Integrating air quality (AQ) and climate change (CC) strategies in Oman

JIHAD JABR ALBUSAIDI

10TH, JANUARY 2022

Is air pollution a problem in Oman?

WE DON'T DO MONITORING, SO DO WE KNOW?

Times of Oman: Sandstorm in Nimr, 3 Aug. 2016

Is climate change a problem in Oman?

I HAD NO IDEA TILL I CONDUCTED THIS STUDY

1. What is the current situation in terms of emissions trends and policies relating to Air Pollution (AP), Climate Change (CC) in Oman?

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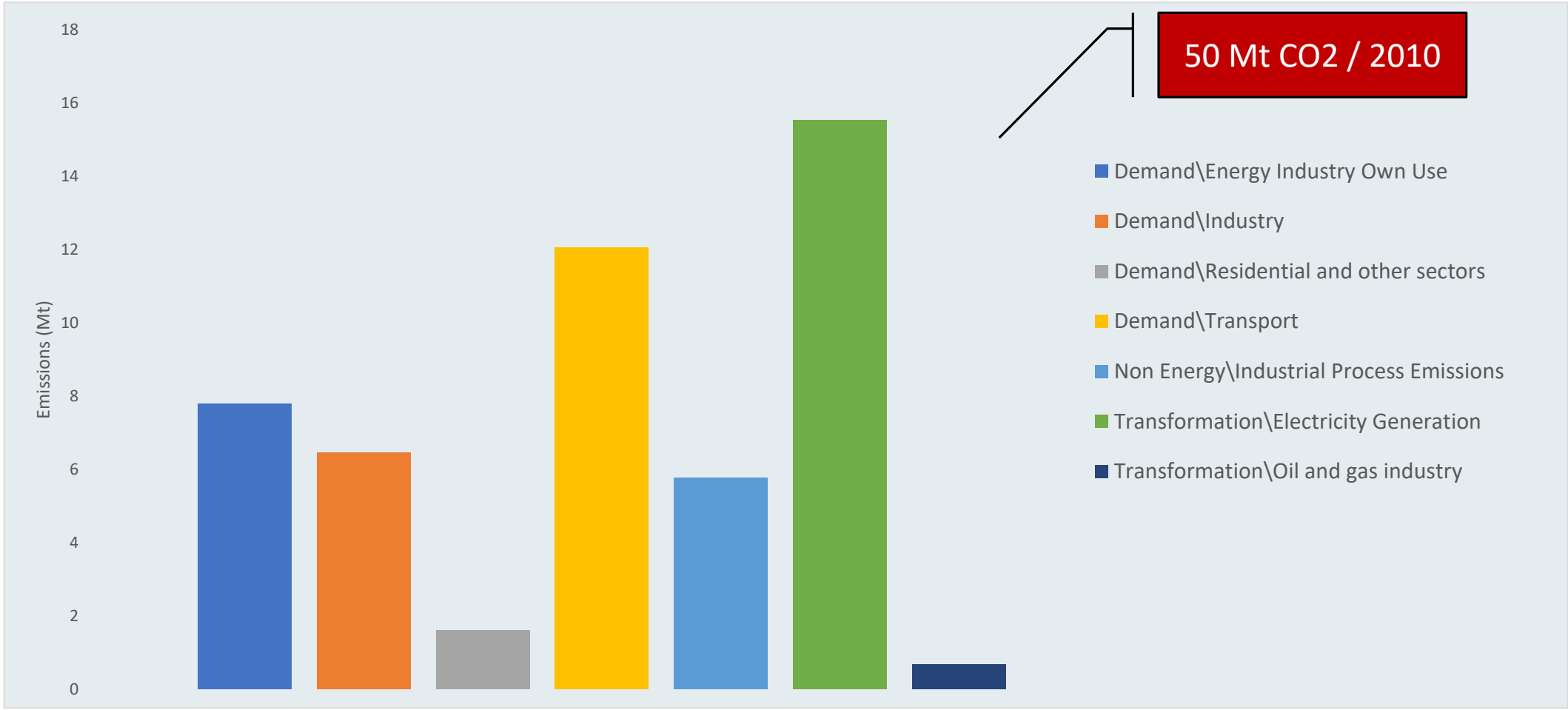
2. How will the situation develop if nothing is done to address the problem (baseline scenario)?
3. What are the possible mitigation measures, and their likely benefits (mitigation scenarios)?
4. What are the current and future impacts (effects) of AP/CC in Oman?
5. What are the policies that could help address the problem?

Estimating current and historic emissions in Oman

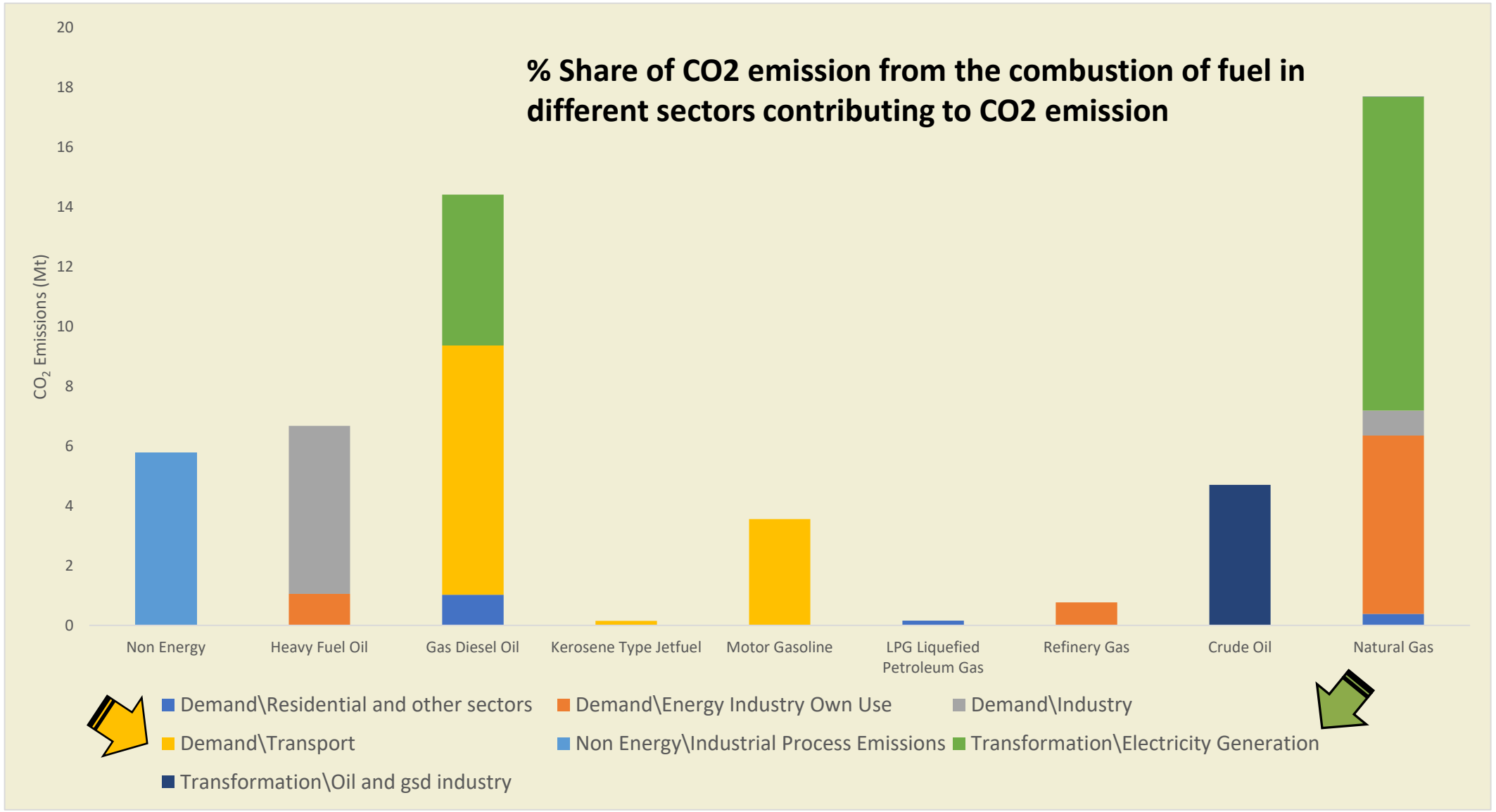
CO_2, CO, CH_4, NMVOC, NO_X, SO_2, $PM_{2.5}$, BC, OC, AND NH_3

WHERE IS OMAN HEADING?

Sources of CO2 emission in Oman for 2010



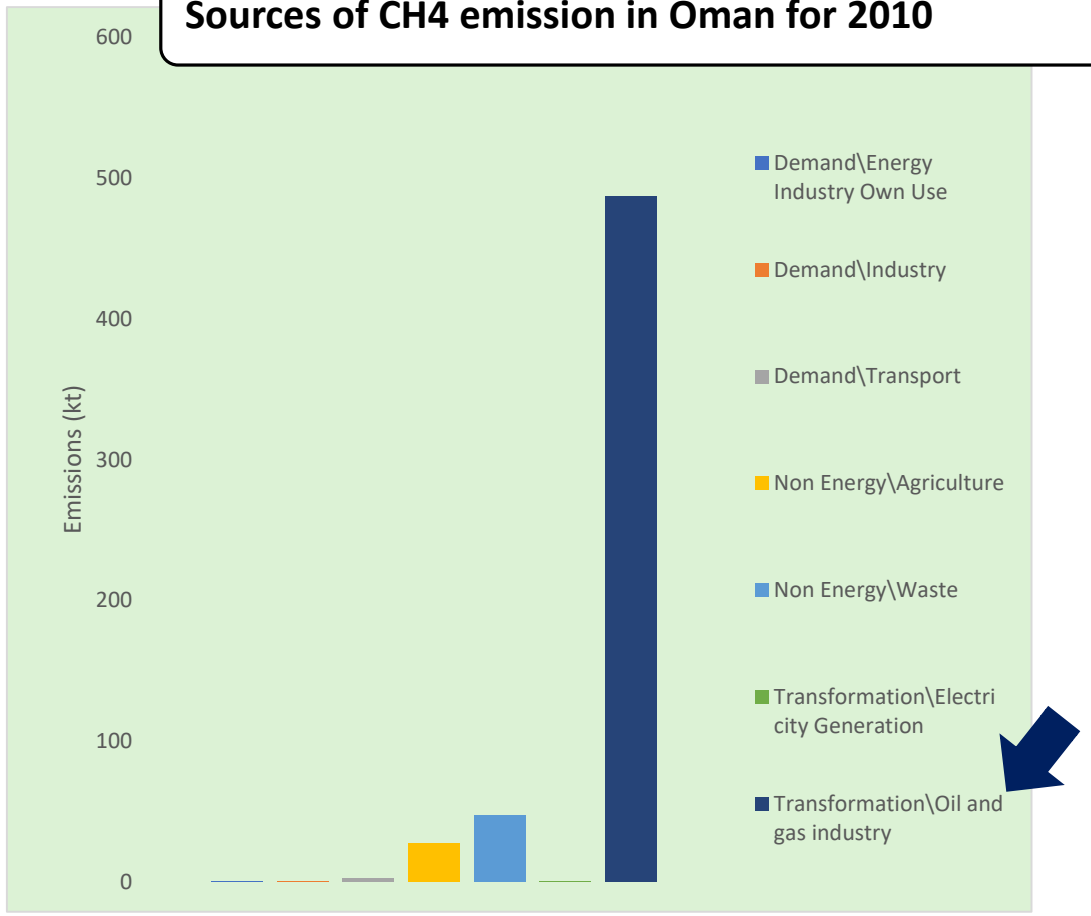
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1



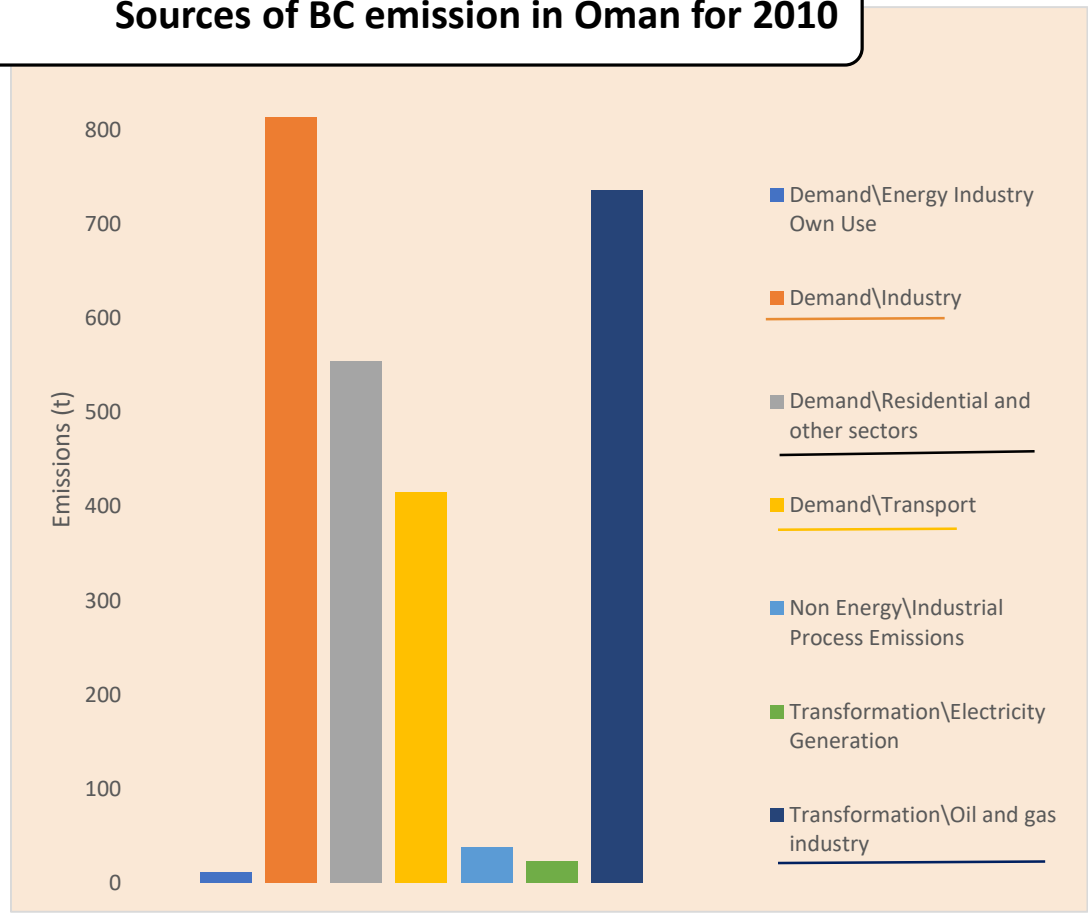
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

Sources of SLCP emission in Oman for 2010

Sources of CH4 emission in Oman for 2010

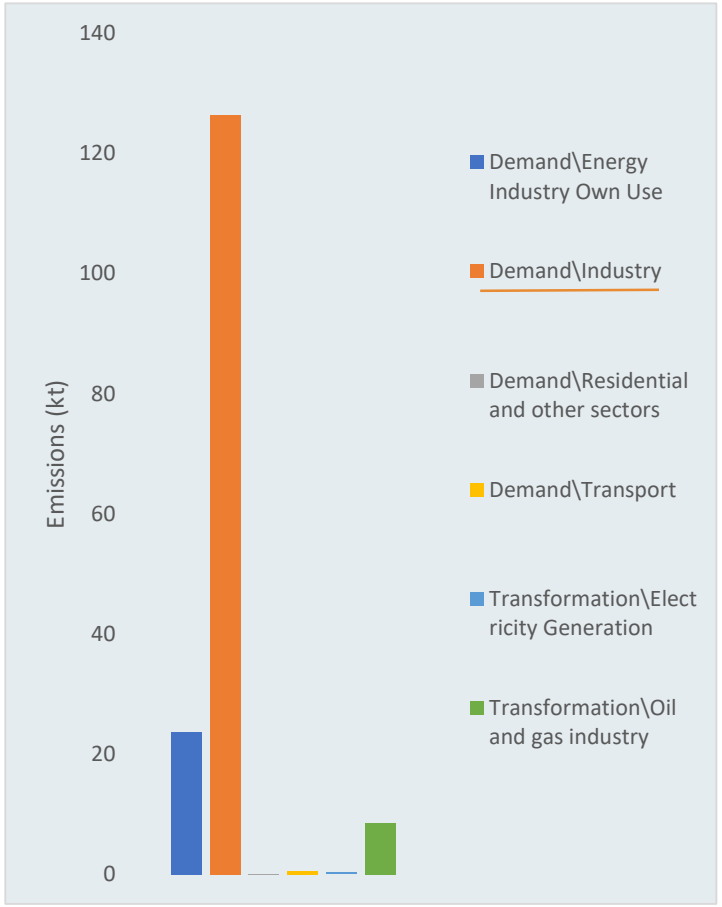


Sources of BC emission in Oman for 2010

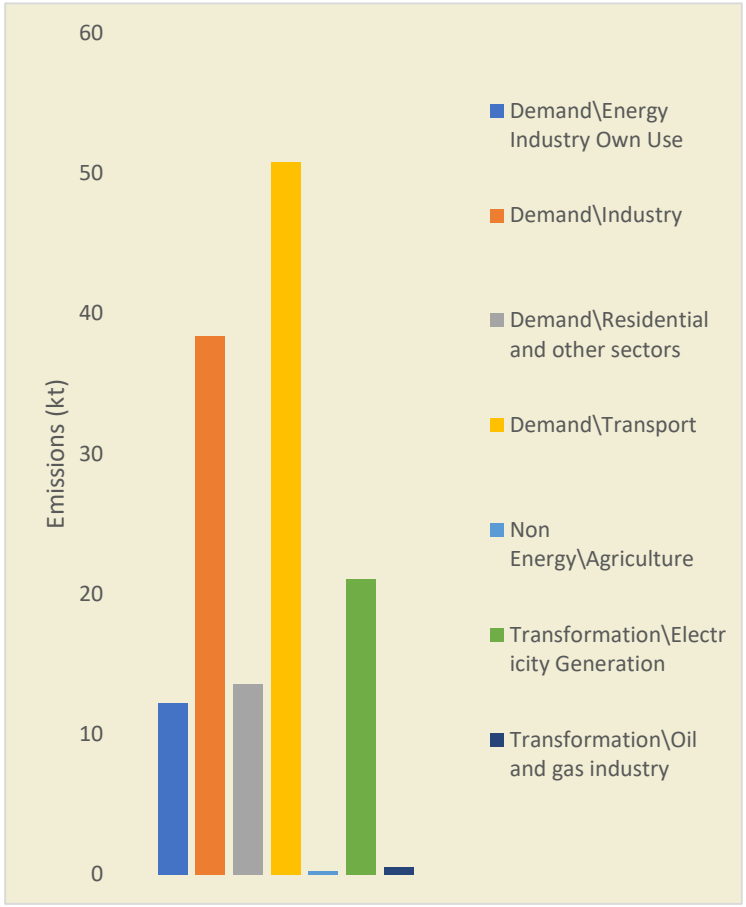


Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

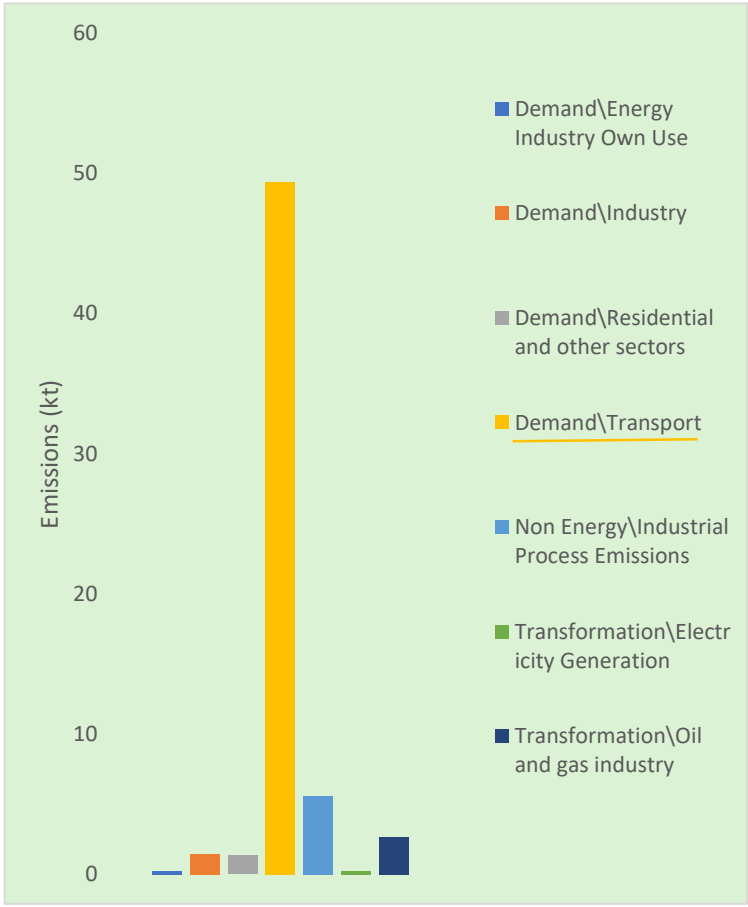
Sources of SO2 emission in Oman for 2010



