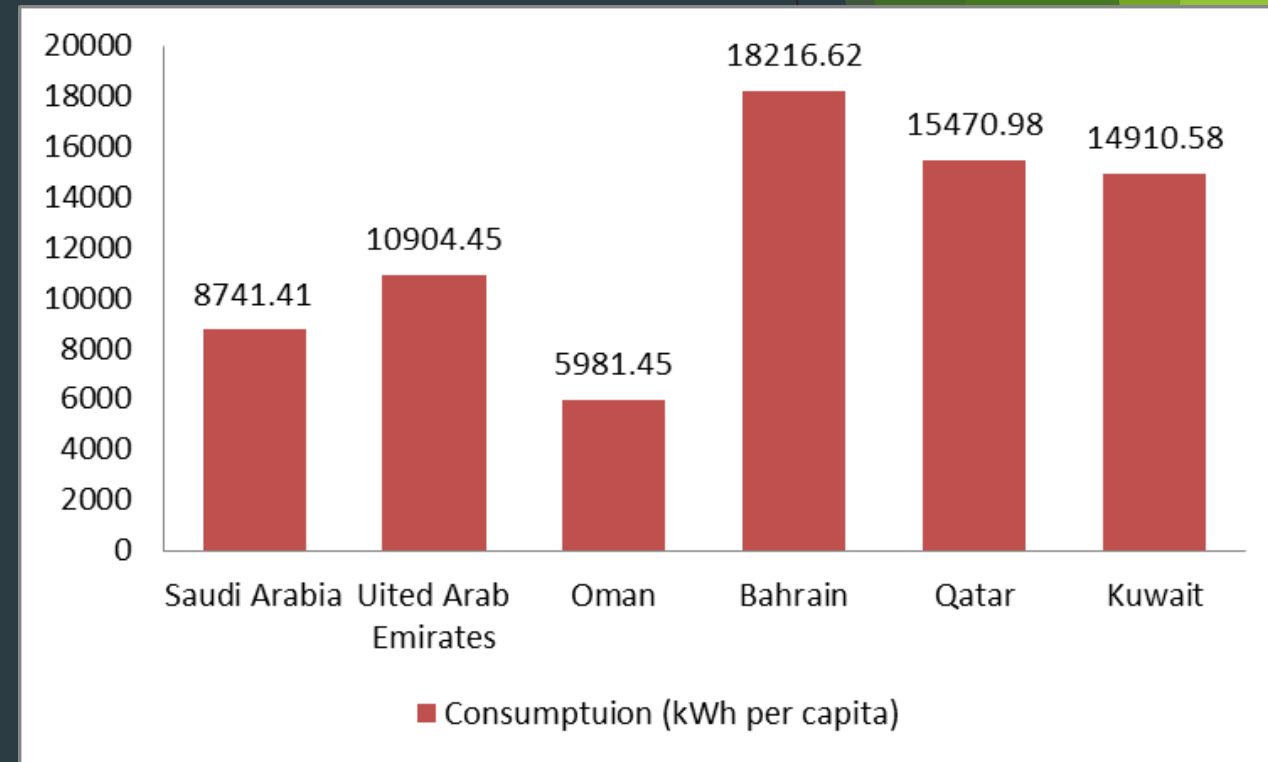
- These resources are not guaranteed to last forever, and are one of the energy security issues in the country
- United Arab Emirates has considered the nuclear and Renewable Energy (RE) as part of their electric generation
- Qatar aims to generate 20% of its energy from renewable by 2024 with 1800MW of installed green capacity by 2020
- The progress of RE development is at a slow pace in Oman
- Omani Vision 2020 seeks to reduce dependence on oil
- The Vision 2020 also stresses on the increased use of natural and renewable resources

➤ Background Oman Conventional Energy:

- Oman's economy is heavily reliant on oil and gas revenues
- 84.2% of the country's export earnings and 48.8% of its GDP (2005)
- Oil accounted for 71% of Oman's total primary energy consumption (2011)
- Natural gas made up the remaining 29%
- Oman's petroleum consumption 154,000 bbl/d (2013)

Electric Power Consumption In GCC:

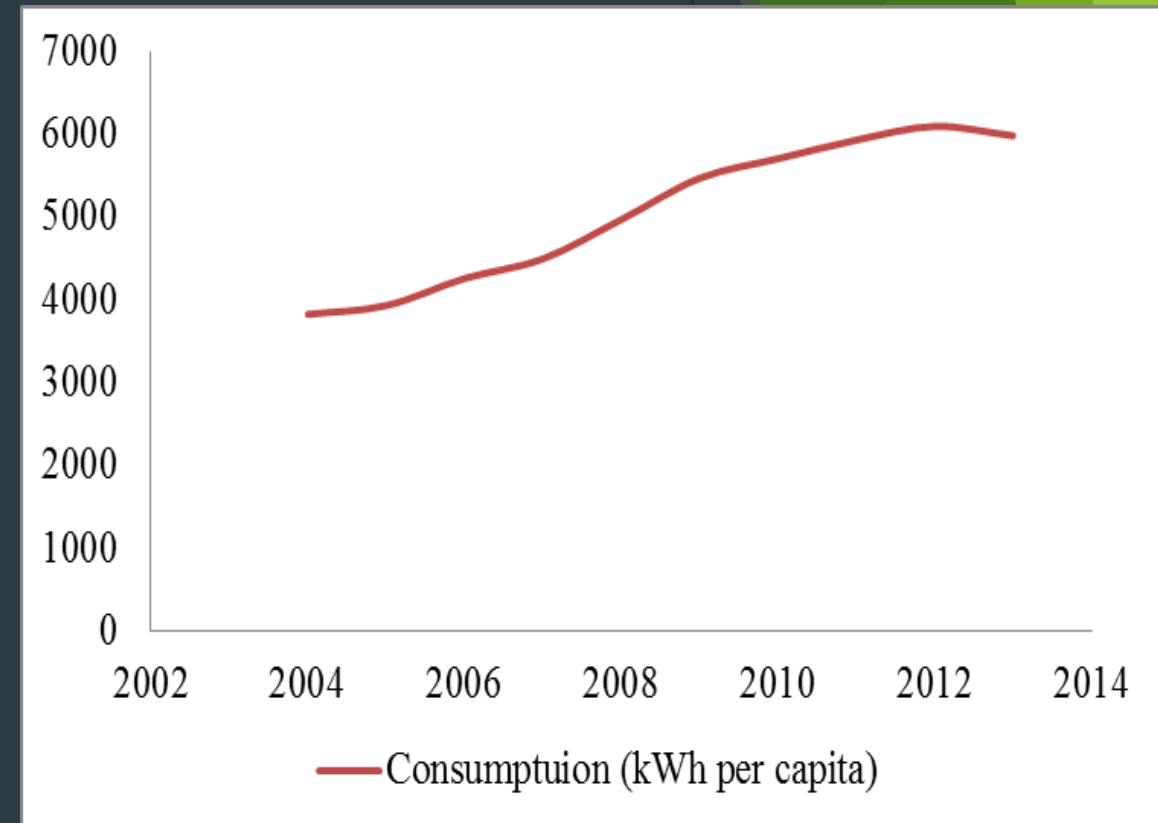
Country	Consumption (kWh per capita)
Saudi Arabia	8741.41
Uited Arab Emirates	10904.45
Oman	5981.45
Bahrain	18216.62
Qatar	15470.98
Kuwait	14910.58



Electric Power Consumption in GCC Countries (2013) - (World Bank 2016)

Electric Power Consumption In Oman:

Year	Consumption (kWh per capita)
2004	3825.26
2005	3930.76
2006	4257.89
2007	4494.65
2008	4968.93
2009	5468.71
2010	5704.29
2011	5928.96
2012	6094.73
2013	5981.45