Sources of NOx emission in Oman for 2010

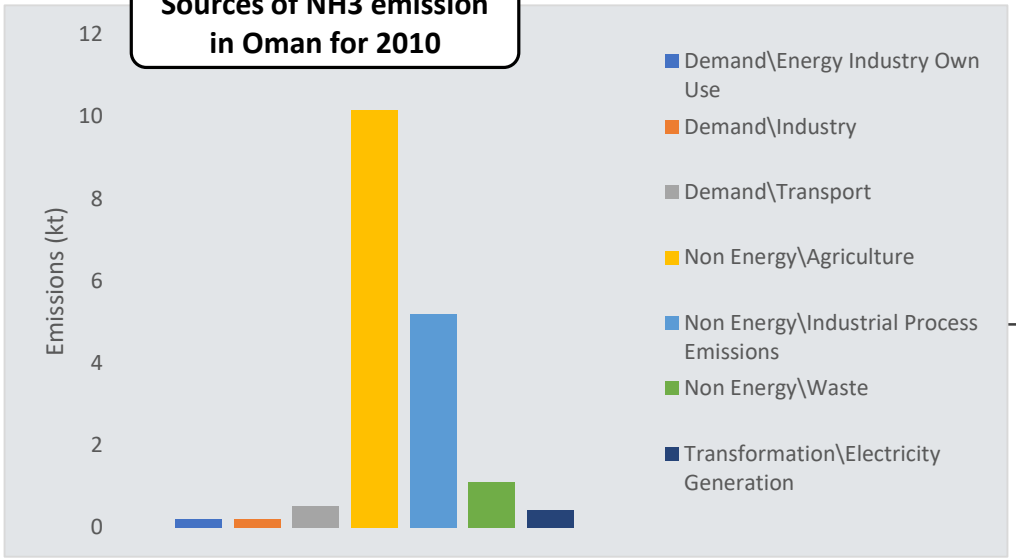


Sources of PM2.5 emission in Oman for 2010

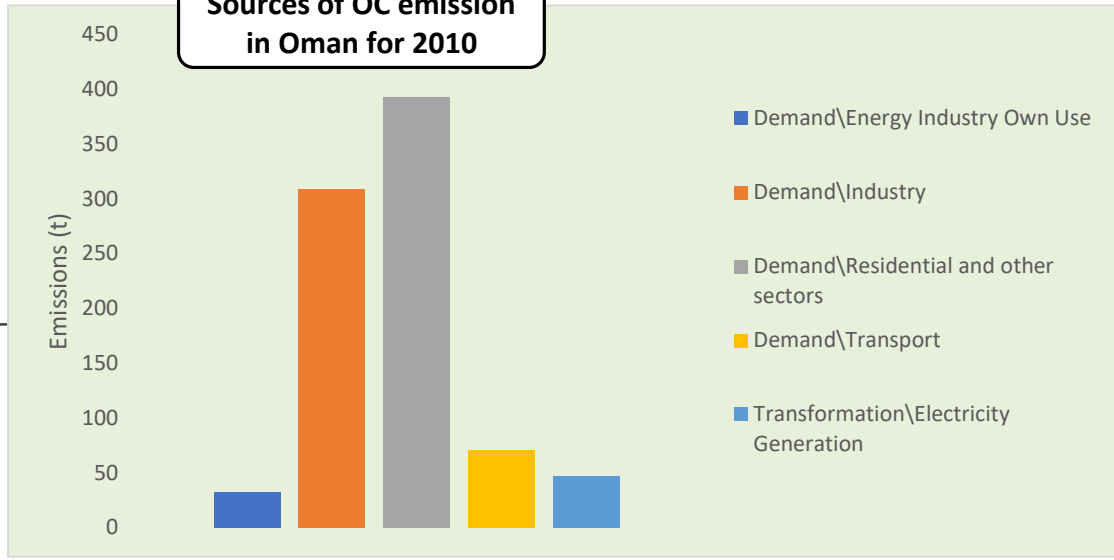


Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

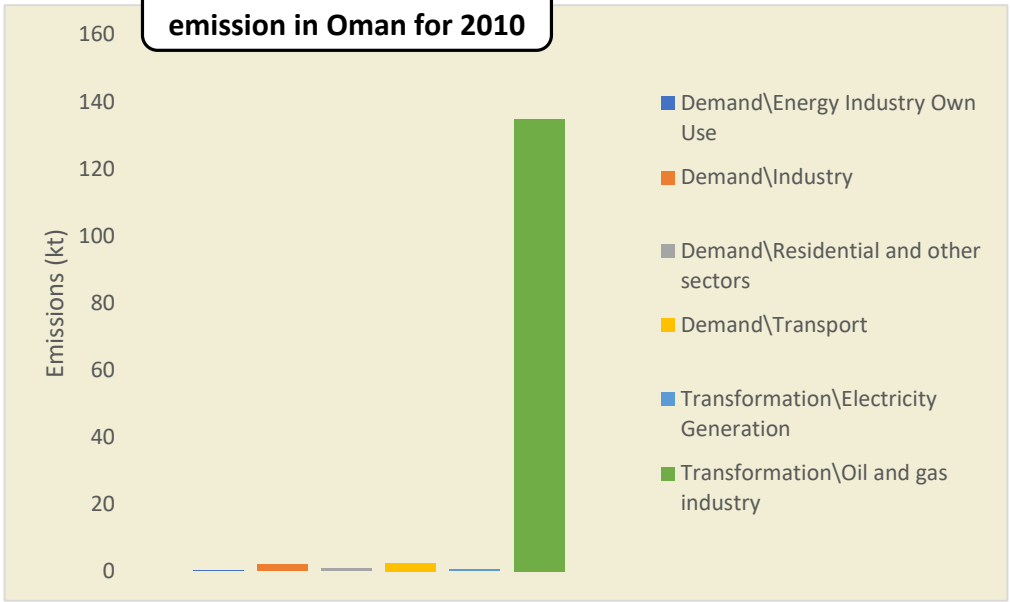
Sources of NH3 emission in Oman for 2010



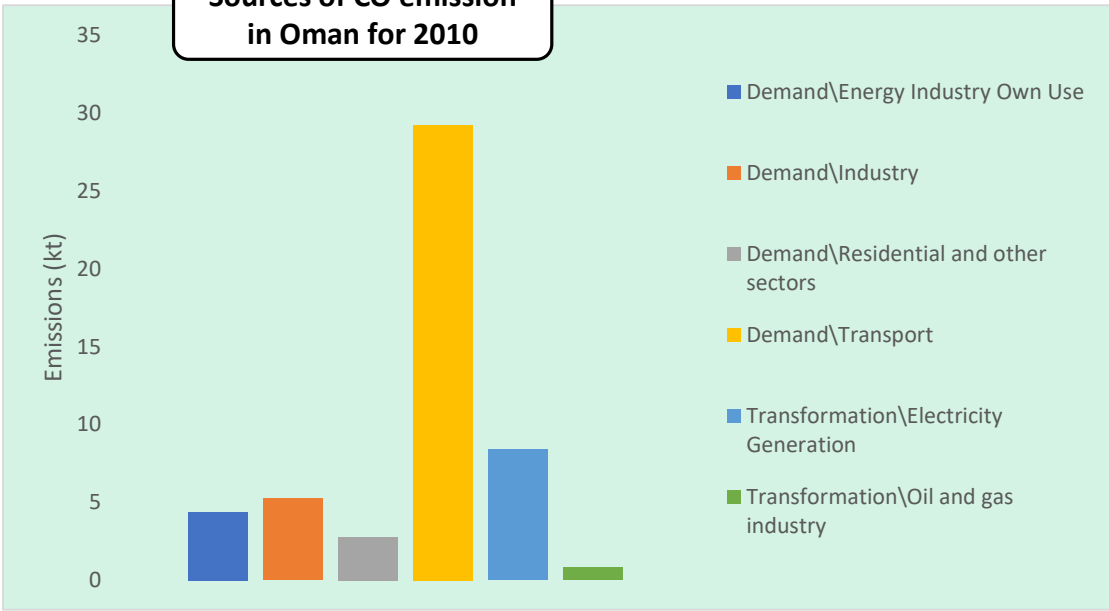
Sources of OC emission in Oman for 2010



Sources of NMVOCs emission in Oman for 2010



Sources of CO emission in Oman for 2010

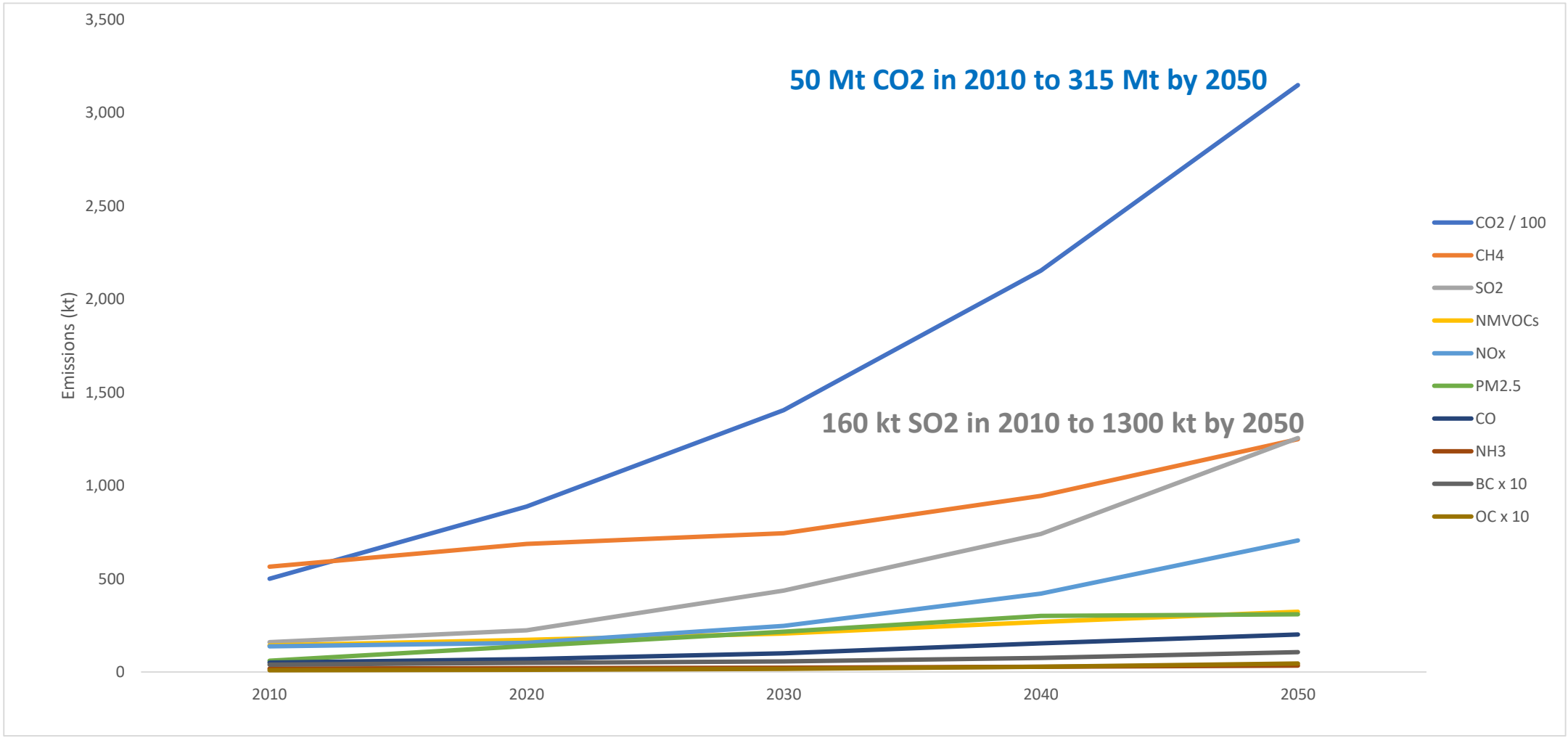


Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

if we don’t do anything, the chance to get worse is high

BASELINE SCENARIOS (BAU)

Baseline scenario emissions estimate from 2010 to 2050



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

Total pollutant emissions in kt for Oman for the BAU scenario

Effects	2010	2020	2030	2040	2050
CO_2	49,948	88,777	140,399	215,334	314,867
CH_4	564.8	687.5	743.9	945.0	1,248.7
SO_2	159.6	222.9	435.9	740.2	1,255.4
NMVOC	142.1	172.6	206.1	267.9	323.7
NO_x	136.9	156.3	247.2	419.7	705.3
$PM_{2.5}$	60.8	138.2	215.6	300.5	309.3
CO	50.8	69.1	99.5	153.9	201.0
NH_3	17.8	20.3	23.4	28.1	34.0
BC	3.9	4.9	5.6	7.5	10.7
OC	0.9	1.1	1.6	2.8	4.6

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 2.5.1

How important is climate change for Oman?

SHOULD WE BE WORRIED ABOUT CLIMATE CHANGE?

1. Heat waves:

A city in Oman may have just had the hottest night ever recorded on Earth

Doyle Rice | USA TODAY
Published 12:07 p.m. UTC Jun 29, 2018

In this Feb. 17, 2018 photo, three camels graze on beach shrubs along the al-Maghsail beach, near Salalah, in southern Oman. A city in Oman may have set the all-time world record for hottest nighttime low temperature this week.
Sam McNeil, AP

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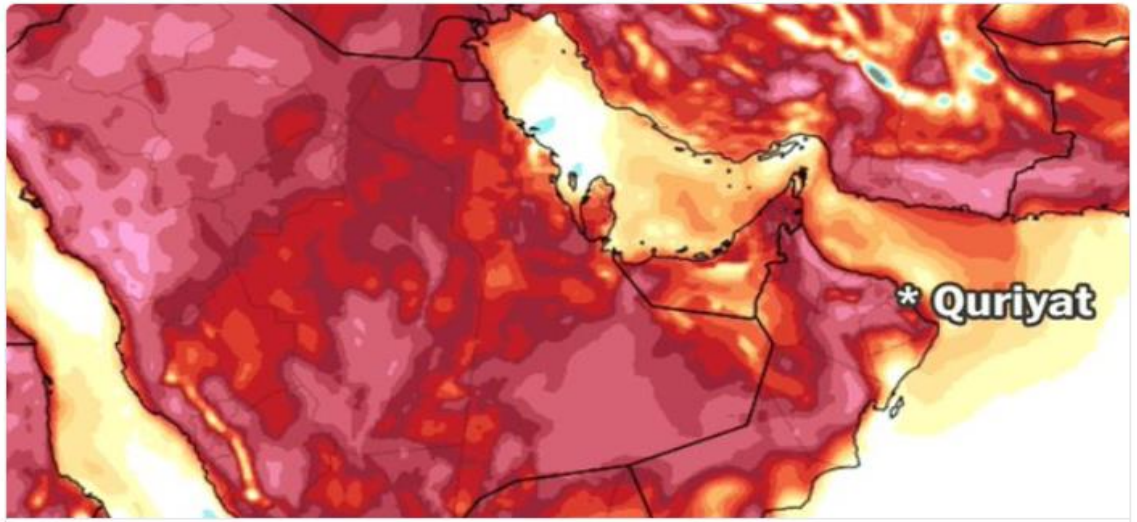
Following

A city in Oman just posted the world's hottest low temperature ever recorded: 109 degrees.

42.8 °C



A city in Oman just posted the world's hottest low temperature ever recorded...
The temperature in the town of Quriyat remained above 107 degrees for 51 straight hours.
washingtonpost.com

8:43 AM - 28 Jun 2018

240 Retweets **258** Likes

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Following
A meteorological station in Qurayyat, Oman, recorded a NIGHT time temperature of 42.6°C (108.7°F) on 25 June. WMO Weather and Climate Extremes archive currently does not include highest minimum temperatures so can not confirm if this is a new world record.
wmo.asu.edu
World Weather & Climate Extremes Archive
3:09 PM - 28 Jun 2018
64 Retweets 68 Likes
Tweet
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Fwd: If you think it is hot | Heat record: A city in Om | Jehad Jabr Na...

Secure | https://mail.google.com/mail/u/0/#inbox/1644b4e22adce68b

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University of York

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1 of 6,013

COMPOSE

Inbox (3,990)
Starred
Sent Mail
Drafts
Important
Chats
All Mail
Spam
Bin

Categories
Manage labels
Create new label

Fewer labels

Fwd: If you think it is hot here think of Oman!

Inbox x

Sarah West
to SEI, Andreas

12:29 (5 minutes ago)

Blimey! Just copying in the PhD students :D

---------- Forwarded message ----------
From: **Andreas Heinemeyer** <andreas.heinemeyer@york.ac.uk>
Date: 29 June 2018 at 12:24
Subject: If you think it is hot here think of Oman!
To: SEI York <sei-york-group@york.ac.uk>

Hi all,

Just digested Jehad's excellent brown bag talk (as I missed it I asked for the slides) and looked up her country ... to my shear horror I stumbled across this temperature fact far beyond my imagination:

CNN: "The city of Quriyat in Oman now has a dubious distinction to its name: It has recorded the highest "low" temperature in known history.

The Middle Eastern town of about 50,000 residents clocked in at a **low** temperature of **42.6°C** (108.7°F) on June 26, 2018."

So, if you think it is hot here think again!
Andreas

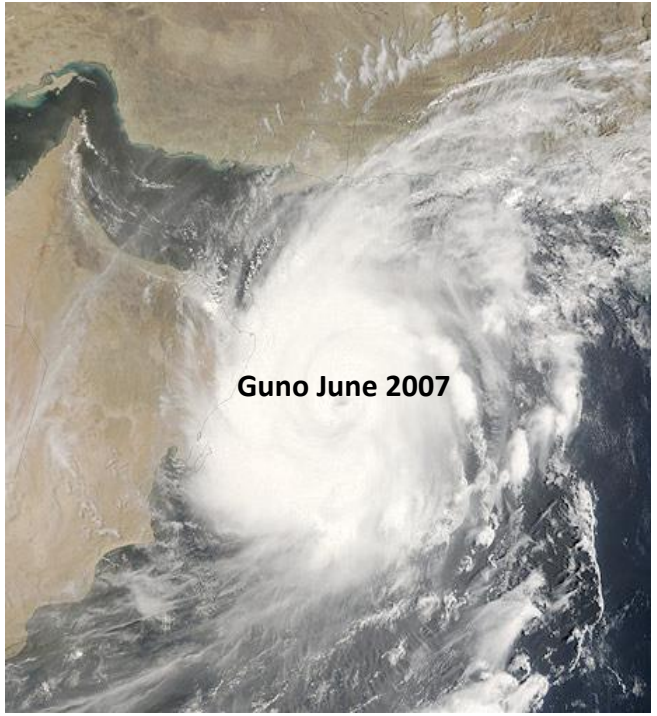
--
Dr. **Andreas Heinemeyer**
Senior Research Fellow (Associate Professor)

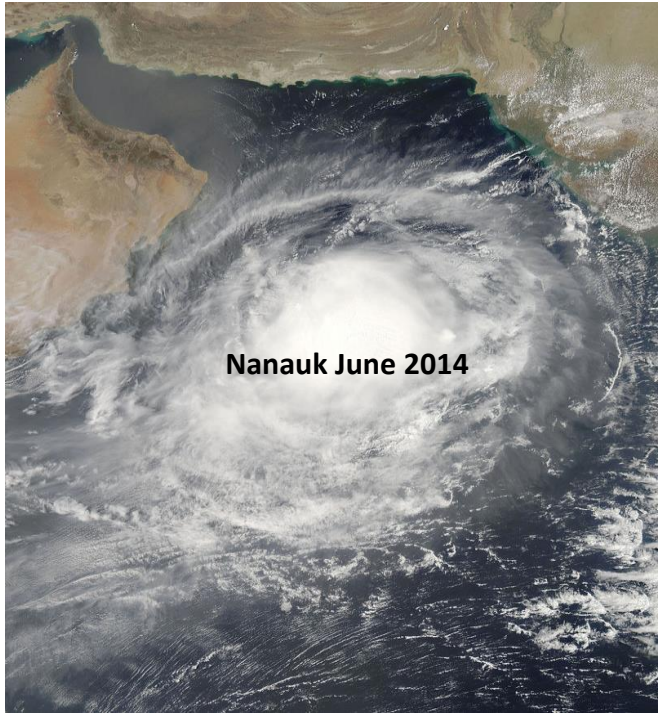
Type here to search

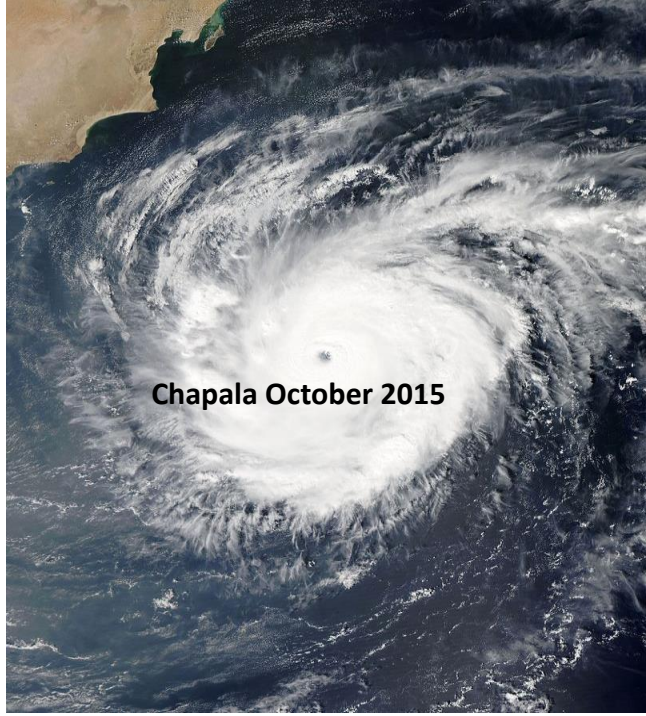
ENG
UK
12:35
29/06/2018

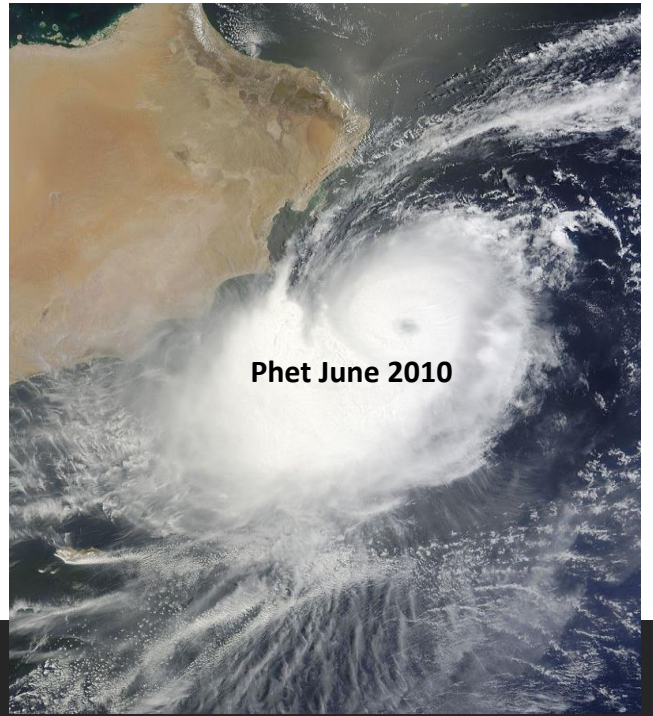
1. Cyclones

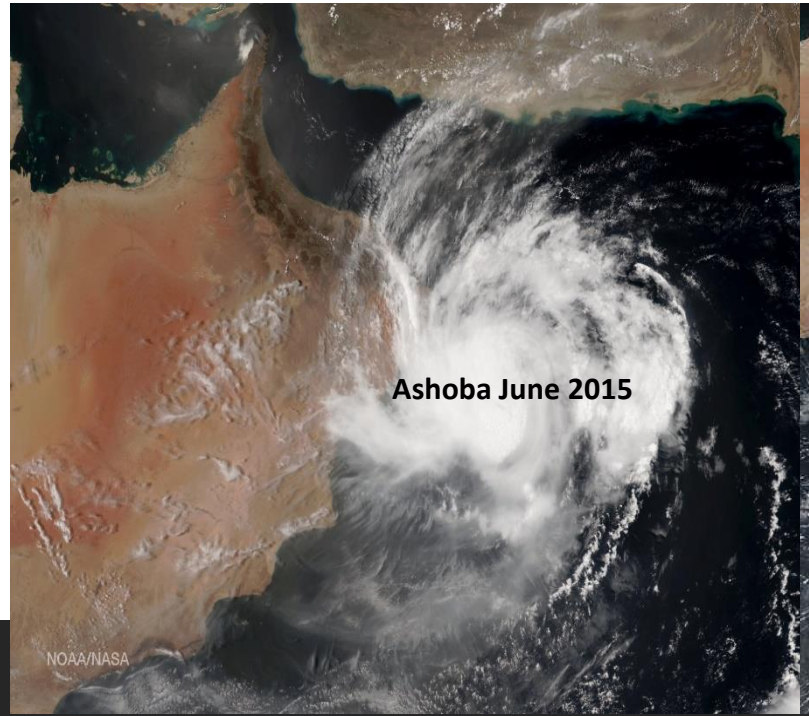
Oman has suffered heavily from severe tropical cyclonic storms in 2007, 2010, 2014, 2015, 2018, 2019, 2021

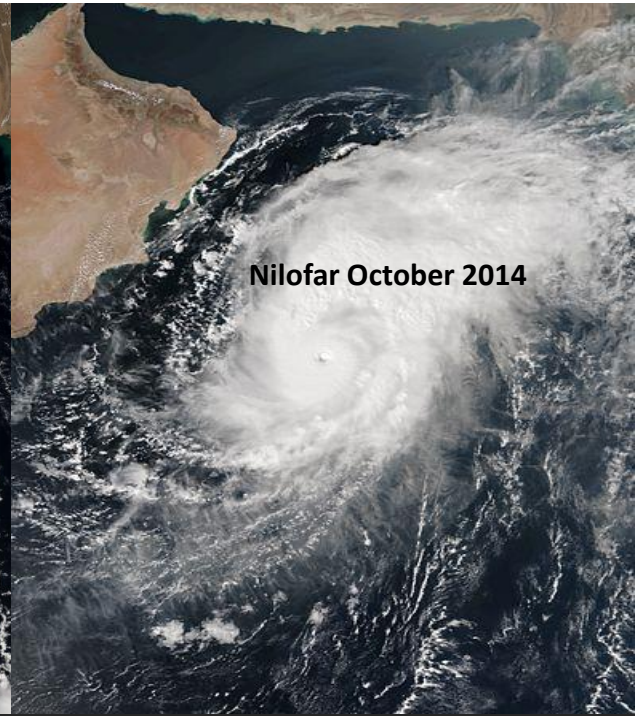




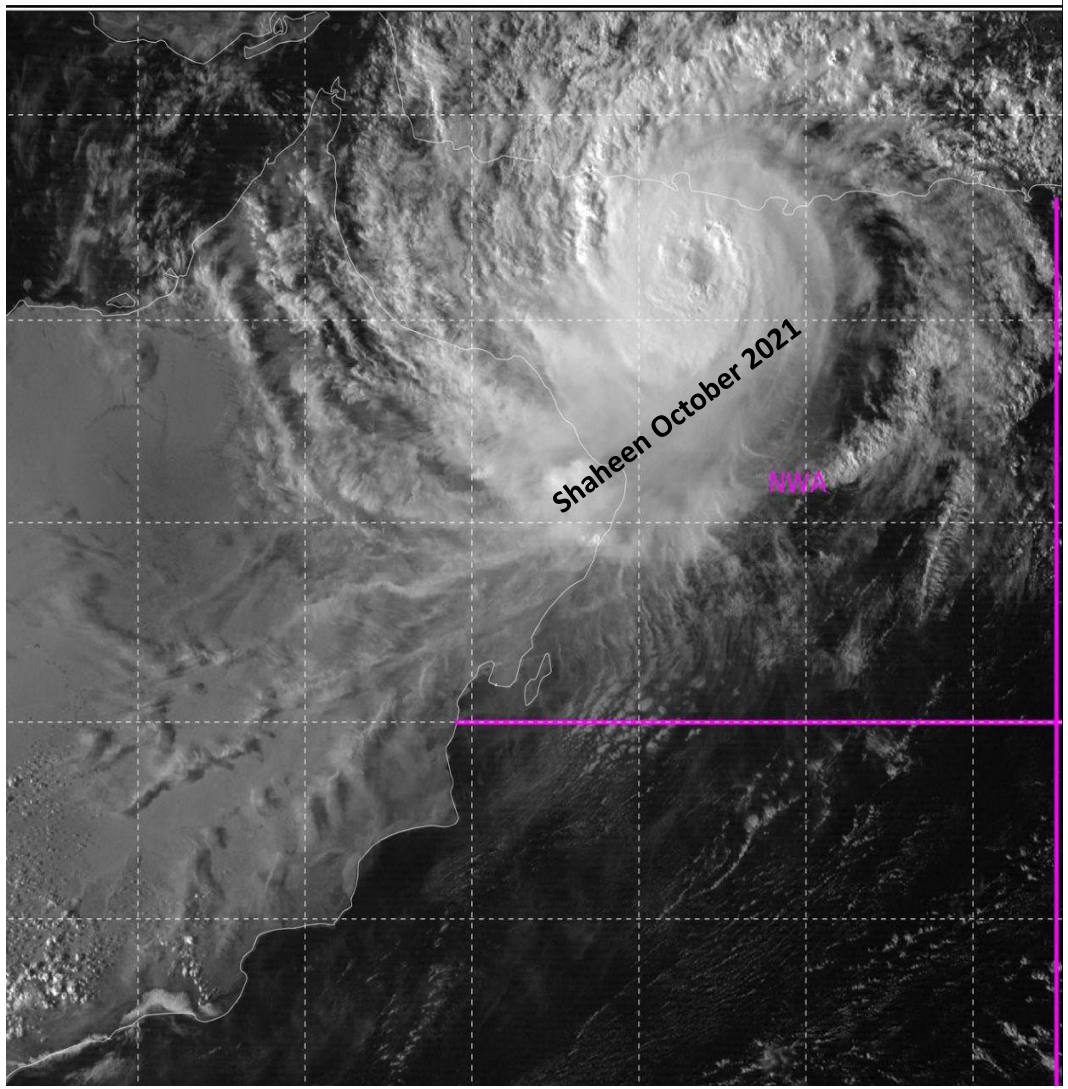


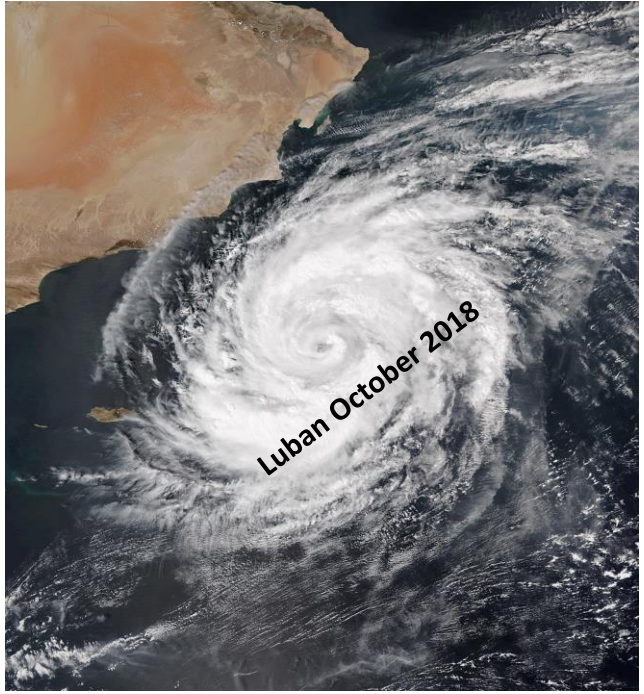


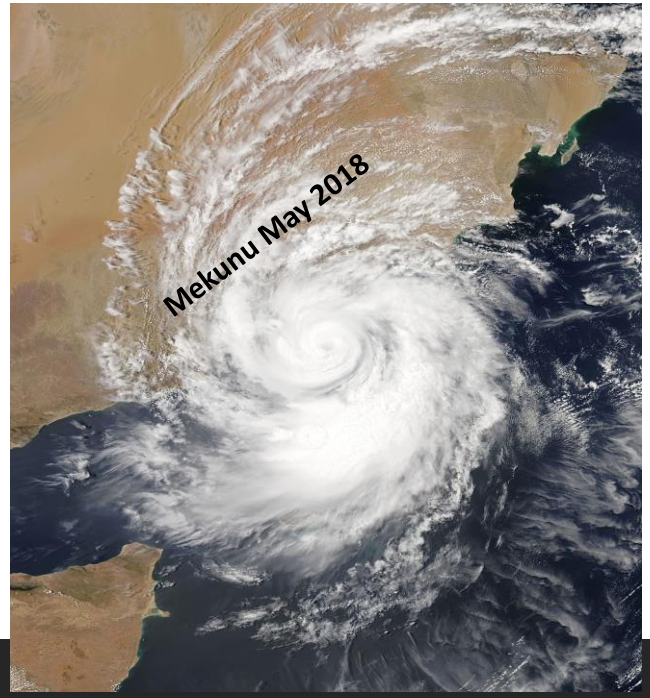




02-10-2021/(1107 to 1112) GMT
02-10-2021/(1637 to 1642) IST







Before Mekunu 2018
Teeq cave, Dhofar
170,000 cubic m size
211 m depth
أحمد الطوقي
ahmedaltoqi.com

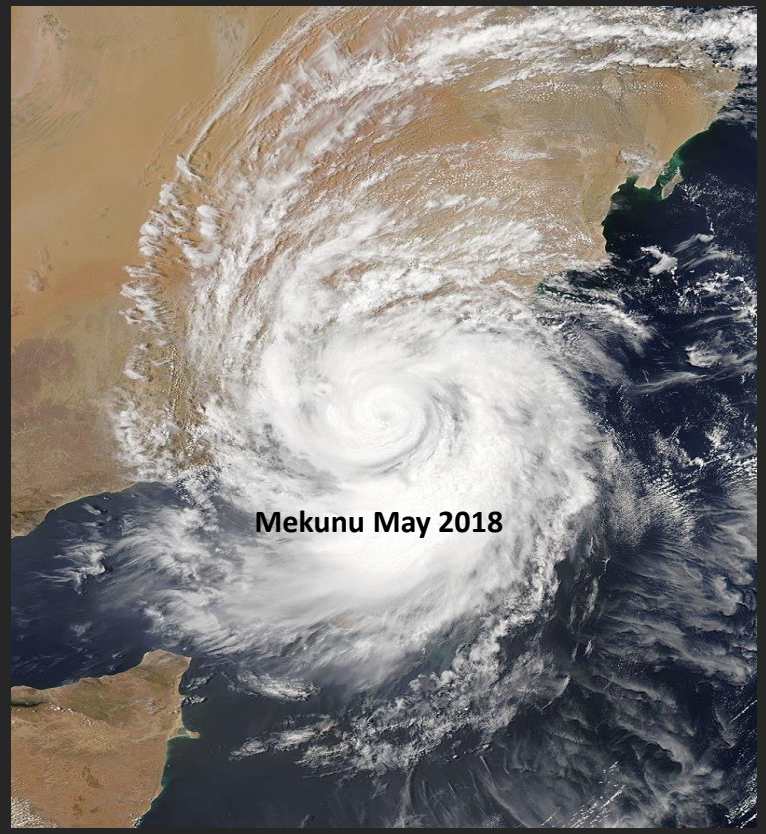
After Mekunu 2018
أحمد الطوقي
ahmedaltoqi.com

We are making progress

OMAN 2040 VISION

Statement of the Council of Ministers

Climate change Impacts



Mekunu May 2018

التواصل الحكومي

مجلس الوزراء

بيان

جلسة الثلاثاء - ٢٩ مايو ٢٠١٨

- استعرض مجلس الوزراء جهود الحكومة للتعامل مع آثار التغير المناخي الأخير الذي شهدته كل من محافظتي ظفار والوسطى.
- المجلس يعرب عن الشكر والثناء لكافة الجهات ويخص بالذكر منتسبي كل من وزارة الدفاع وقوات السلطان المسلحة والحرس السلطاني العُماني وشرطة عُمان السلطانية والأجهزة الأمنية واللجنة الوطنية للدفاع المدني والأرصاد الجوية والأجهزة الإعلامية وخاصة الهيئة العامة للإذاعة والتلفزيون
- المجلس يشيد بجهود الشباب المتواصلة من تقديم الإرشادات والتوعية بطبيعة مجريات الحالة المناخية.
- المجلس يؤكد ان كافة الوزارات والوحدات المعنية قامت بدور هام لمعالجة عدد من الآثار التي تعرضت لها بعض المرافق والاستمرار تدريجيا في استئناف التشغيل لخدماتها.
- إشادة بإسهامات محافظتي ظفار والوسطى وكافة الولاة والقطاع الخاص والهيئة العُمانية للأعمال الخيرية بعطاء وافر وشعور بالمسؤولية الوطنية في التعامل مع تطورات الحالة المدارية.
- مجلس الوزراء يتقدم بالتعازي والمواساة لأسر المتوفين إثر الظروف المناخية داخل السلطنة وفي دول الجوار الشقيقة، داعيا المولى عزّ وجلّ بالسلامة للجميع.