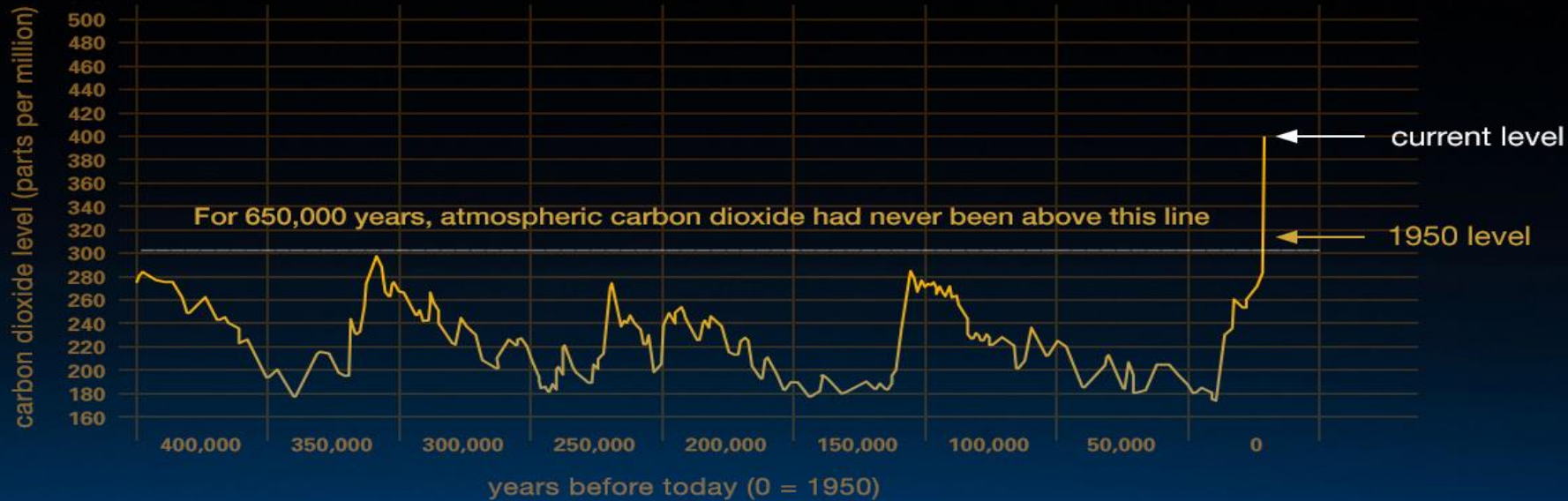
Electric Power Consumption in Oman From 2003 - 2013,
(World Bank 2016)

Climate Change:

- ▶ Evidence
- ▶ Causes
- ▶ Effects
- ▶ Solution



Climate Change: Evidences

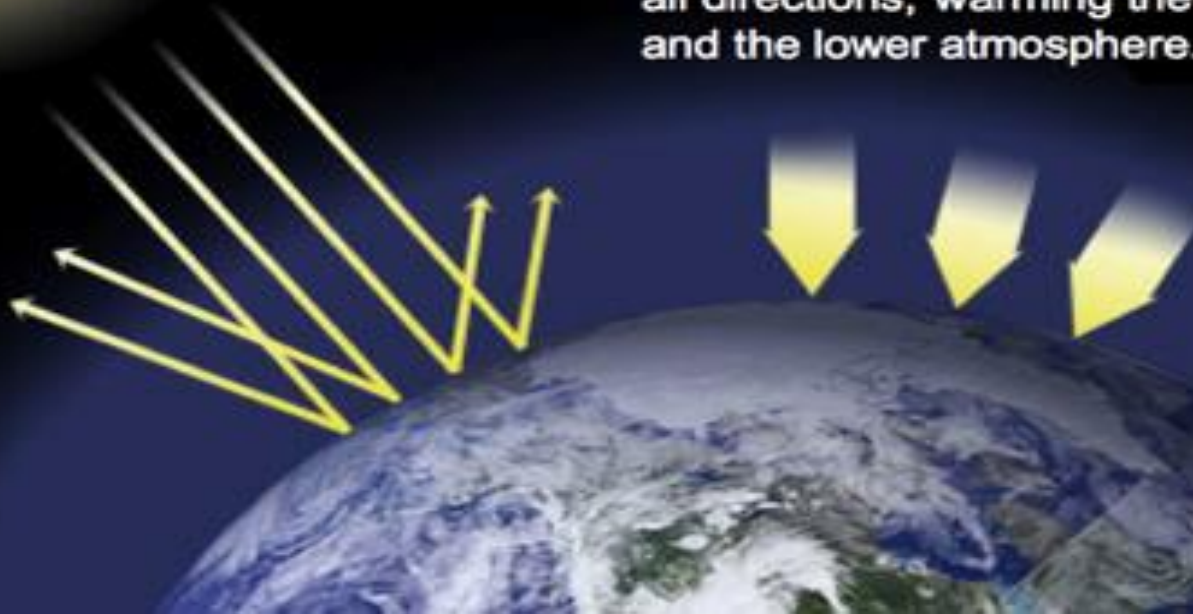


This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO₂ has increased since the Industrial Revolution. (Credit: Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO₂ record.)

Climate Change: Causes

Sunlight passes through the atmosphere and warms the Earth's surface. This heat is radiated back toward space.

Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.



Climate Change: Causes

A degree of difference;

So, the Earth's average temperature has increased about 1 degree Fahrenheit during the 20th century. What's the big deal?

One degree may sound like a small amount, but it's an unusual event in our planet's recent history. Earth's climate record, preserved in tree rings, ice cores, and coral reefs, shows that the global average temperature is stable over long periods of time. Furthermore, small changes in temperature correspond to enormous changes in the environment.

For example, at the end of the last ice age, when the Northeast United States was covered by more than 3,000 feet of ice, average temperatures were only 5 to 9 degrees cooler than today.



Climate Change: Effects



Climate Change: Solutions

▶ Mitigation and Adaptation:
Responding to Climate Change

▶ Government Resources

Government to set climate policy or prescribe particular responses or solutions to climate change, providing the robust scientific data needed to understand climate change and evaluating the impact of efforts to combat it

▶ Energy Innovations



Climate Change a Global Issue: Every where! Everyone!

Nations Unies

Conférence sur les Changements Climatiques 2015

COP21/CMP11

Paris France



#ParisAgreement

**“Long live the planet.
Long live Humanity. Long live life itself.”**

Oman at Glance - Conventional Energy Resources:

▶ Oil Sector

▶ Gas Sector

Longer Lasting (Sustainable) ?

Contribution toward Climate Change ?

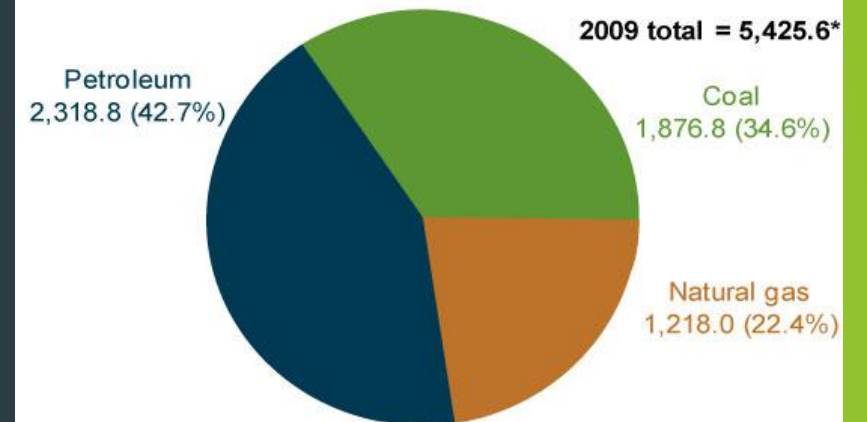
About 19.64 pounds of carbon dioxide (CO₂) are produced from burning a gallon of gasoline that does not contain ethanol. About 22.38 pounds of CO₂ are produced by burning a gallon of diesel fuel.