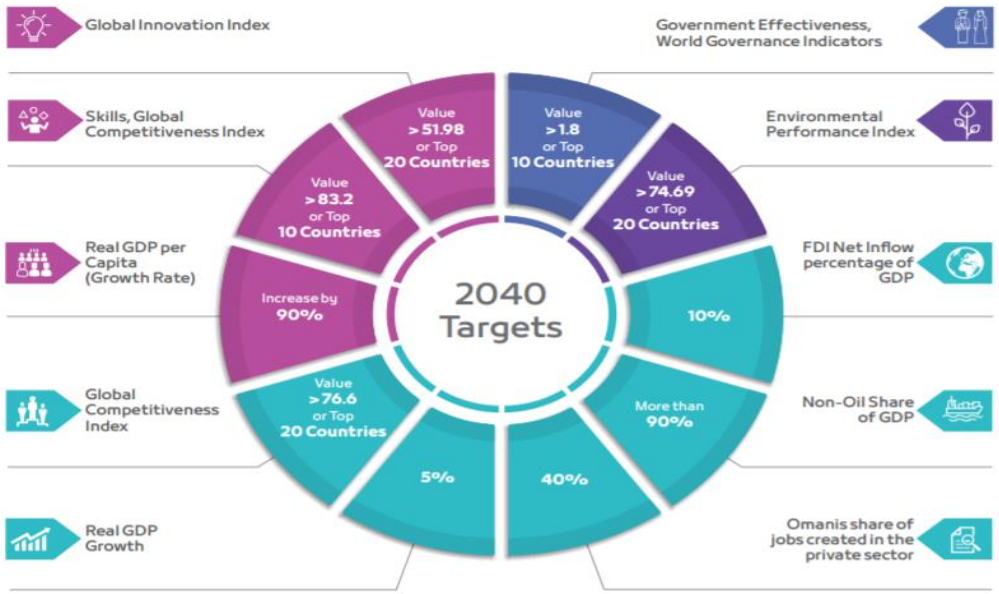
Oman 2040 vision

Environment and Natural Resources

An Environment with Sustainable Components Safe and well-preserved environment, with effective and balanced ecosystems and renewable resources

Our Vision

Oman: Joining the World's Developed Countries

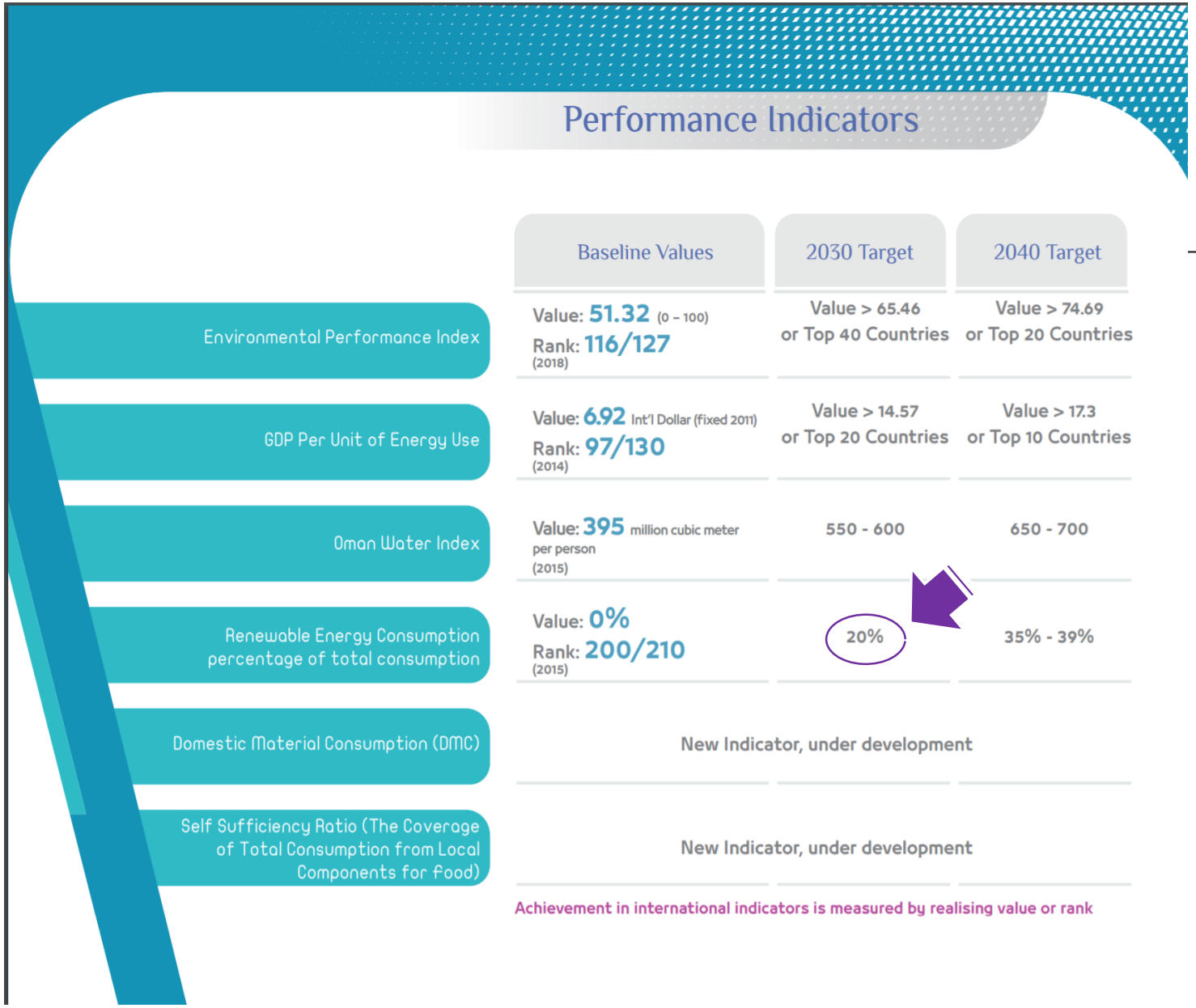


Main Oman 2040 Vision Indicators

Environmental Performance Index

Top 20 Countries

In the 2018 Environment Performance Index (EPI), Oman ranked 179 out of 180 countries in the air pollution category



statement to the media made by the Undersecretary of the Ministry of Oil and Gas in June 2019, saying that the Sultanate has raised its 2030 target for renewable energy share to 30%.

We can do better

MITIGATION SCENARIOS

Sector		Scenario	Abbreviation
	1	Business - as - Usual	BAU
Oil and gas	2	Fugitive Reduction Scenario	FRS
	3	Zero Flaring Scenario	ZFS
Electricity generation	4	Renewable Energy Scenario	RES
	5	Zero Coal Scenario	ZCS
Manufacturing industry	6	Efficient Industry Scenario	EIS
	7	Clean Fuel Scenario	CFS
Transport	8	Electric Vehicle Scenario	EVS
	9	Public Transport Scenario	PTS
	10	Paved Road Scenario	PRS
Residential	11	Efficient Air Conditioning Scenario	REACS
Commercial and Public services	12	Efficient Air Conditioning Scenario	CEACS
(2-12) All measures combined			AM

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.1

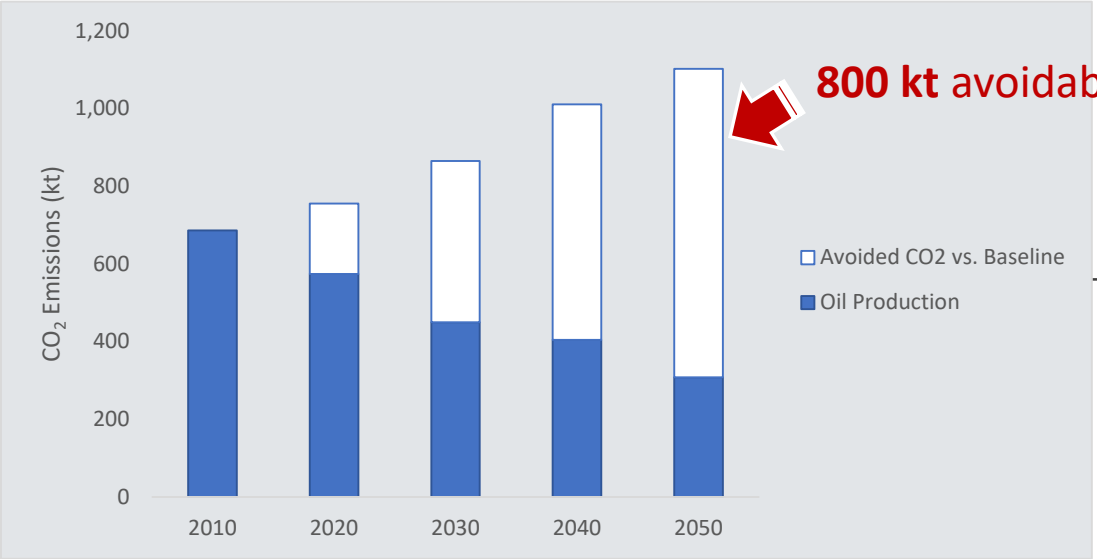
Oil and gas industry mitigation scenario:

FUGITIVE REDUCTION SCENARIO (FRS)

ZERO FLARING SCENARIO (ZFS)

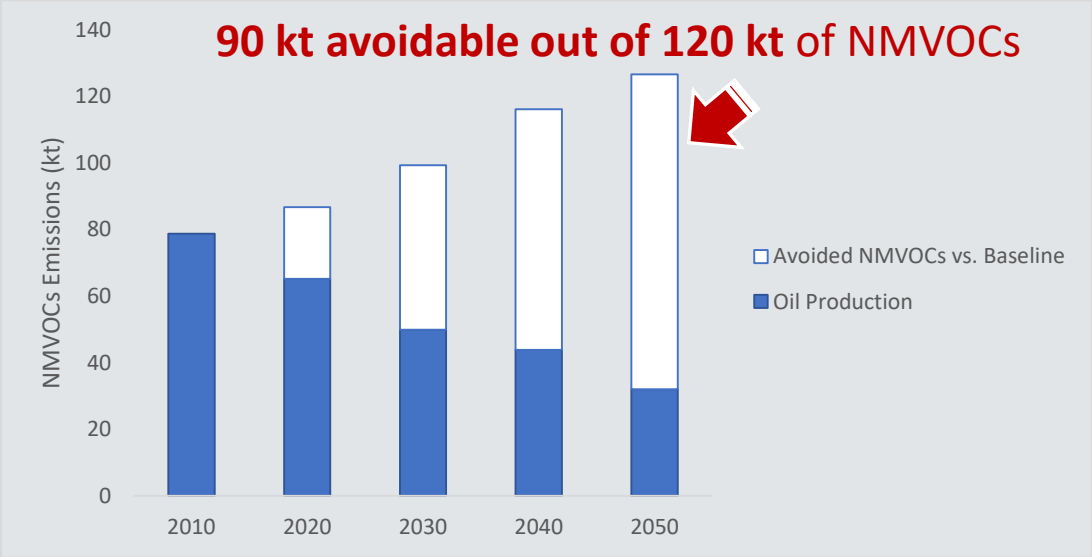
	(BAU)	Measure of mitigation scenario
Fugitive Reduction Scenario (FRS)	no activity data required, as the projection is driven by the growth in the demand for oil and gas	Extended recovery and use—rather than venting—of associated gas, and improved control of unintended fugitive emissions from oil production. Reduced gas leakage from long-distance transmission pipelines. Avoid fugitive emission by advanced technology. Emissions control of venting and flaring of CH_4, NMVOCs, and CO_2 as follows: (2030,50,2050,75)
Zero Flaring Scenario (ZFS)	Based on actual historical data of volume of gas flared from oil and gas industry as illustrated before in table 4.10b	Elimination of flaring by 2030 based on Zero flaring initiative from oil and gas production; Methane flaring: (2030,0) NMVOCS flaring: (2030,0) And from the refineries; Flaring: (2030,0)

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.2.2

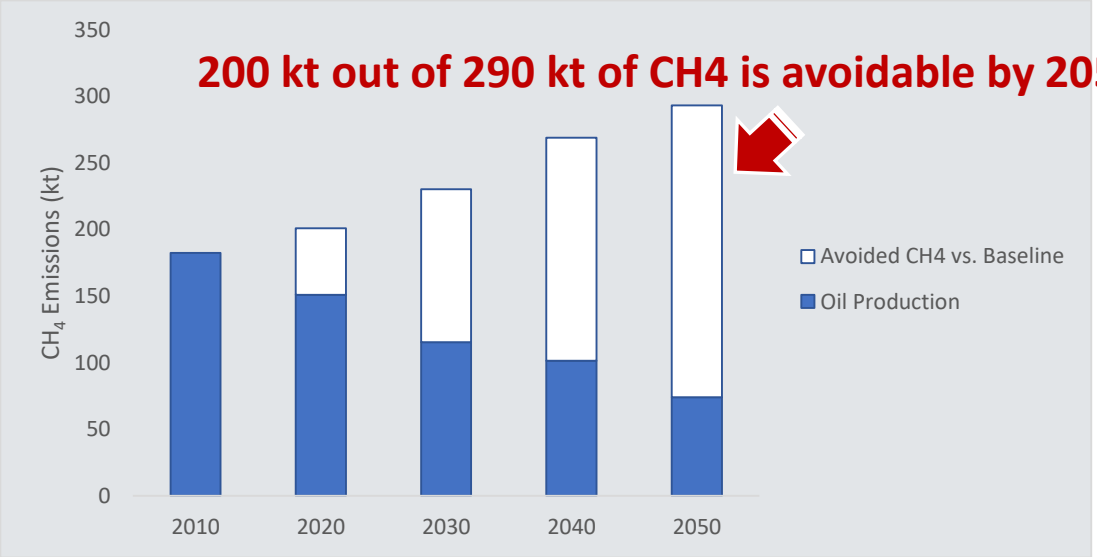


800 kt avoidable of CO_2 by 2050

Fugitive reduction scenario in oil and gas sector



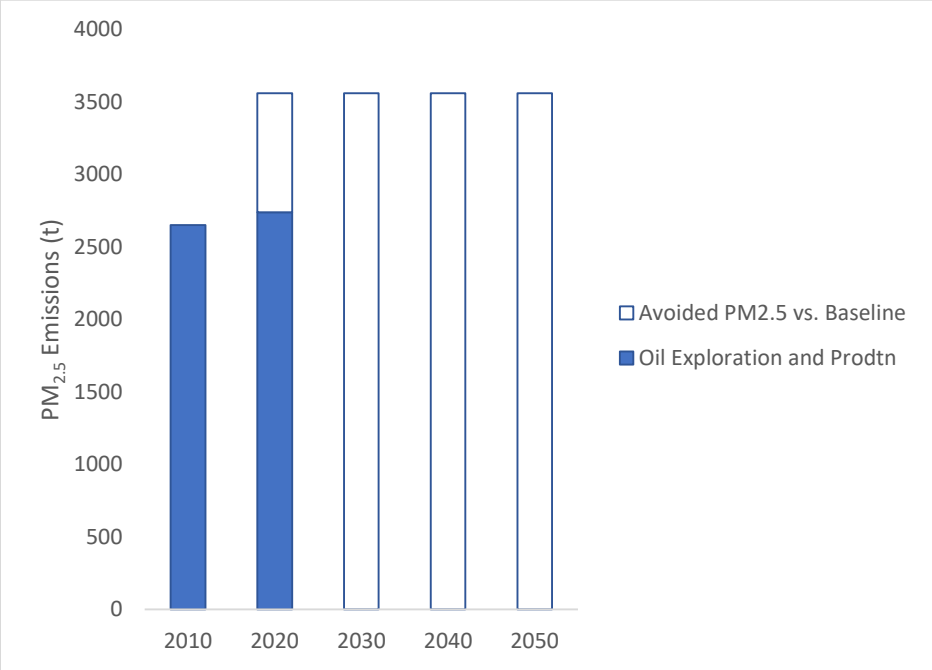
90 kt avoidable out of 120 kt of NMVOCs

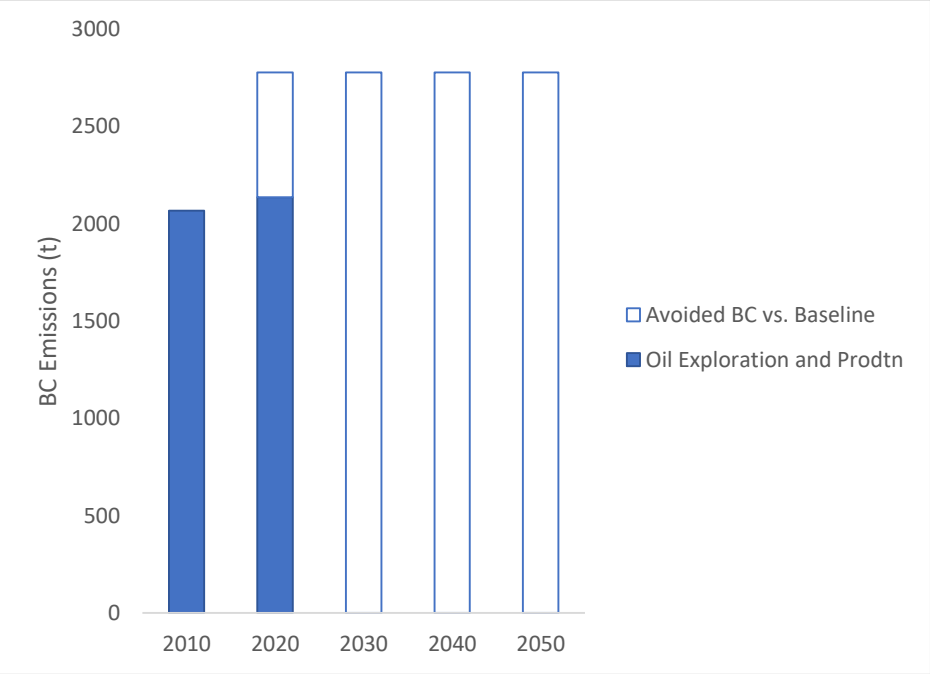


200 kt out of 290 kt of CH4 is avoidable by 2050

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.2

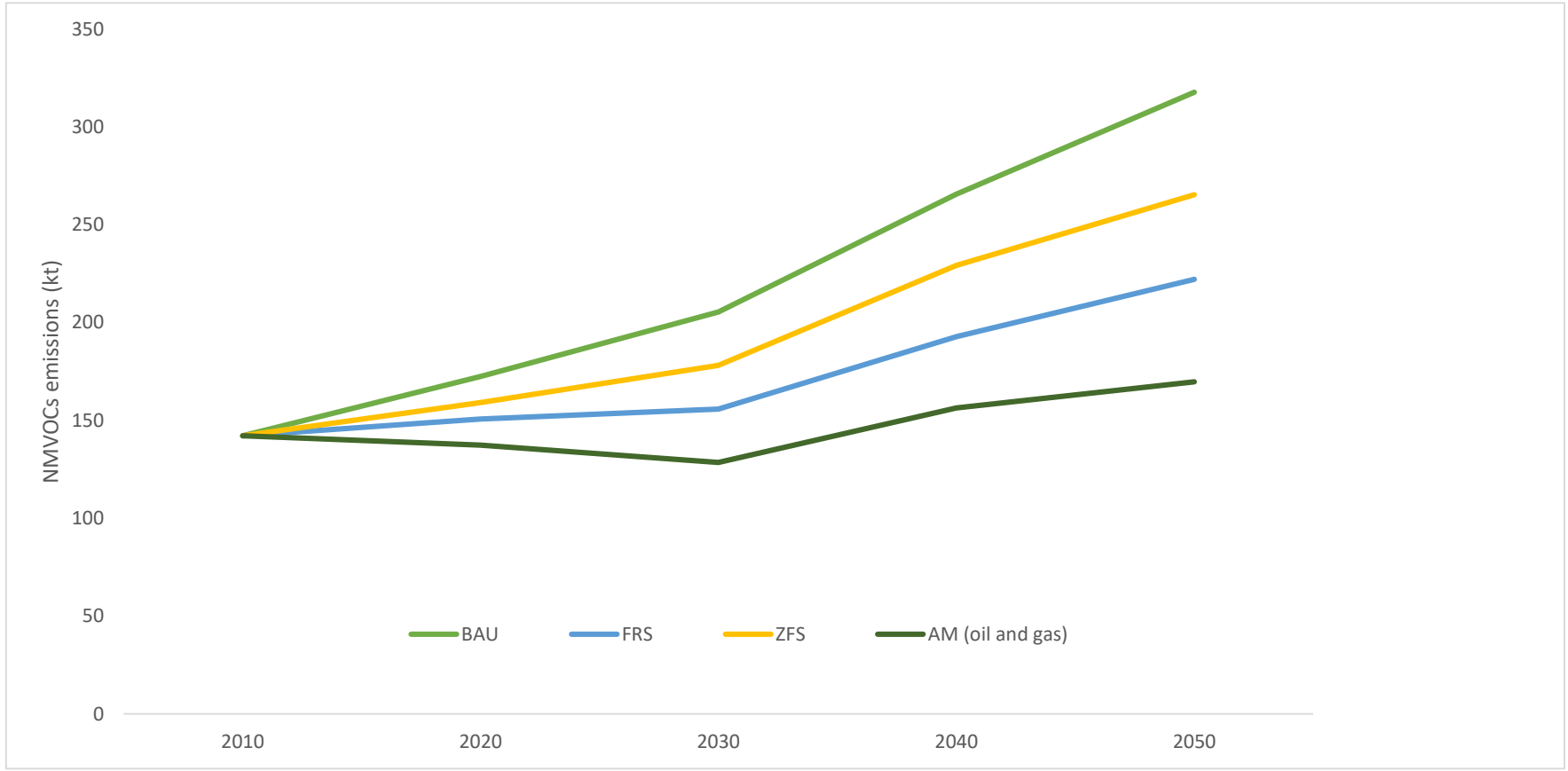
Zero flaring scenario in oil and gas sector





Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.2

Comparison of NMVOCs emissions projection 2010 – 2050 for the **fugitive reduction scenario**, **zero flaring scenario**, **business as usual scenario** and the **All Measures** scenario for the oil and gas sector



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.2

Electricity generation mitigation scenario:

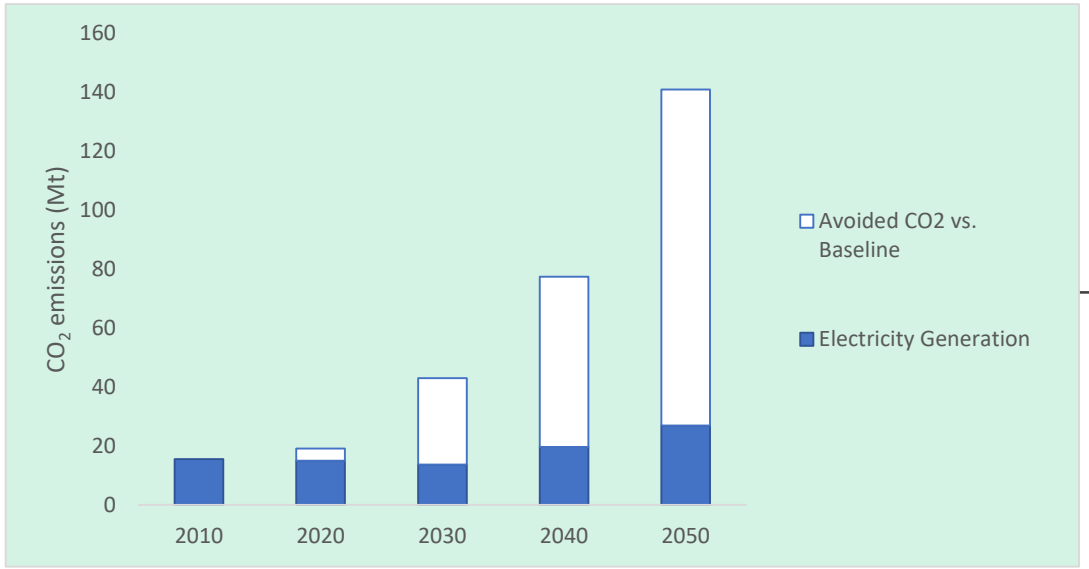
RENEWABLE ENERGY SCENARIO (RES)

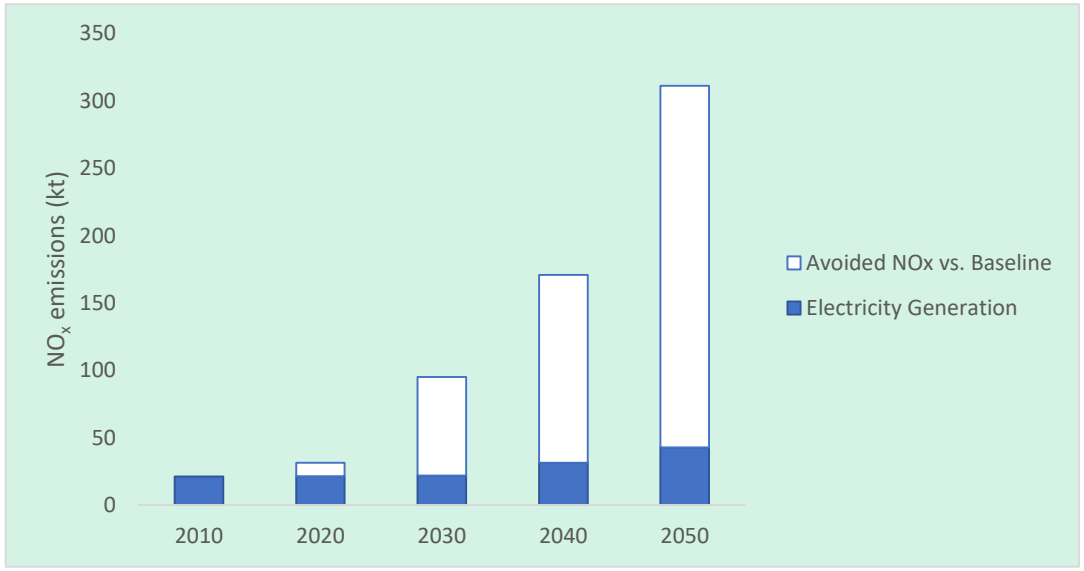
ZERO COAL SCENARIO (ZCS)

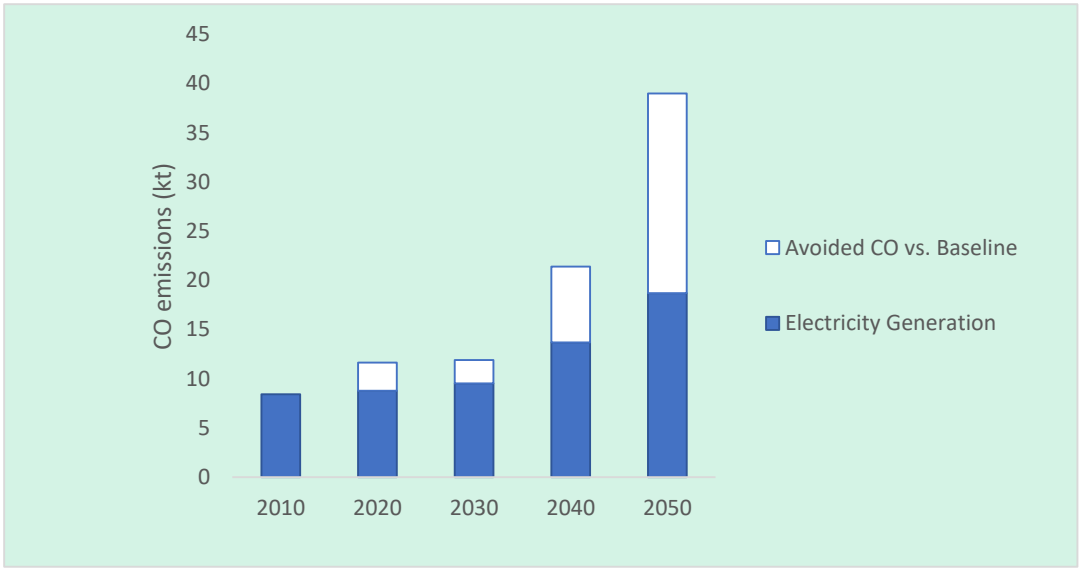
	(BAU)	Measure of mitigation scenario
Renewable Energy Scenario (RES)	OPWP plans to develop 2,600 MW of installed capacity of renewable energy (RE) projects by 2024, or renewable energy will generate at least 10% of electrical energy by 2025*. Coal:(7% in 2024, 50% in 2030) Diesel:(3% in 2016)	More ambitious vision for using renewables, going far beyond the government vision, as follows: Solar:(40% in 2030, 50% in 2050) Wind:(10% in 2030, 20% in 2050) NG:(50% in 2030, 30% in 2050) Diesel: (0%)
Zero Coal Scenario (ZCS)	Coal will be utilized to fuel up to 3,000 MW of generation capacity by 2030*	Coal: (0%) Diesel: (3% in 2016) NG: (97% in 2016)

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.2.3

Renewable energy scenario in electricity generation sector

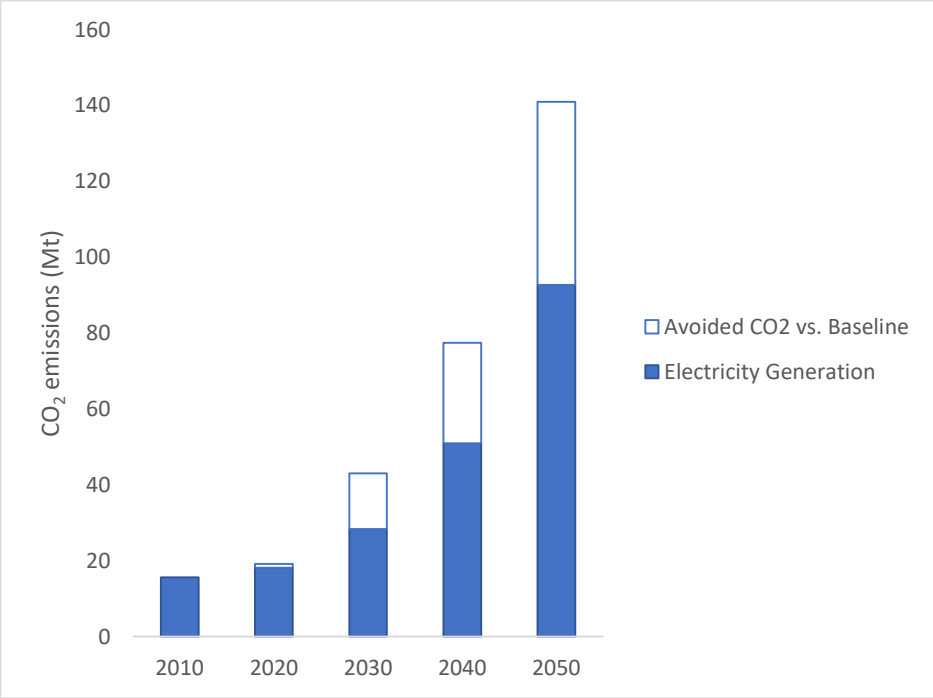


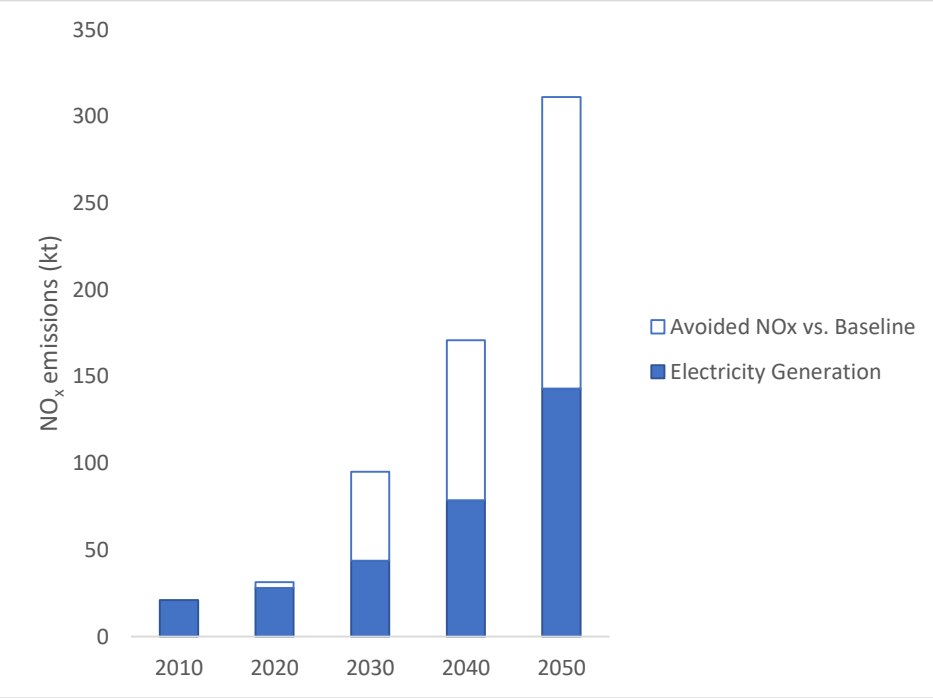




Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.3

Zero coal scenario in electricity generation sector





Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.3

Manufacturing industry mitigation scenario:

EFFICIENT INDUSTRY SCENARIO (EIS)

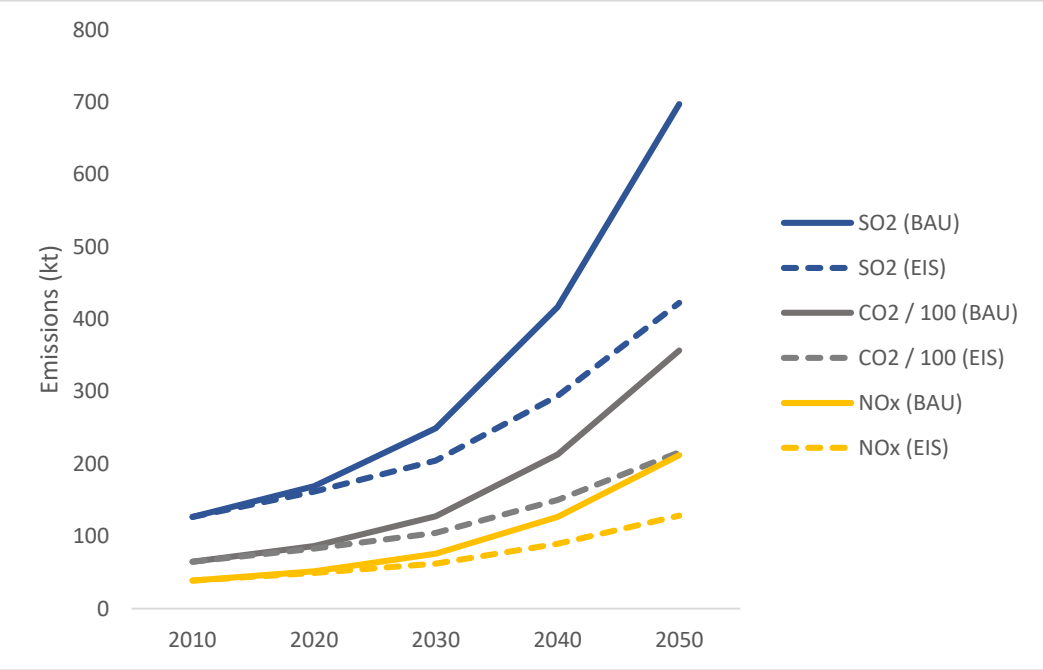
CLEAN FUEL SCENARIO (CFS)

	(BAU)	Measure of mitigation scenario
Efficient Industry Scenario (EIS)	No change in energy intensity	To reduce growth of the final energy intensity in the industry sector to (0%, 2018) and, (-2.0/100)
Clean Fuel Scenario (CFS)	The percentage share of fuel in the manufacturing industry is: HFO: 78% NG: 16% Electricity: 6%	To shift from using HFO in the industry to cleaner fuel as a preventive action to reduce pollution as follows: HFO: (2050, 0%) NG: (2050, 50%) Electricity: (2050, 50%)

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.2.4

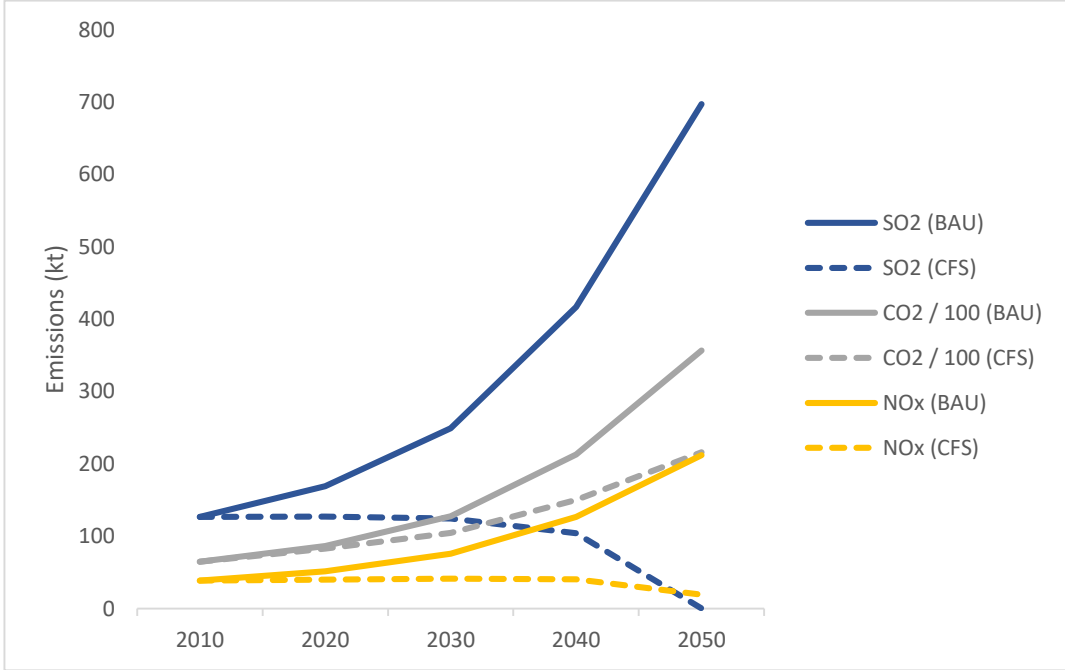
Efficient industry scenario

in manufacturing industry sector



Clean fuel scenario

in manufacturing industry sector



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.4

Transport mitigation scenario:

ELECTRIC VEHICLE SCENARIO (EVS)

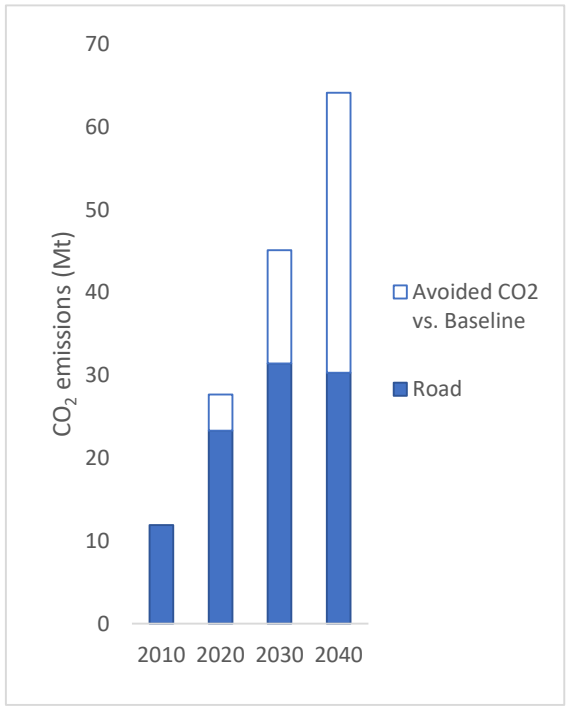
PUBLIC TRANSPORT SCENARIO (PTS)

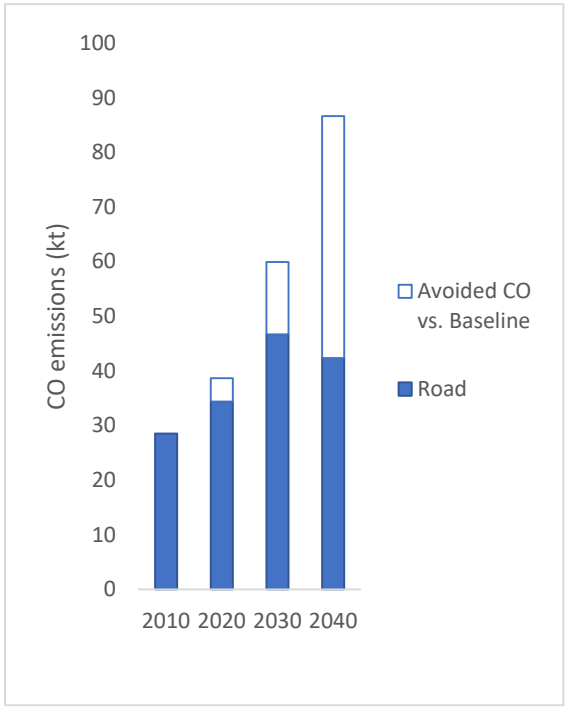
PAVED ROAD SCENARIO (PRS)

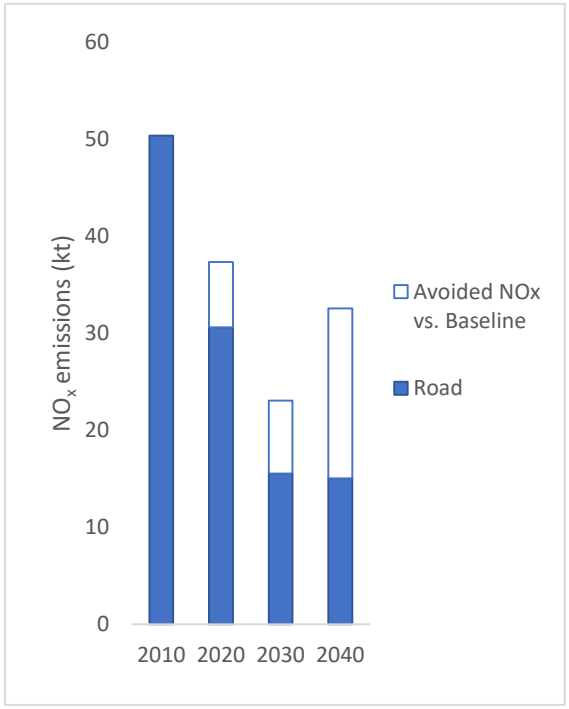
	(BAU)	Measure of mitigation scenario
Electric Vehicles Scenario (EVS)	Gasoline and diesel vehicles are projected based on the stock turnover model described in section 4.2.1.2	penetration of electric vehicles: ★ Passenger cars: (20% in 2030,80% in 2050) ★ Light commercial vehicles (20% in 2030, 80% in 2050) ★ Heavy duty vehicles (10% in 2030, 30% in 2050) ★ Motorbikes (50% in 2030, 100% in 2050) ★ Urban buses (50% in 2030, 100% in 2050)
Public Transport Scenario (PTS)		Improving the public transport system, and adding trams. The assumption here is reduction by 20% in 2030 and by 40% in 2050 in passenger cars km travelled. This would reduce the number of vehicle users, and the money used in other forms of private transportation. It will also reduce road traffic accidents in Oman, and reduce demand for petrol and diesel
Paved Road Scenario (PRS)		Unpaved roads play a major role in the emission of $PM_{2.5}$, so having more paved roads will help to reduce $PM_{2.5}$: By 2030, 30% of unpaved roads will be paved, and by 2050, 70% of unpaved roads will be paved.

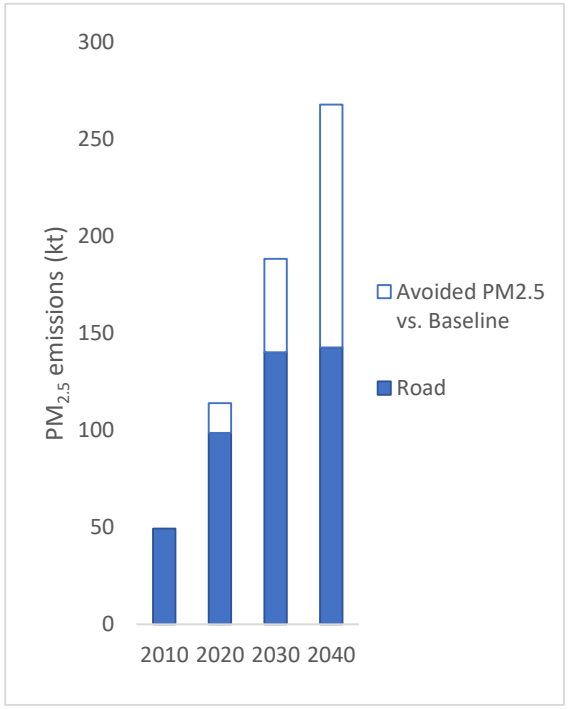
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.2.5

Electric vehicles scenario in road transport sector



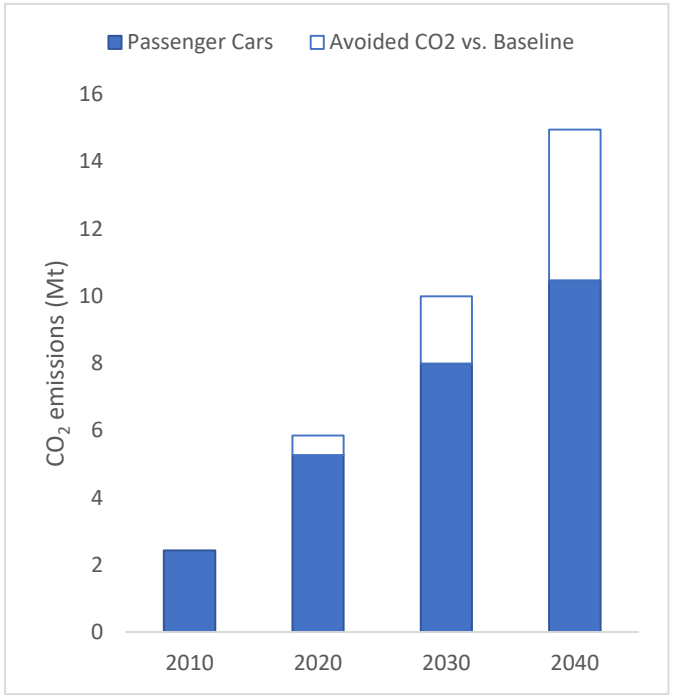


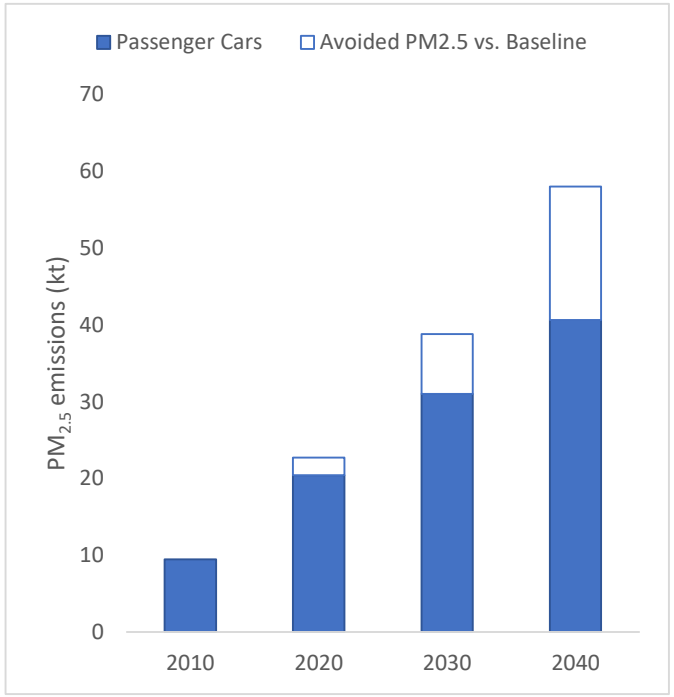


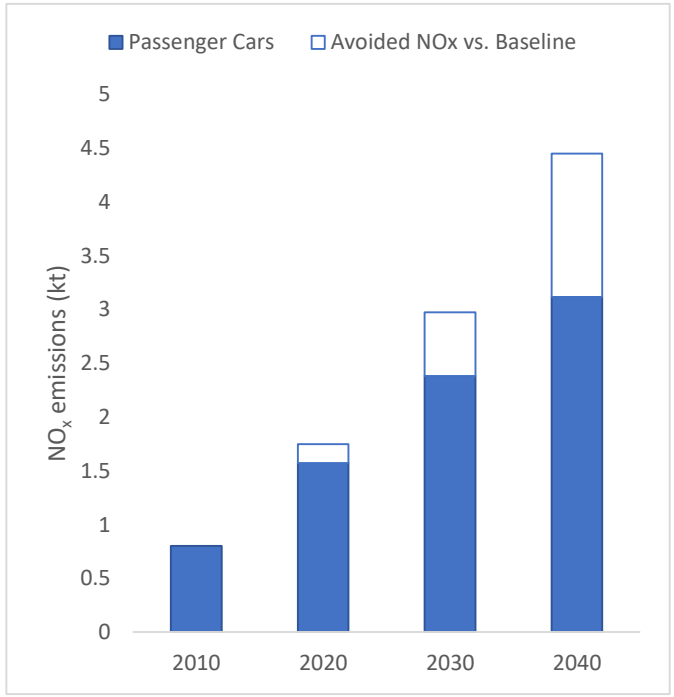


Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.5

Public Transport Scenario in road transport sector

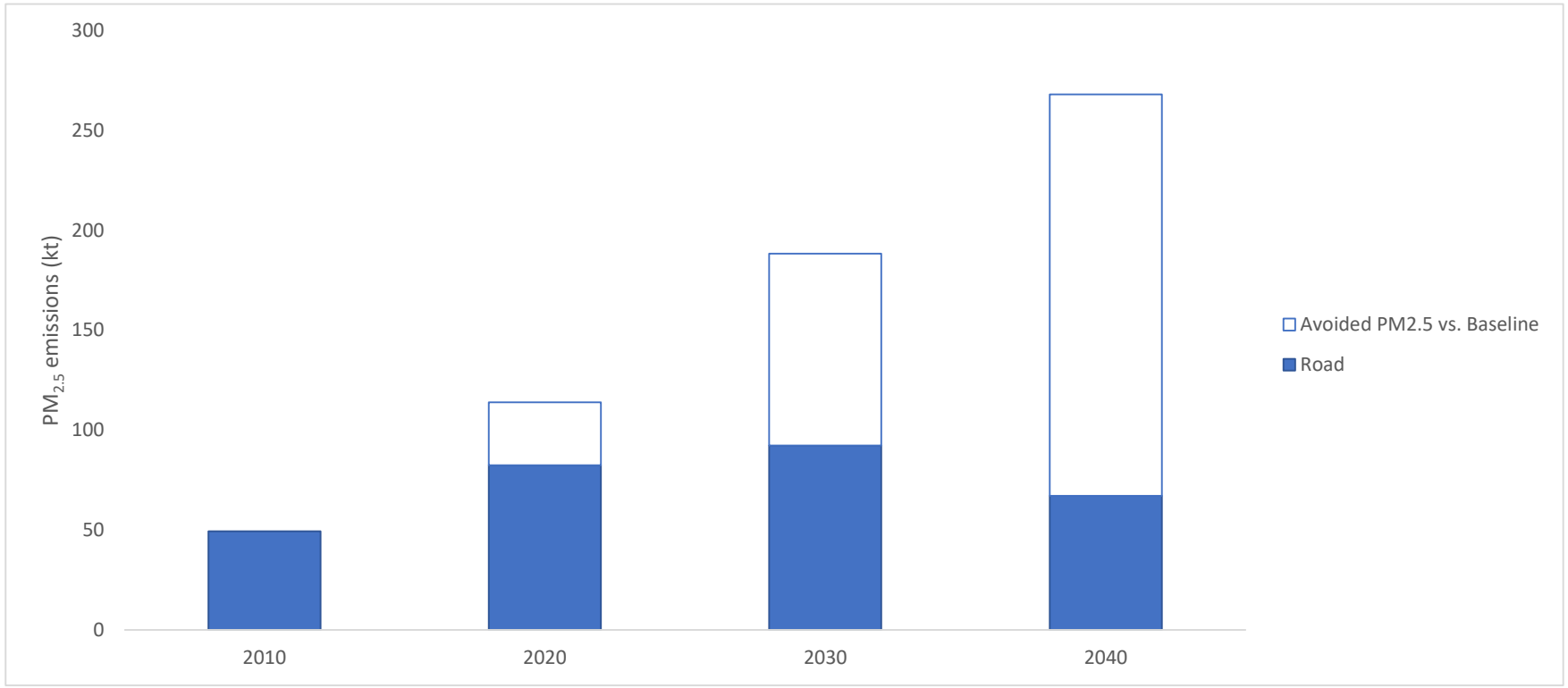






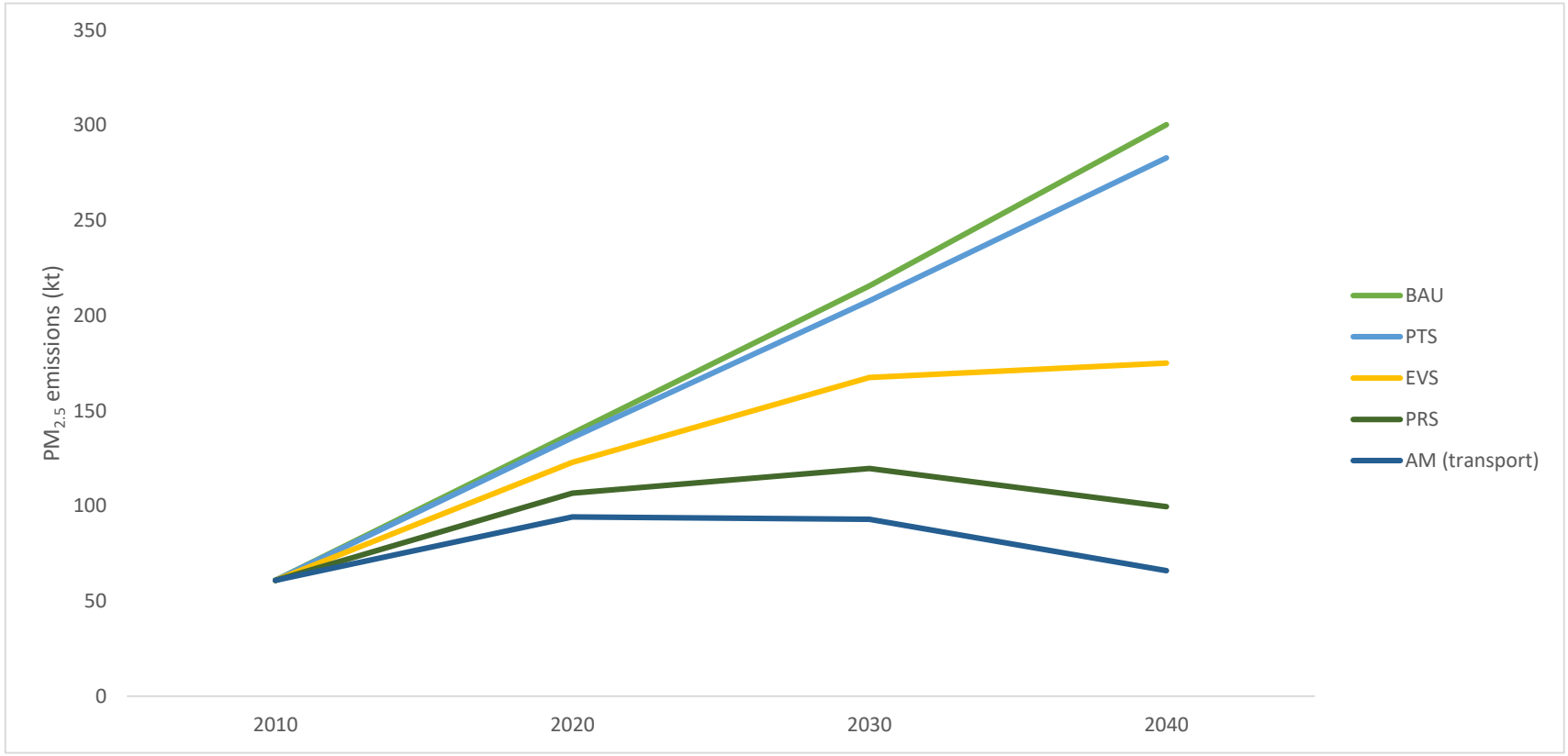
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.5

Paved Road Scenario in road transport sector



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.5

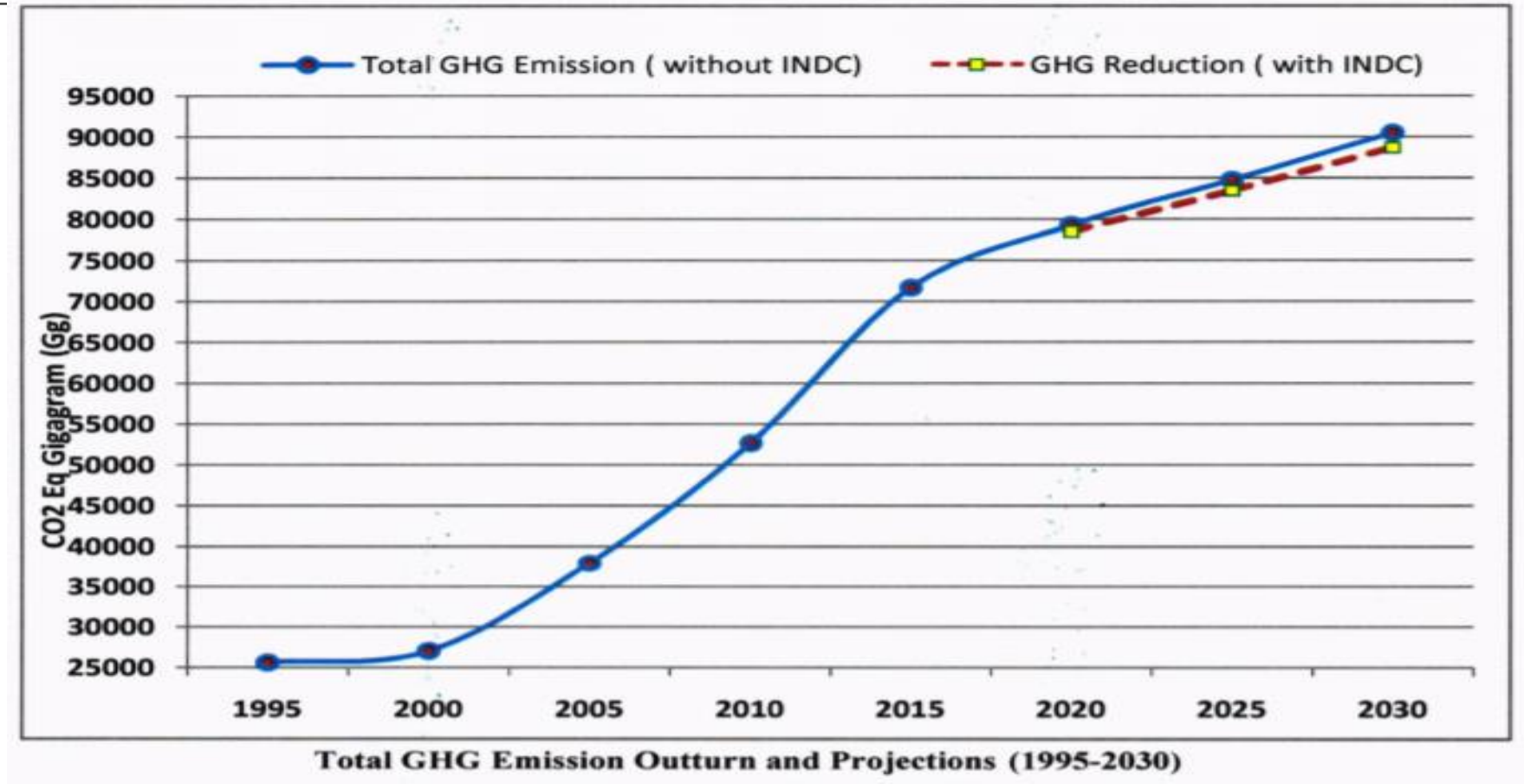
Comparison of PM2.5 emissions projection 2010 – 2040 for the **electric vehicles scenario**, **paved road scenario**, **public transport scenario**, **business as usual scenario** and the **All Measures** scenario for the transport sector