▶ How we Can Change

Adopt Renewable Energy Resources

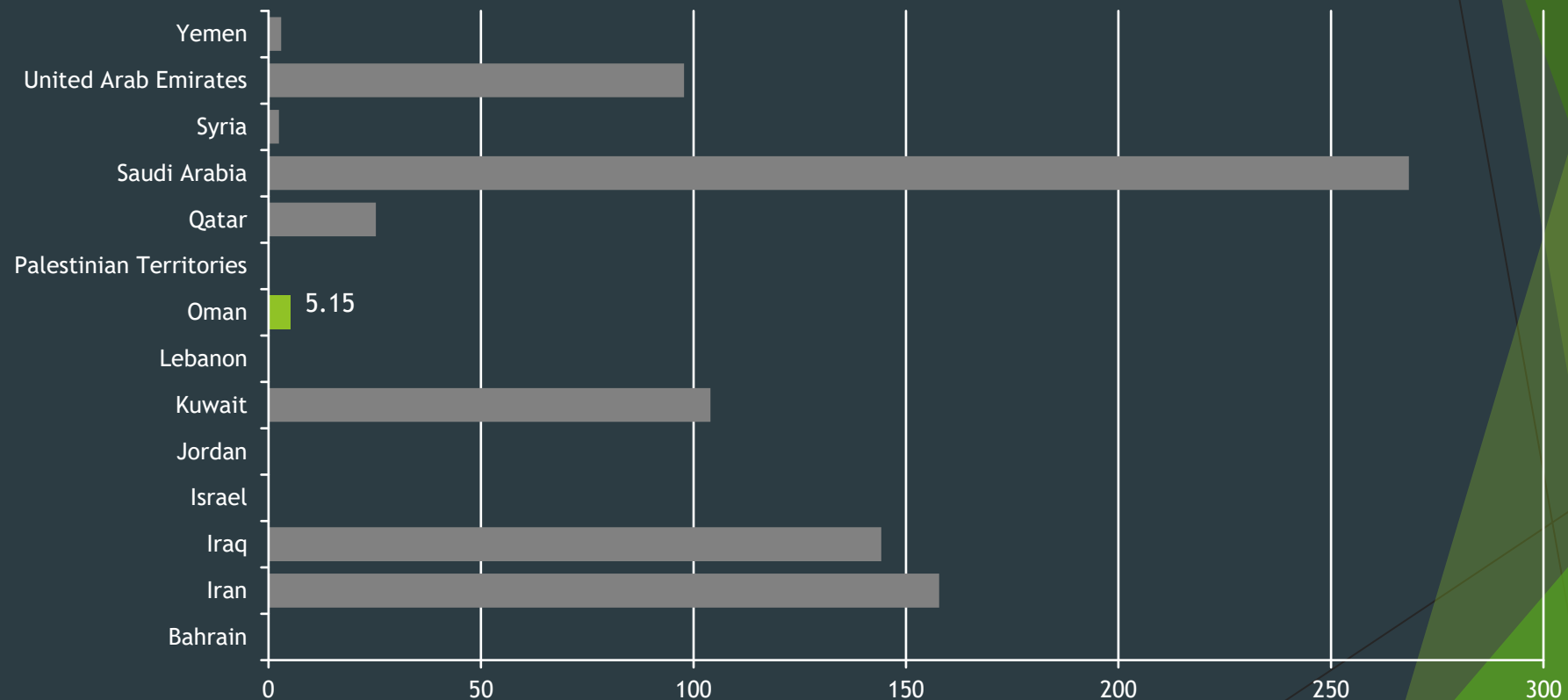
Figure 2. U.S. energy-related carbon dioxide emissions by major fuel, 2009

million metric tons carbon dioxide



➤ **Oil Sector:**

➤ **Selected Middle East Proven Oil Reserves in Billion Barrels (2015)**



Source: U.S. energy Information Administration, International Energy Statistics

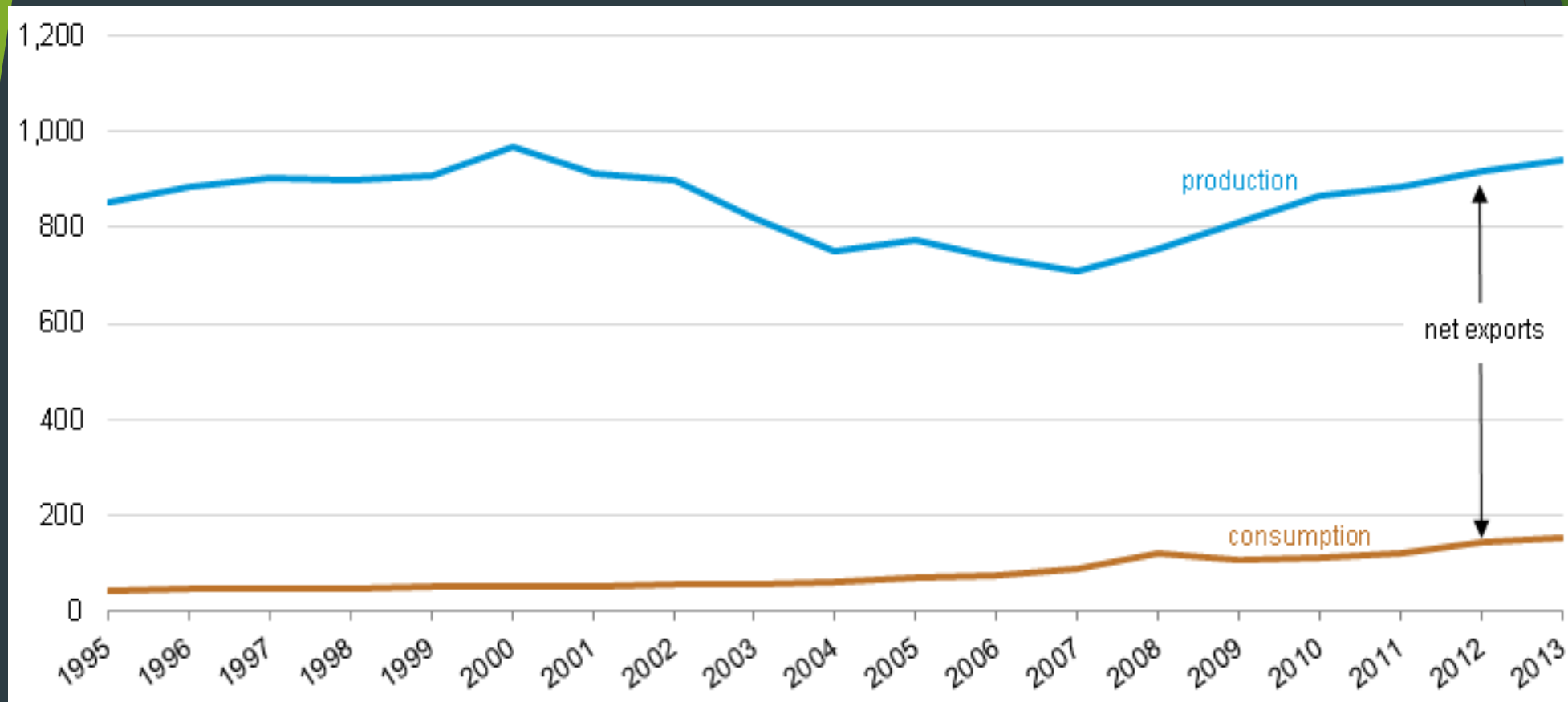
➤ Oil Export:

Oman crude oil and condensate exports, by country

Country	Amount (thousand bbl/d)
China	495
Japan	80
Taiwan	75
Thailand	47
India	44
Singapore 37	37
South Korea 14	14
Sri Lanka	13
Oman Oil Refineries and Petroleum Industries (ORPIC) and Other	28
Total	833

Source: US. Energy and Information Administration, International Energy Data and Analysis (Oman) dated 5th December, 2014.

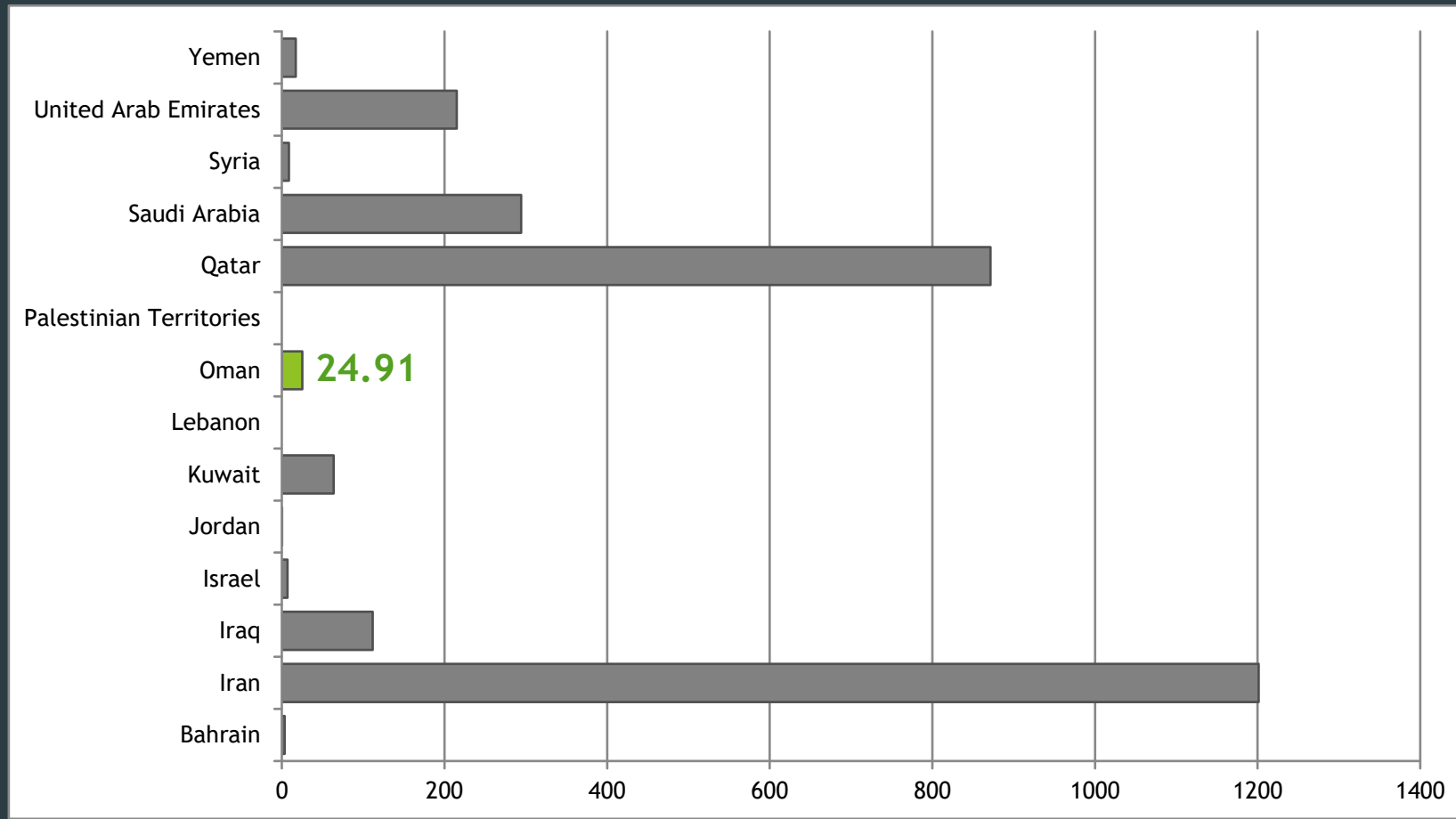
➤ Oil Production, Consumption and Export (1995-2013)



sources: U.S energy Information Administration

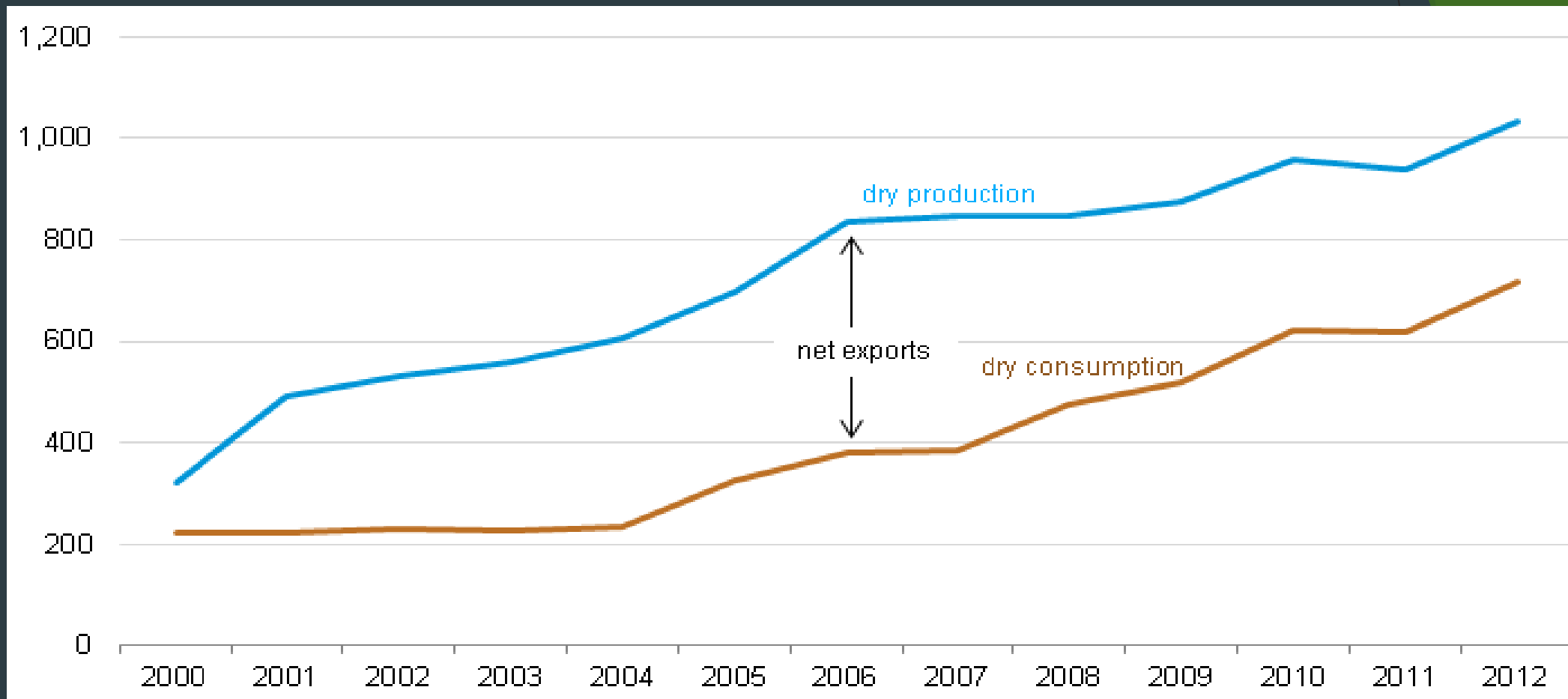
➤ Natural Gas:

Selected Middle East Proven Natural Gas Reserves in Trillion Cubic Feet (2015)



Source: U.S. energy Information Administration, International Energy Statistics

➤ Natural Gas Production, Consumption and Export (2000-2012):



Source: BP statistical Review of World Energy 2014, US energy Information Administration

➤ Renewable Energy Resources in Oman:

- The Oman Authority of Electricity Regulation study report on the renewable resources in Oman (2008)
- The study finds significant potential sources of renewable energy which covers
 - wind energy
 - solar energy
 - Bio Gas
 - Wave Energy
 - Geothermal Energy

➤ Wind Energy:

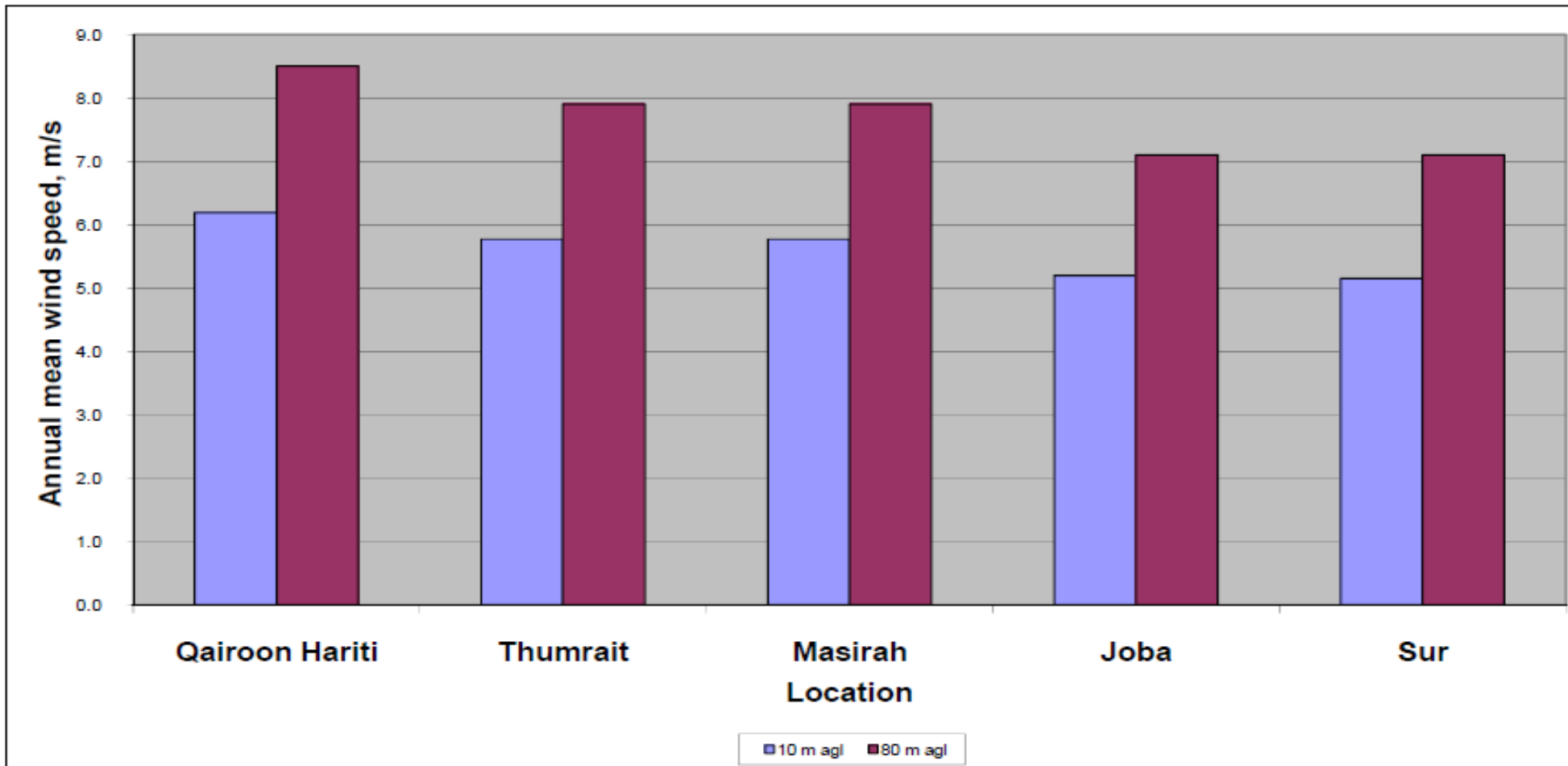
- The assessment of the wind energy resources is based on the wind data measured at twenty one stations in Oman under the responsibility of Directorate General of Civil Aviation and Meteorology
- The wind data is measured at 10 m above ground level
- The data indicate that five stations are having high wind speed (2005)
- The highest wind energy speeds are observed during the summer period
- The summer period is also the period with the highest electricity demand in Oman