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.5

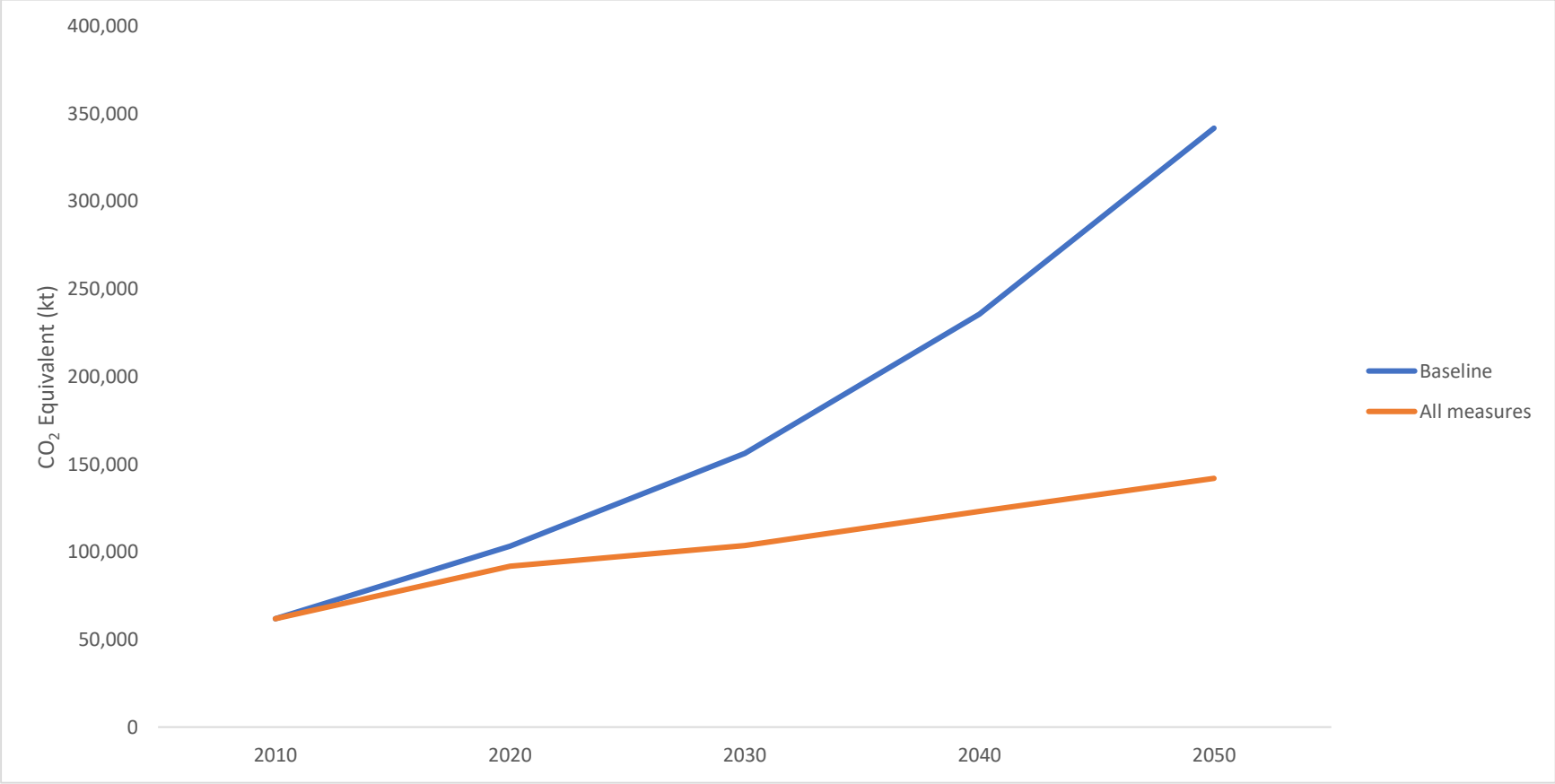
Comparing this study with the Oman NDC

Oman GHGs emission projection as business as usual scenario and mitigation scenario, 1994 has been considered for the GHG growth projections



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.7

Oman CO2 equivalent projection as BAU scenario and mitigation scenario (all measures) which revealed from this study



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 4.3.7

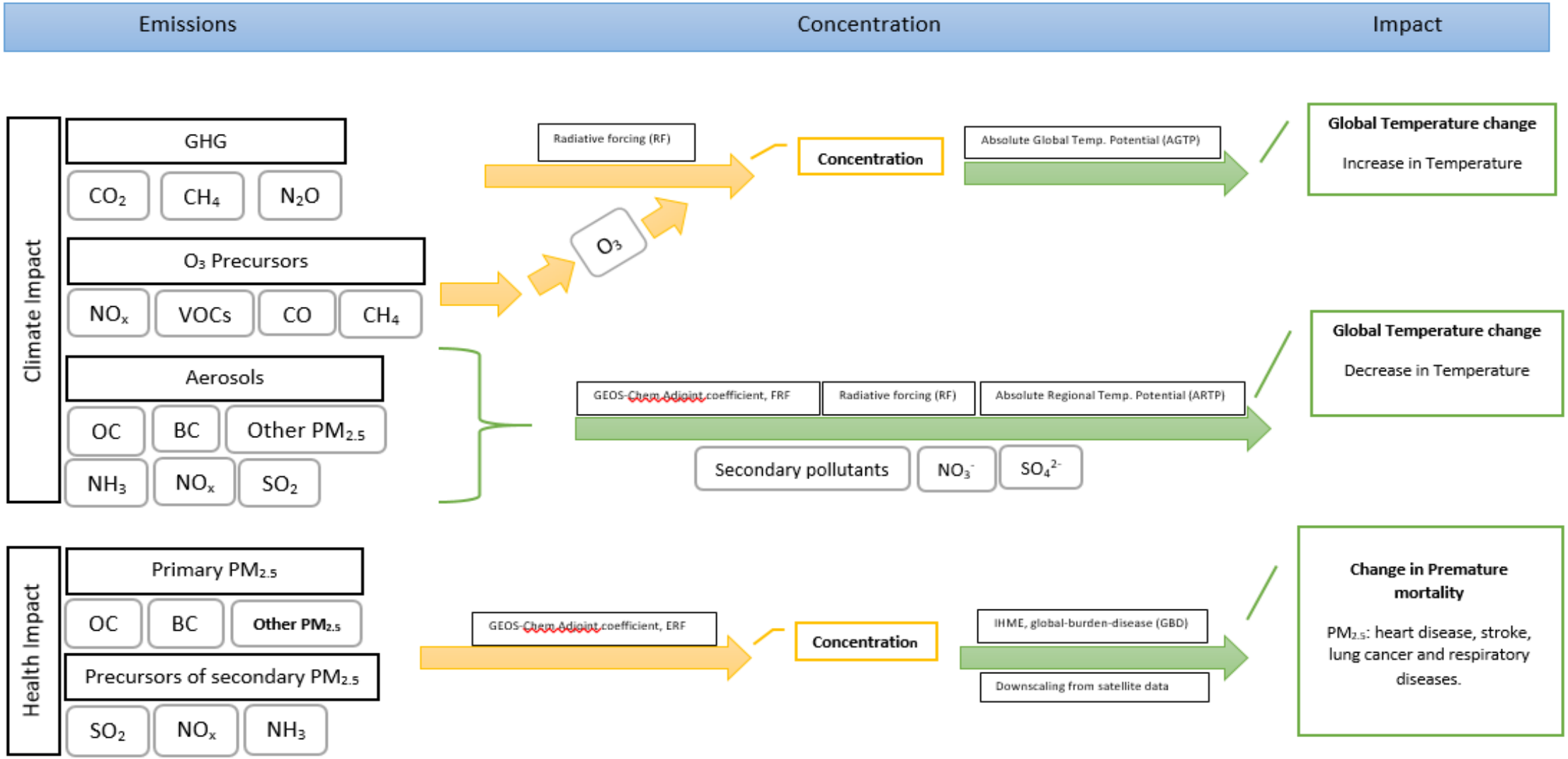
Estimating Impacts of current and historic atmospheric emissions from Oman

HEALTH (OMAN PREMATURE DEATHS ATTRIBUTABLE TO PM2.5)

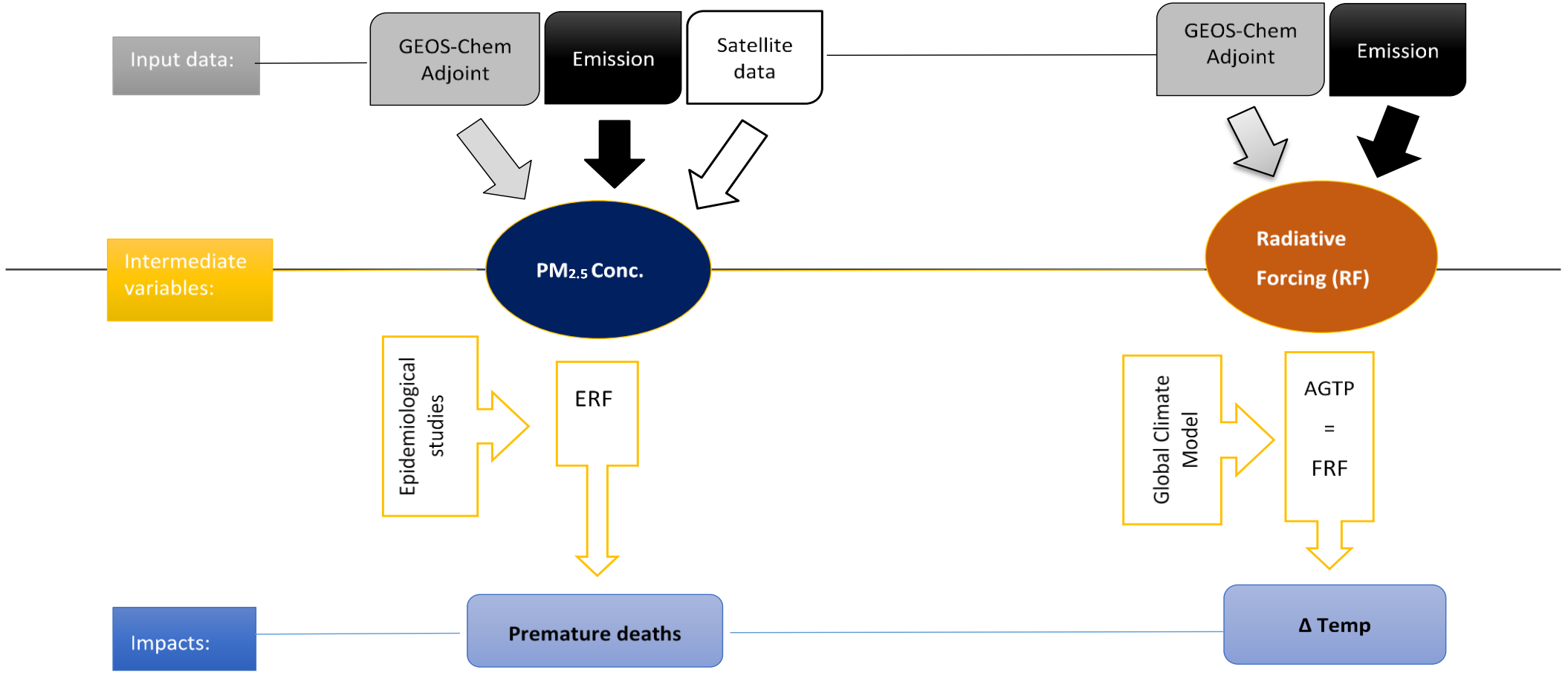
CLIMATE CHANGE (GLOBAL TEMPERATURE CHANGE)

Method of estimating the impacts on climate and health from different pollutants,

FRF and ERF is Forcing Response Function and Exposure Response Function respectively



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.2.1

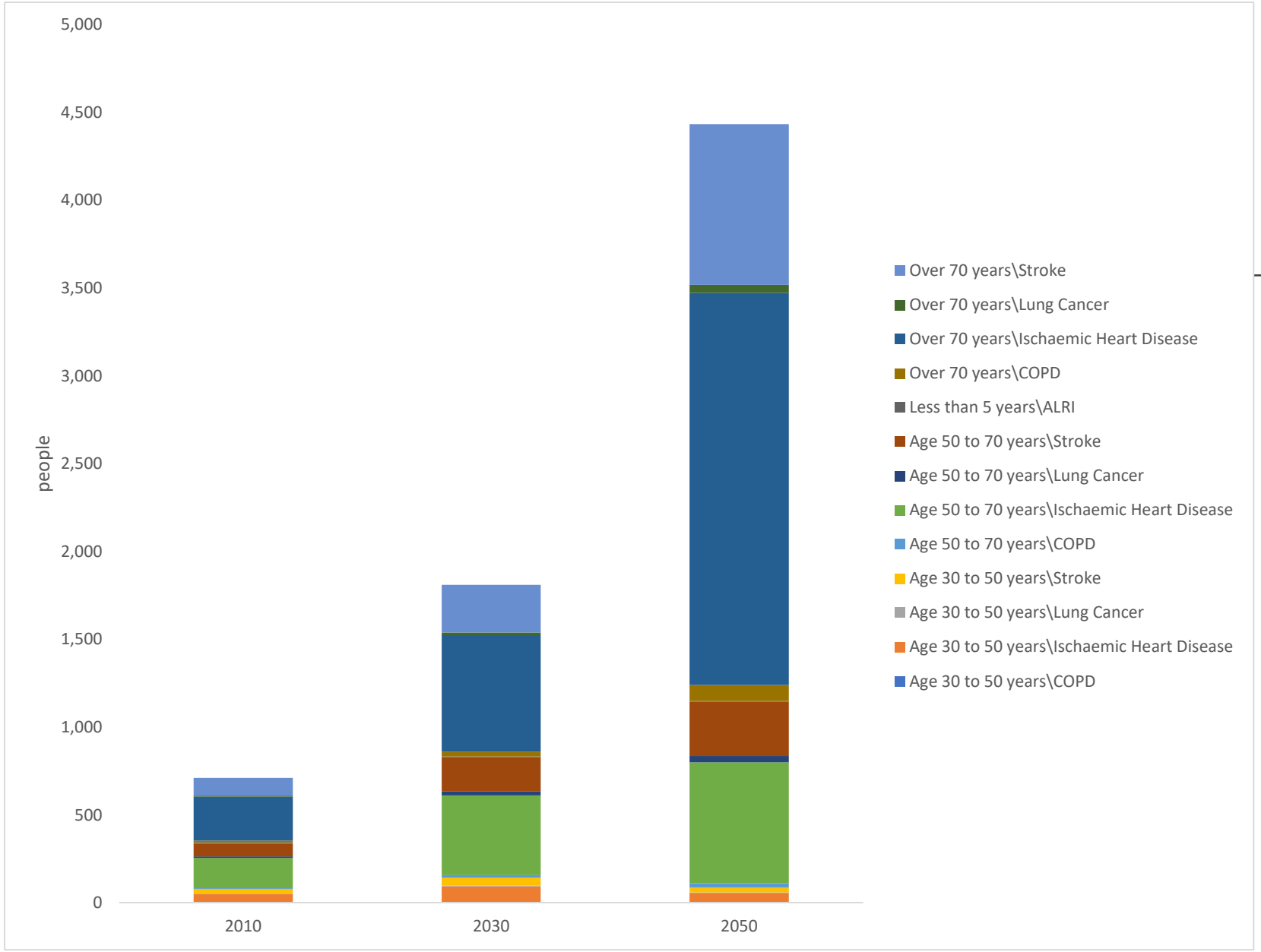


ERF: Exposure Response Function, **FRF**: Forcing Response Function, **AGTP**: Average Global Temperature Potential, **Δ AGTP**: change in Average Global Temperature

How LEAP convert emission into **health and climate impact**

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.2.3.5

Oman premature deaths attributable to PM2.5

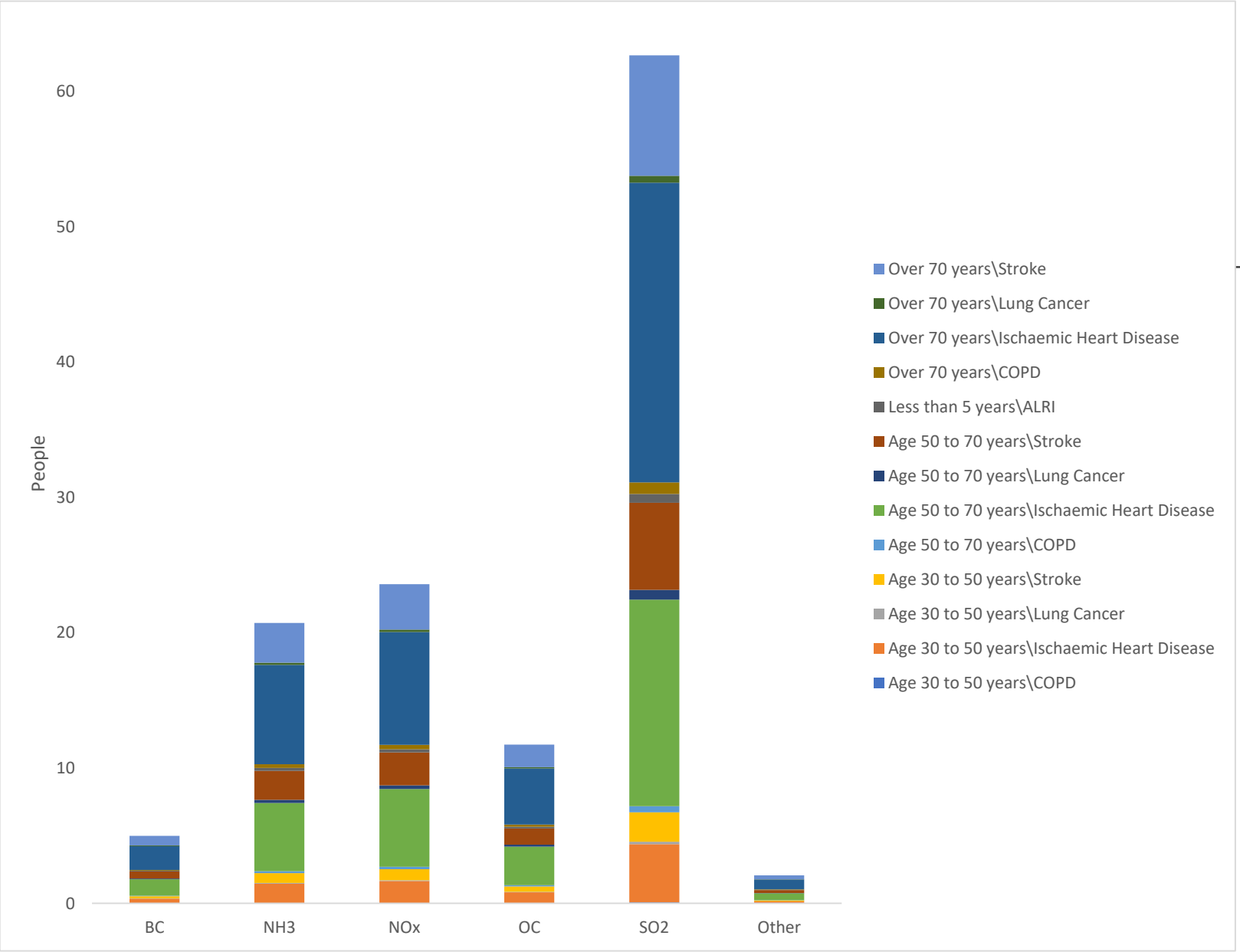


Premature deaths in 2010

attributed to PM2.5 based on age group and cause of death, and projection for 2030 and 2050 as BAU scenario

711 cases of premature death in Oman attributed to PM2.5 in 2010; this figure would rise to 1810 cases in 2030, and to more than 4400 cases in 2050, according to the BAU scenario