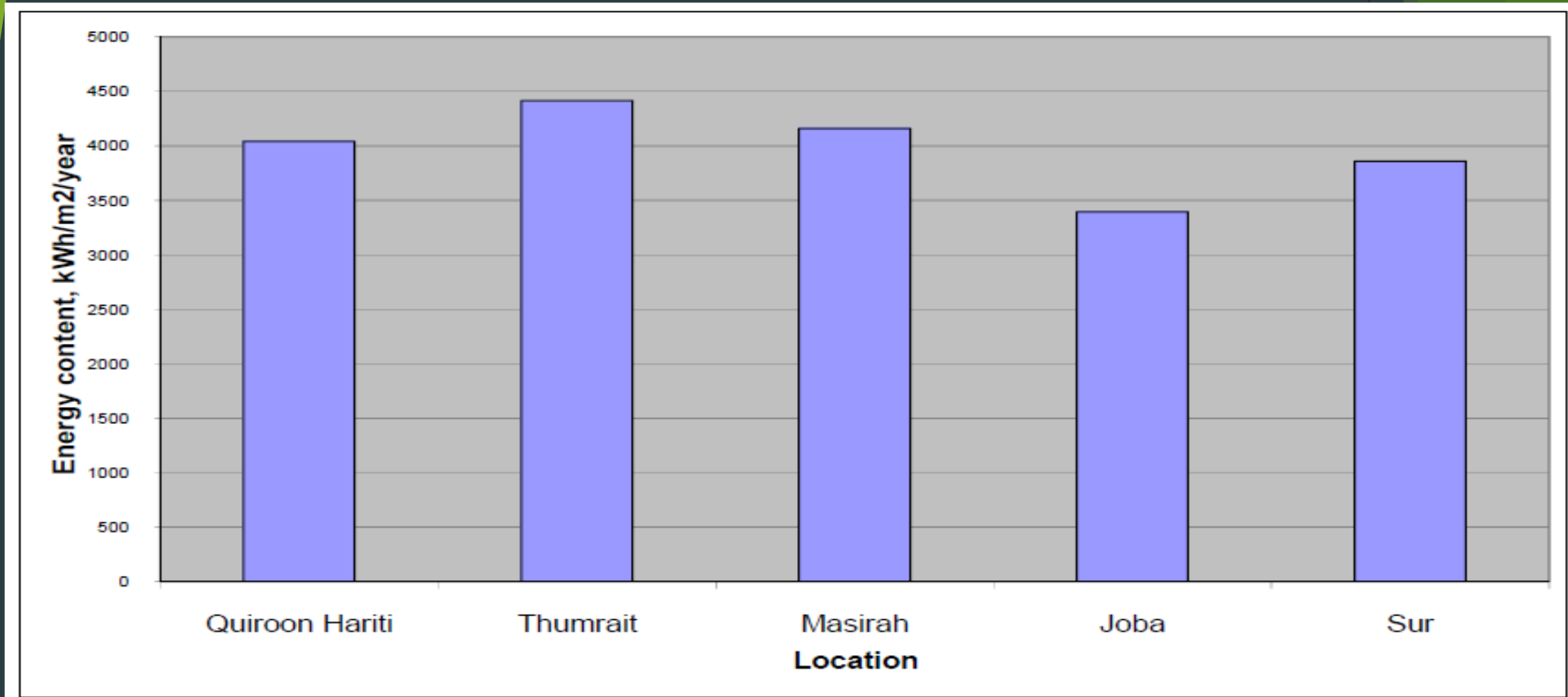
➤ Wind Energy:

Annual mean wind speed at 10 m and at 80 m above ground level at five meteorological stations



➤ Wind Energy:

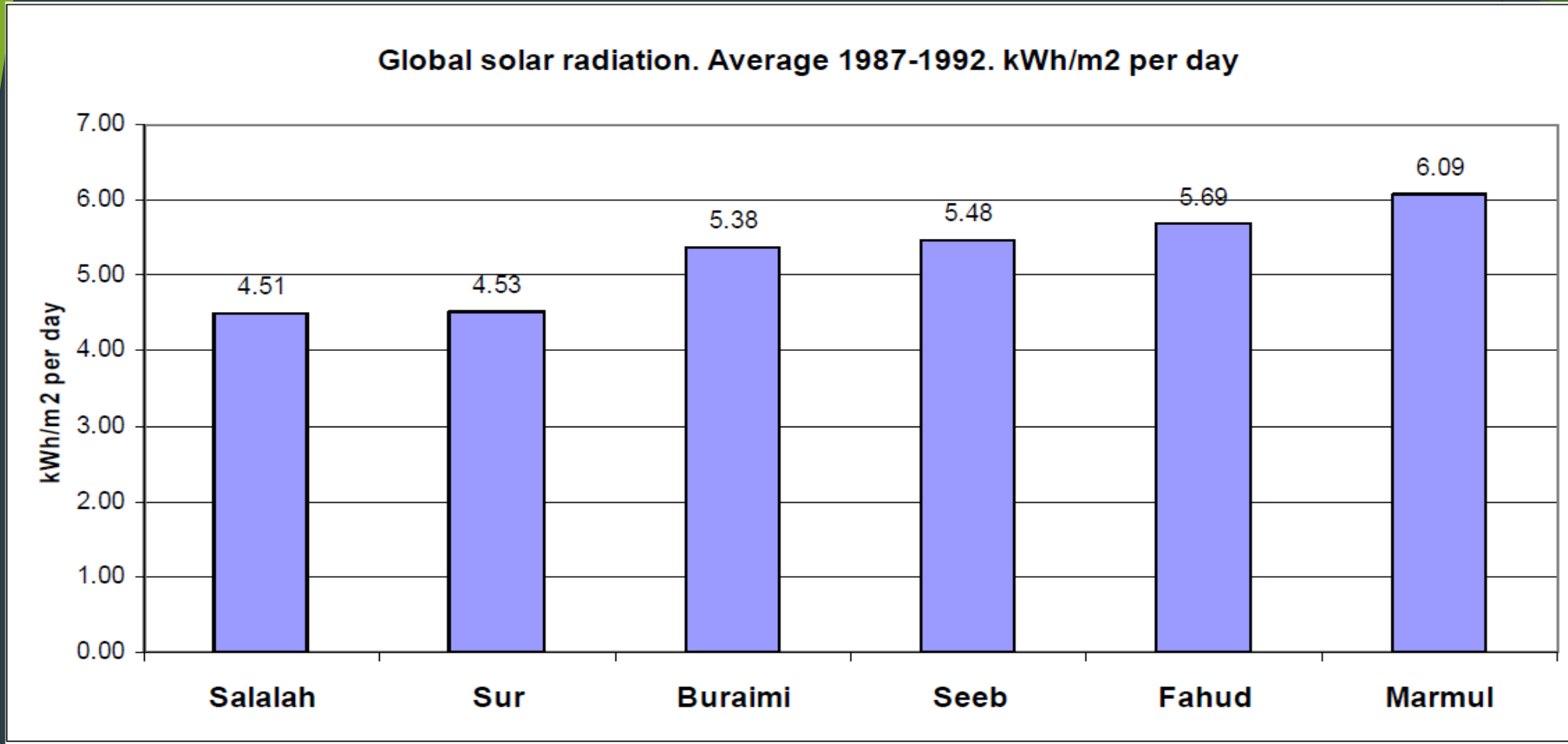
Energy content in the wind at 80 m above ground level at five meteorological stations.



➤ Solar Energy:

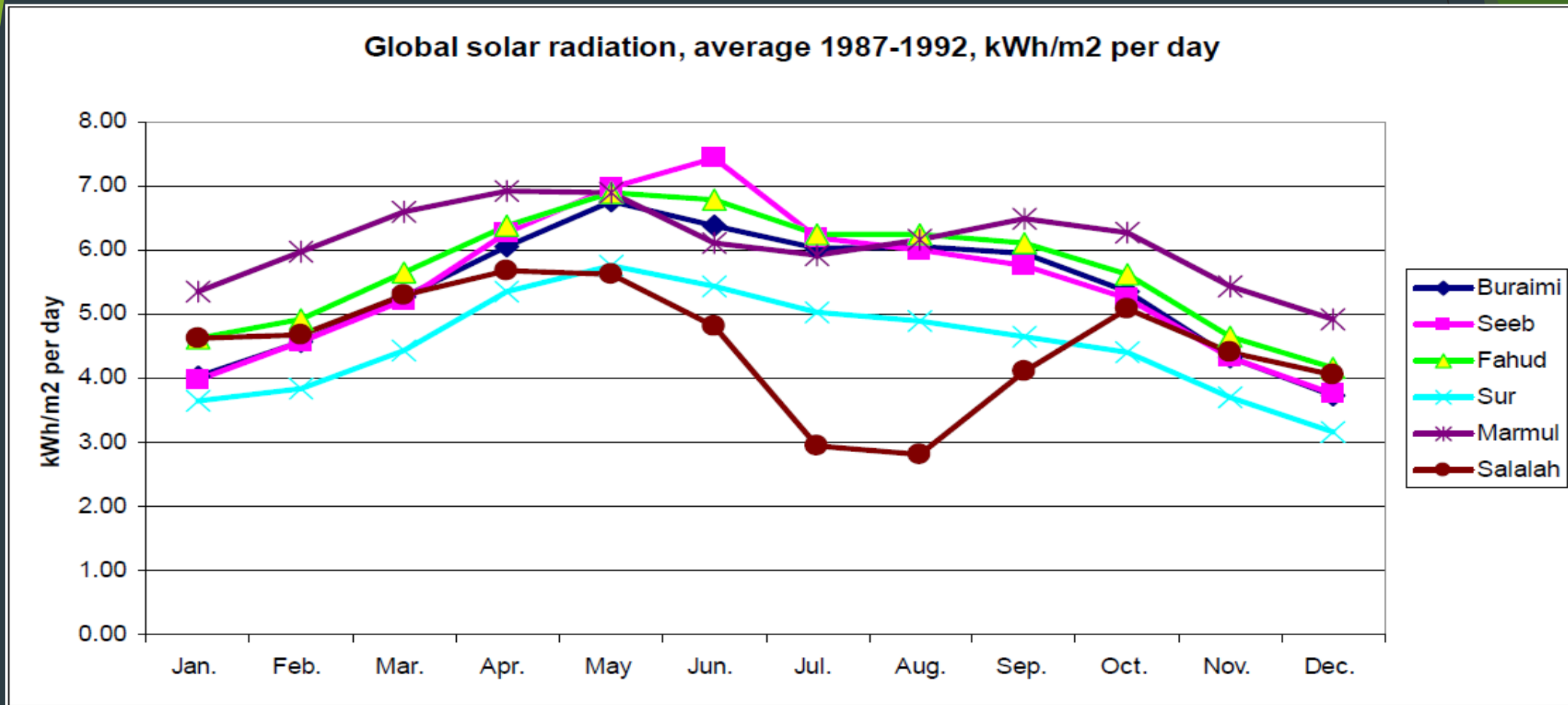


Global insolation average for 1987-1992 for the stations



➤ Solar Energy:

Global solar insolation (on horizontal) average 1987-1992 for the 6 Stations



➤ Bio Gas: Waster Water Sludge

- The Ministry of Regional Municipalities and Water Resources operates several sewer networks and treatment plants in the country
- Oman Wastewater Services Company (OWWC) and Salalah Wastewater Services Company are operating waste water systems in Muscat and Salalah,
- The amount of waste water treated is rapidly increasing
- The amount of organic matter is about 50-70% of total solids (TS). Thus the organic matter collected in the sludge is presently 5-7 ton/day which will increase 5 fold before year 2025. 7 ton organic matter per day corresponds to about 2500 tons per year from which it is theoretically possible to produce about 1 mill Nm³ CH₄ (methane) per year, equivalent to 11,000 MWh

Year	2007	2010	2015	2020	2025
Waste water m ³ /day	43,544	72,757	151,128	197,560	218,840
Sludge 20% TS kg/day	54,430	90,946	188,910	246,950	272,550

➤ **Bio Gas:
Solid Waste (dung)**

- **Overview of Total Solid Waste (dung) Resource by 2005 (Source: Ministry of Agriculture Year Book 2006)**

Types of Animal	Cows 250 kg	Camels 250 kg	Sheep 30 kg	Goats 25 kg
Estimated Population No.	301,600	117,300	351,000	1,55,700
Manure Total solids (TS) tonnes/year per animal	1.98	1.5	0.18	0.15
Total TS tonnes/year	597,168	175,950	63,180	233,355
VS (Volatile Solids = organic matters) tonnes/year at VS/TS = 0.75	447,876	131,962	47,385	175,016
Percent of Total	56	16	6	22

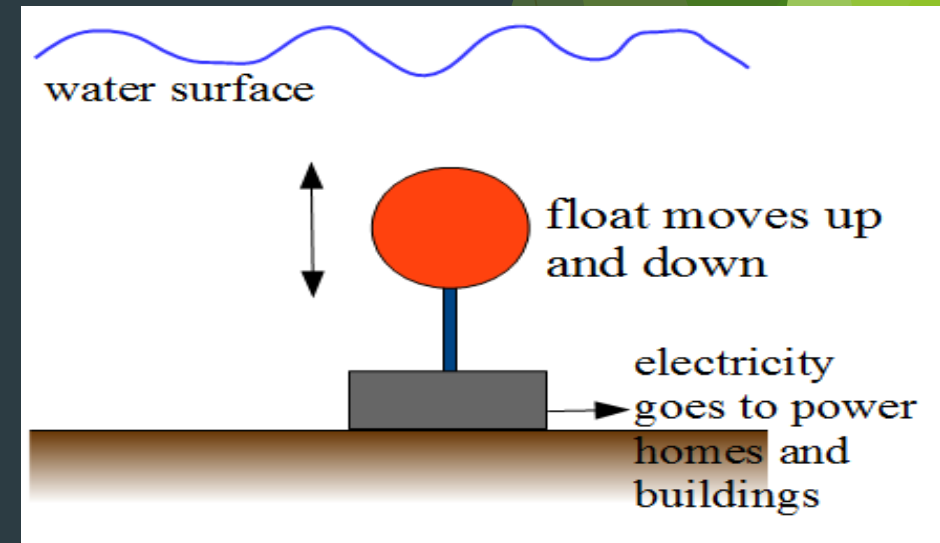
➤ Bio Gas: Solid Waste (dung)

- The theoretic potential biogas production at 100% conversion rate can be estimated as follows:
- Cows, cattle, sheep and goats 9%TS: 0.21 Nm³ CH₄ per kg VS
- Waste water sludge 0.25% / 20% TS: 0.4 Nm³ CH₄ per kg VS
- Sorted organic household waste: 0.35 Nm³ CH₄ per kg VS
- Vegetable, fruit and grass waste: 0.5 Nm³ CH₄ per kg VS
- Cereals: 0.22 Nm³ CH₄ per kg VS
- Vegetable oil e.g. from palm or animal fats: 1.44 Nm³ CH₄ per kg VS

The total biogas production for the animals is about 150,000,000 Nm³ CH₄ per year or 1,650,000 MWh

➤ Wave Energy:

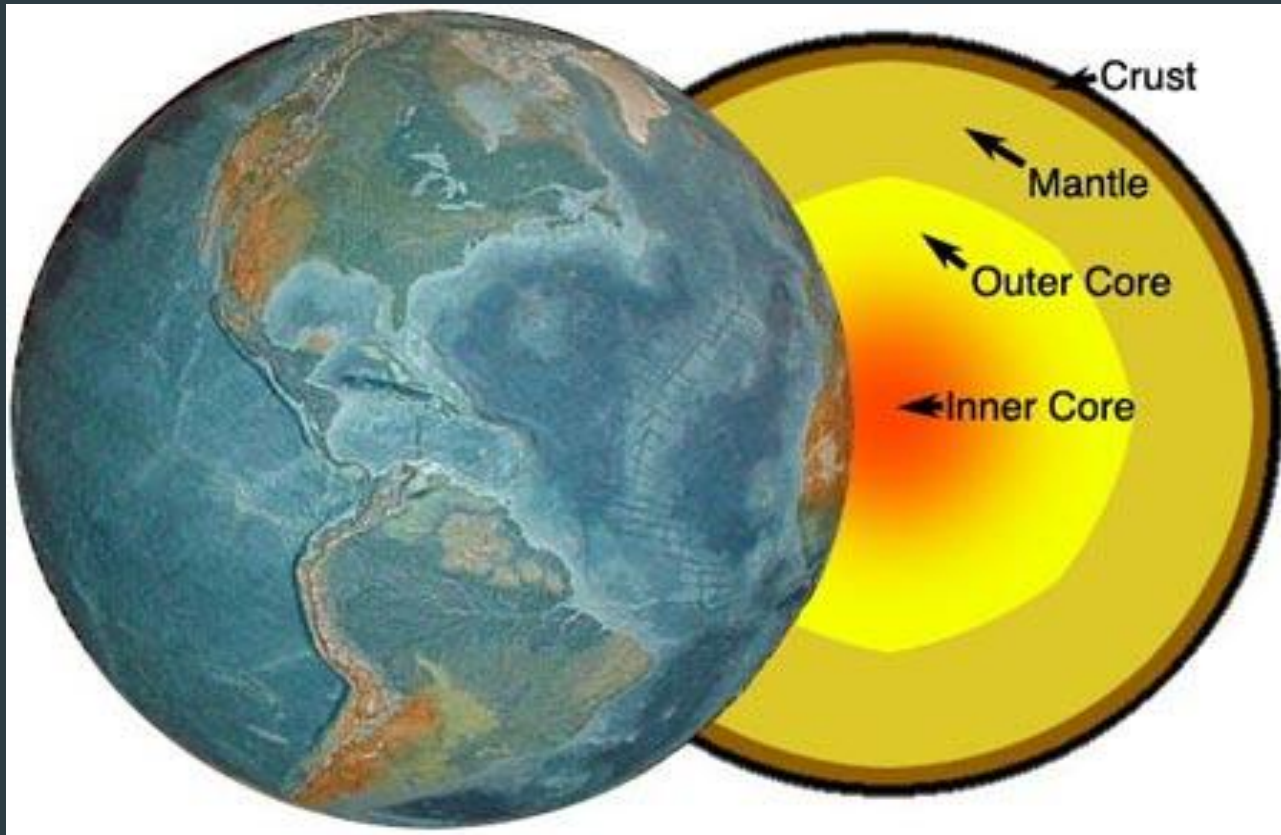
- An estimation of the wave energy in the world oceans indicate that the wave energy flux in the world oceans varies from approximately 10 kW per m wave length and up to approximately 100 kW/m
- The wave energy potential in the Arabian Sea is among the lowest in the world
- The wave energy flux in the open sea is in the order of 17 kW per m wave length, corresponding to 150,000 kWh/m/year
- Along the coast to the Arabian Sea the wave energy flux is lower than at the open sea
- Compared to the world wide wave energy resources the wave energy resources at the coast of Oman are relatively small
- However this is need to be properly evaluated on current wave data



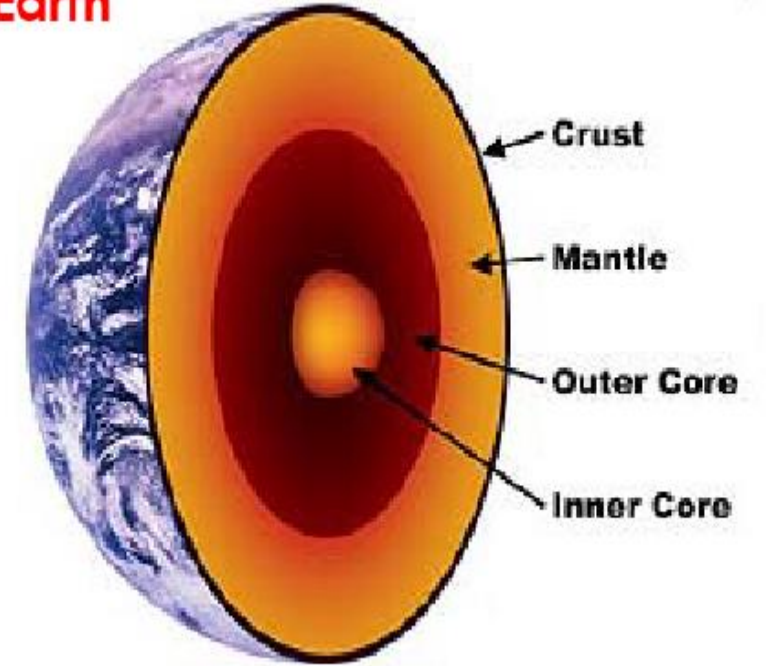
➤ Geothermal energy:

- At least 64 countries around the world are enjoying the use of geothermal resources in variable forms
- Iceland obtains 50% of the total primary energy use from geothermal
- The study report compiled by Authority for Electricity Regulation, Oman in 2008 indicates the temperature of boreholes of 500 m and 1500 m depths at different locations. The number of the boreholes having a temperature above 100 °C is 55.
- The highest observed temperatures are located in the northern part of Oman
- The highest observed borehole temperature is 174 °C
- This temperature is below the temperature required for directly use of the hot water for steam power plants
- This required further exploration to investigation high temperature suitable for geothermal energy

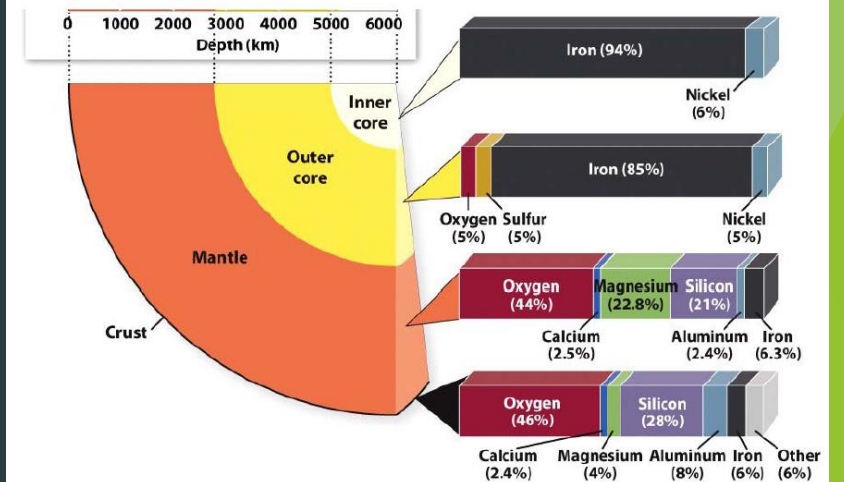
Geothermal energy: How does it Work!



The Earth



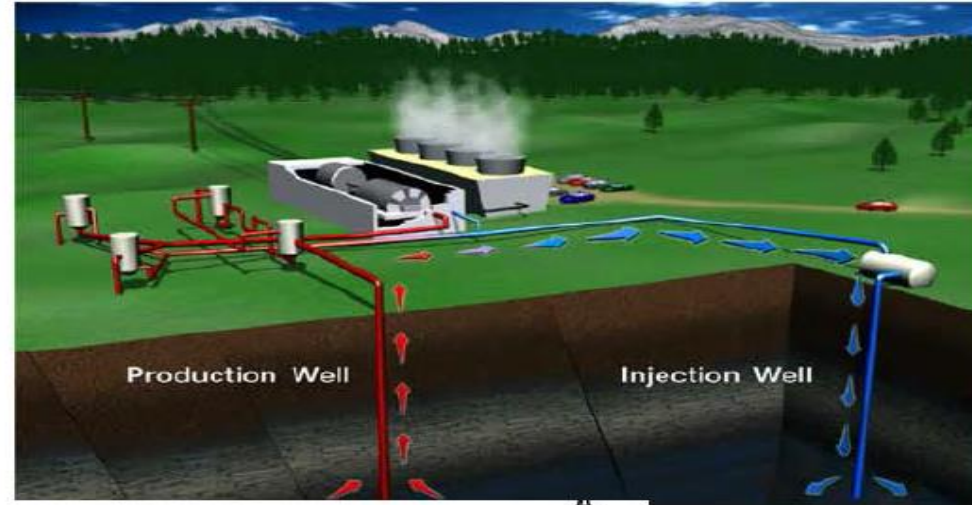
Distribution of elements in the Earth



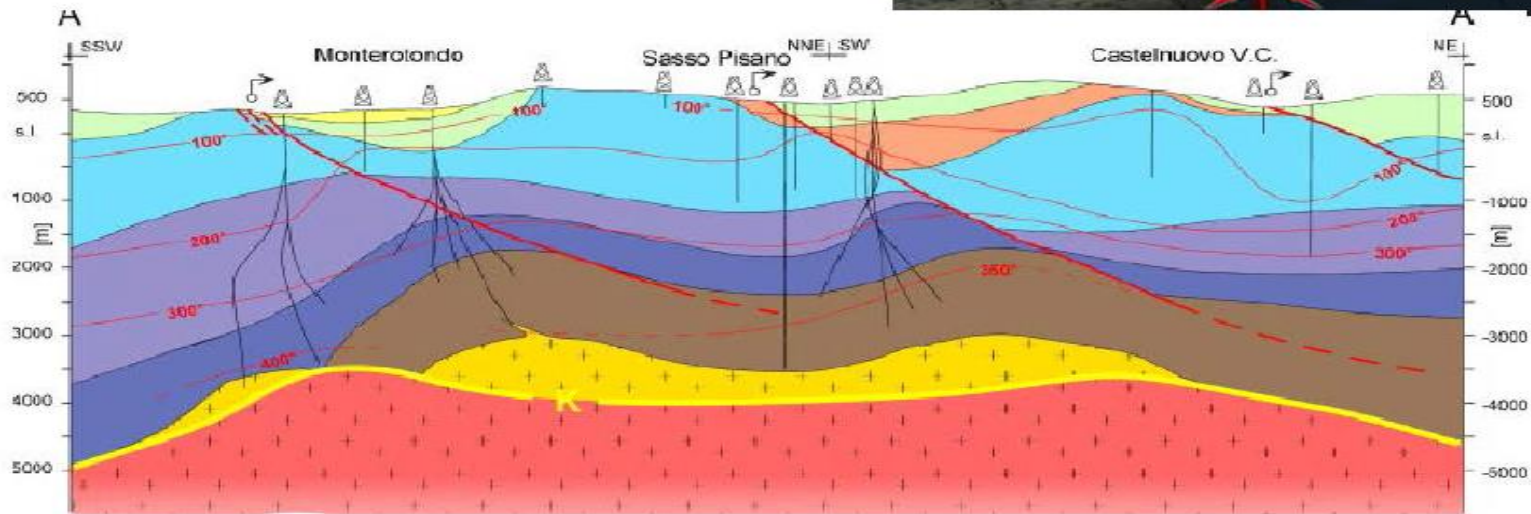
Geothermal energy:

1-element to rock

geothermal energy



The **Larderello** geothermal field





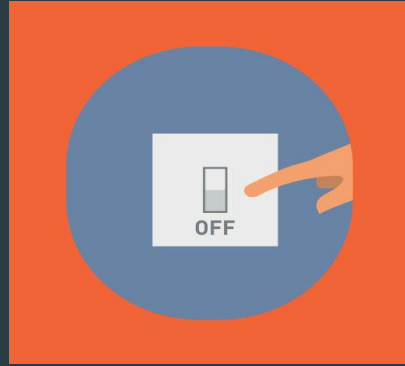
**Welcome to one of CalEnergy's
geothermal power plants.**

Way Forward!

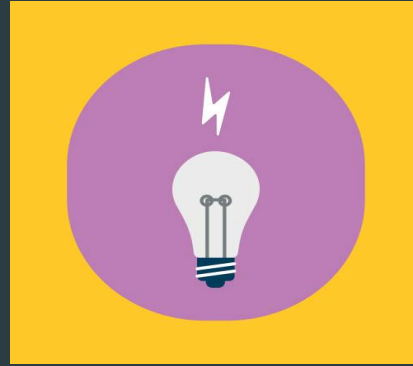
What to Do! Our Role! 10 climate friendly habits



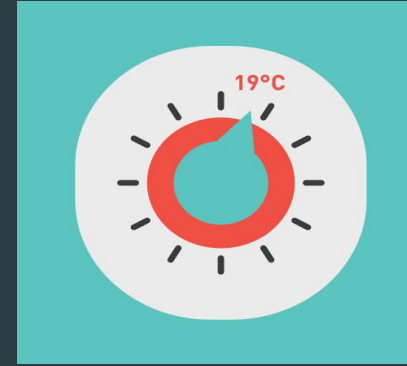
Use energy-efficient appliances



Switch off appliances on standby mode



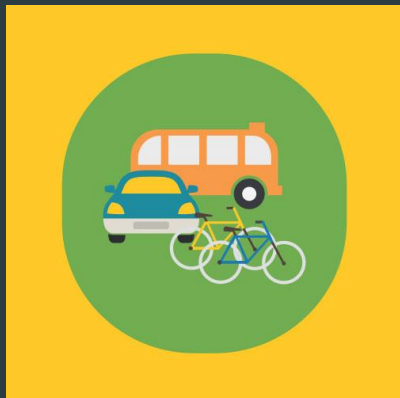
Turn off the light when leaving a room



Keep the thermostat of AC at appropriate level



Reduce Internet use on your computer, phone and tablet



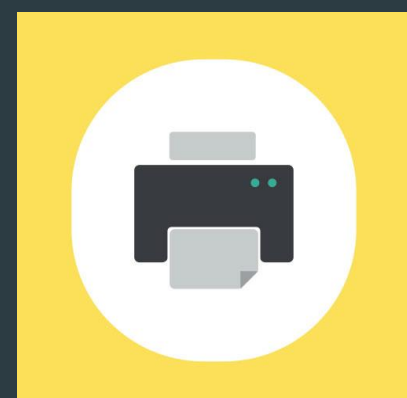
Cycling, using public transport



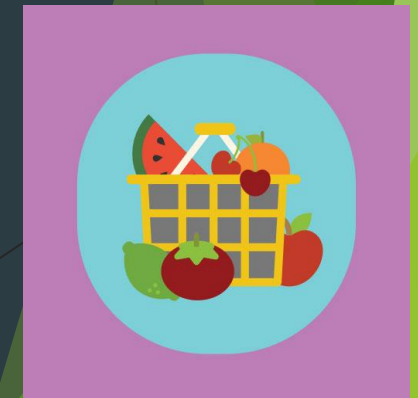
Do not waste water



Recycle waste and use fewer disposable



Cut down on paper



Change your eating habits

Carbon Footprint!

<http://cotap.org/carbon-footprint-calculator/>



UN 17 Sustainable development Goals



UN 17 Sustainable development Goals

Goal No.7 : Affordable and Clean Energy

Ensure Access to affordable, reliable, Sustainable and Modern Energy for All

7.1: By 2030, ensure universal access to affordable, reliable and modern energy services

7.2: By 2030, increase substantially the share of renewable energy in the global energy mix

7.3:By 2030, double the global rate of improvement in energy efficiency

7.4:By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

7.5:By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

UN 17 Sustainable development Goals

Goal No. 13: Climate Action

Take Urgent Action to Combat Climate Change and its Impact

13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

13.2 Integrate climate change measures into national policies, strategies and planning

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

13.4: Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible

13.5: Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

Questions:

Thank You!

Please send feedback at tariqumar1984@gmail.com