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.3.2

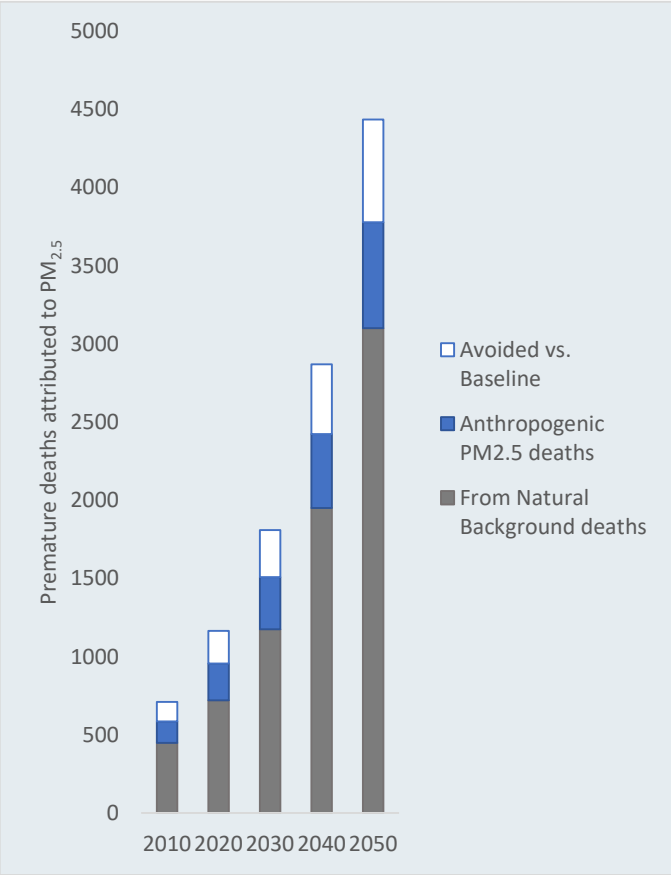


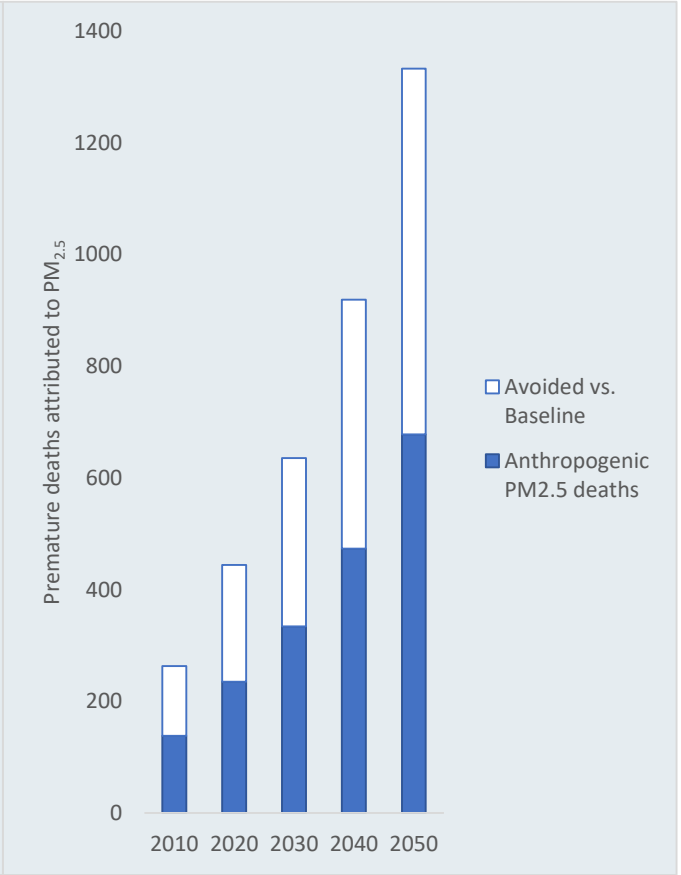
Premature deaths for 2010

caused by national anthropogenic PM2.5 emissions

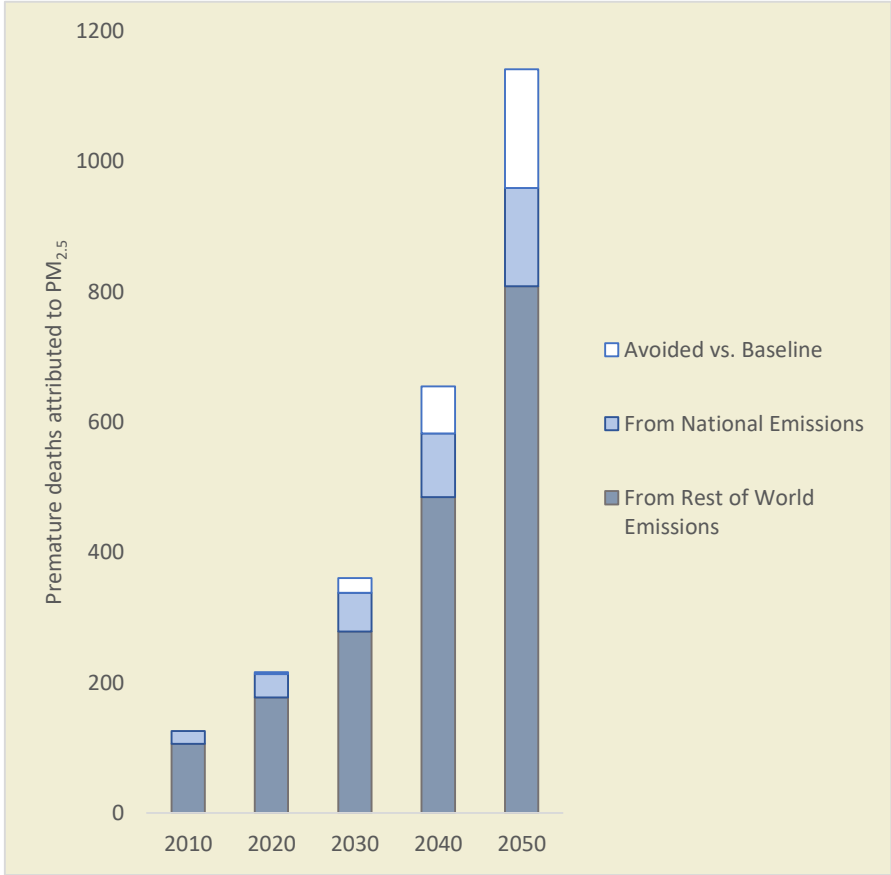
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.3.2

All measures Avoided vs. BAU scenario
for the premature deaths attributed to PM2.5





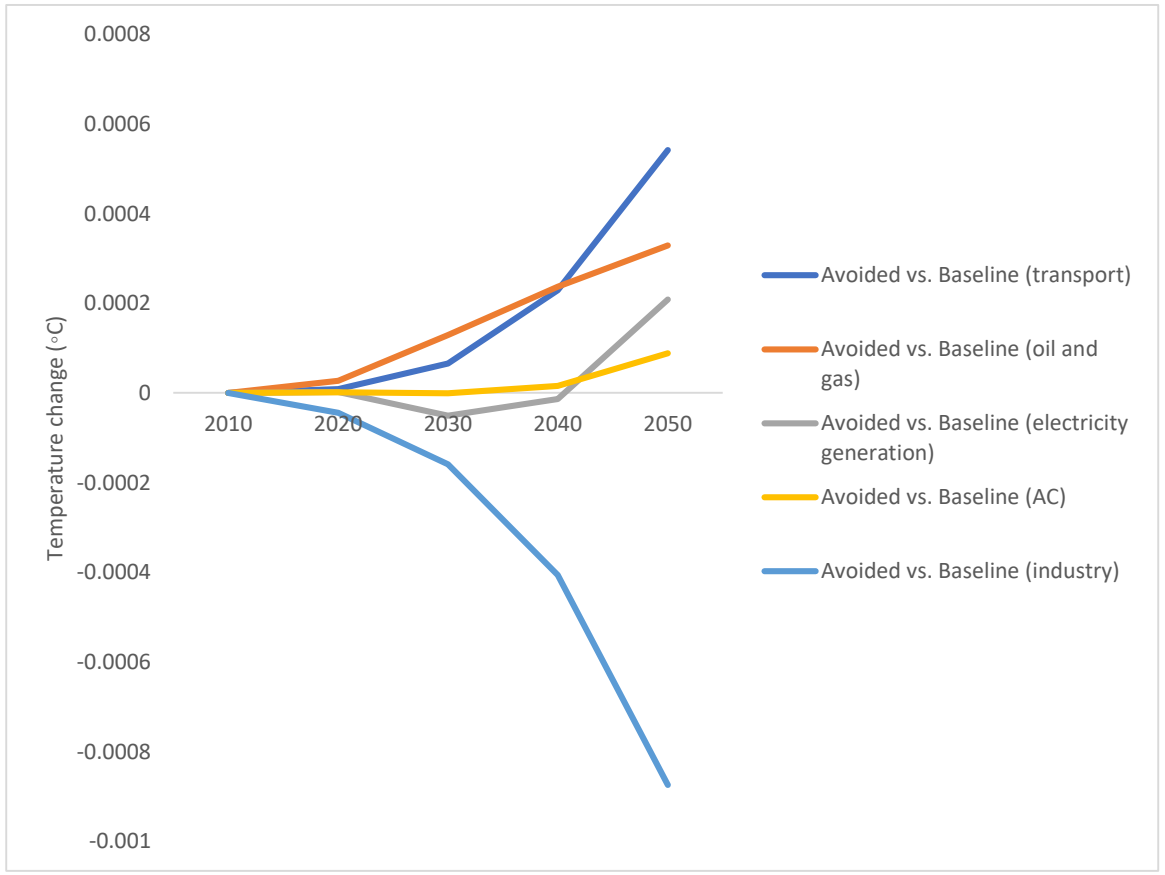
All measures Avoided vs. BAU scenario
for the premature deaths attributed to PM2.5 (national and rest of the world)



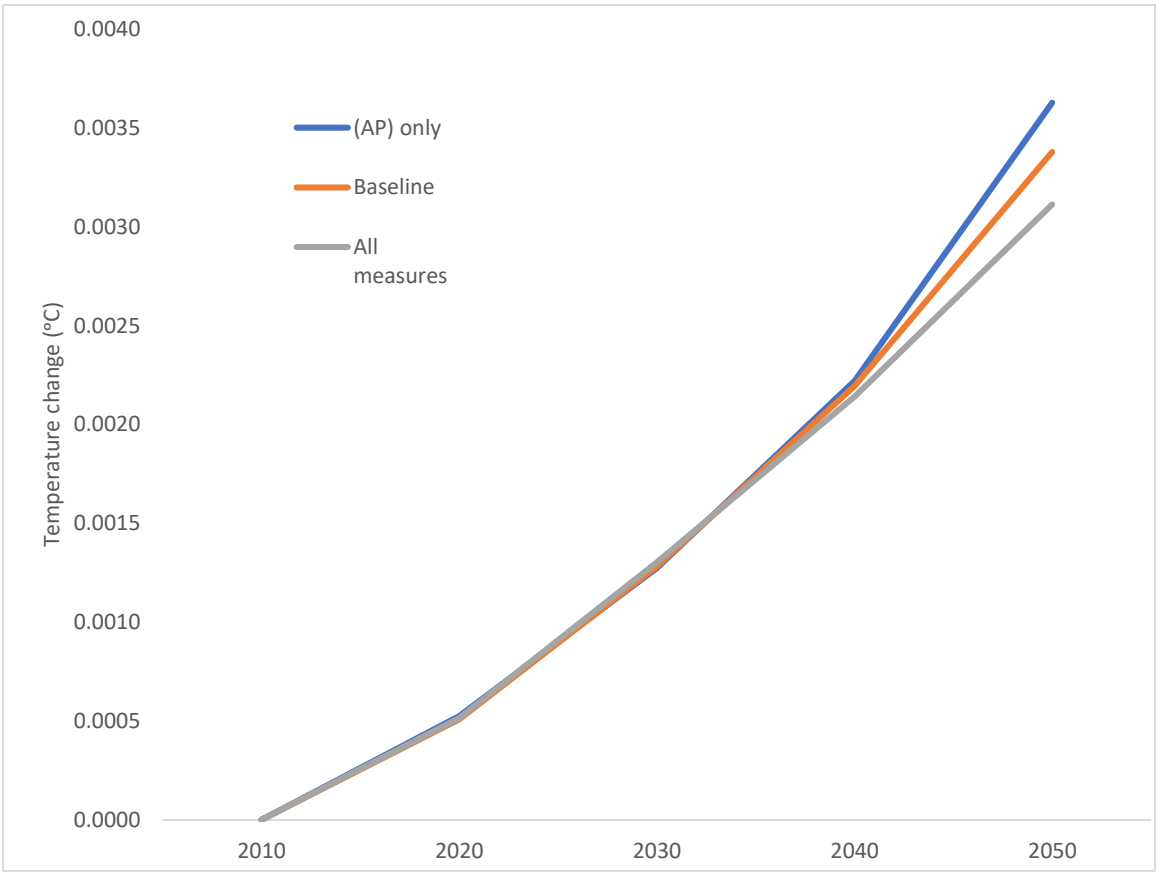
Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.3.2

Global Temperature Change

Avoided vs. baseline global temperature change projection (2020-2050) for different sector scenarios



Comparison of the effects of **baseline scenario and all measures scenario in global temperature change** due to Oman emissions



Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 5.3.3

Conclusion

INTEGRATING AQ & CC STRATEGIES

Total emissions

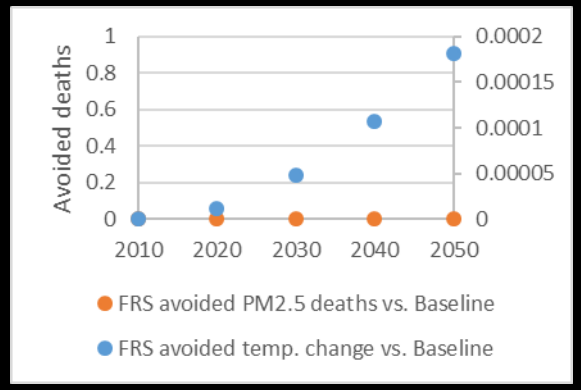
AQ & CC in Oman 2010, 2050 (BAU), and avoided emissions if all measures were to be implemented

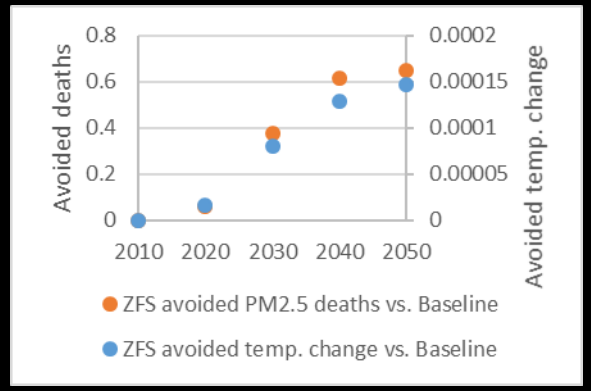
Pollutants	main sources	Total emissions (2010) kt	Total emissions (2050) kt	Avoided emissions (2050) kt	
SO_2	Manufacturing industry	160	1,255	144	11%
NMVOCs	Oil and gas industry	142	324	92	28%
NO_x	Transport, Manufacturing industry, and Electricity generation	137	705	211	30%
$PM_{2.5}$	Road transport	61	309	34	11%
CO	Road transport	51	201	81	40%
NH_3	Agriculture	18	34	3	
OC	Residential, and Industry	0.9	5	-	

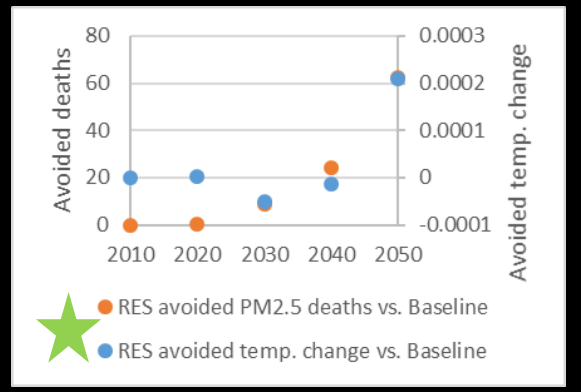
pollutants	main sources	Total emissions (2010) kt	Total emissions (2050) kt	Avoided emissions (2050) kt	
CO_2	Electricity generation, Road transport, and Manufacturing industry	50,000	314,867	191,000	61%
CH_4	Oil and gas industry	565	1,249	840	67%
BC	Manufacturing industry, Oil and gas industry, Residential, and Road transport	4	11	-	

Source: Albusaidi, J 2020, 'Integrating air quality and climate change strategies in Oman', PhD thesis, University of York, York. CH. 6.2 & 6.3

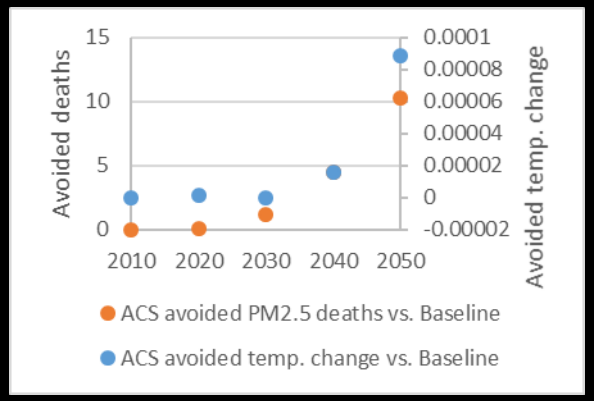
The avoided change in global temperature against the avoided premature mortality for 2020-2050 for the different scenarios

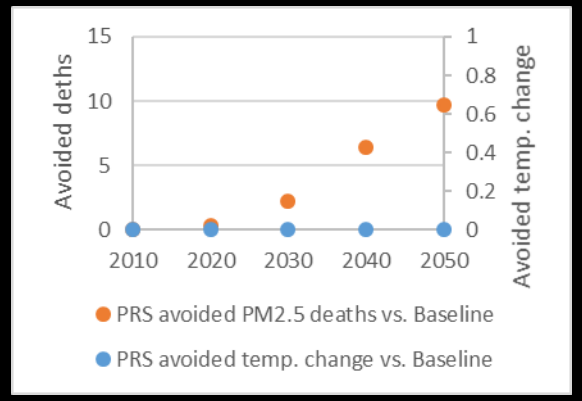


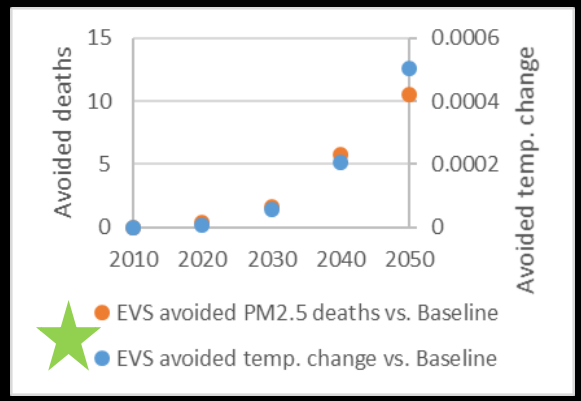


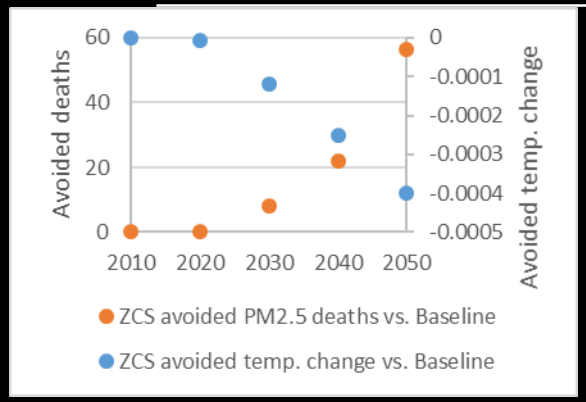


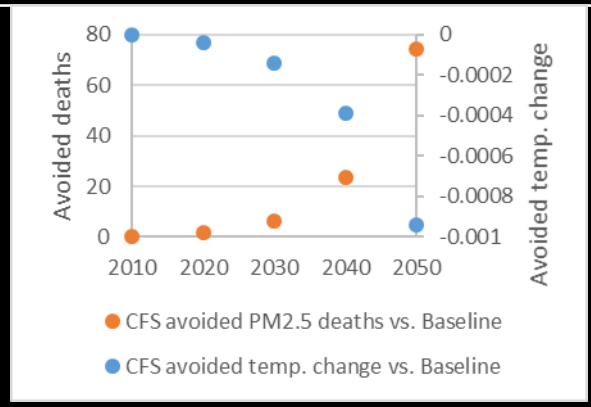
‘low hanging fruit’★
RES and EVS represents the most beneficial senarios in terms of both the avoided temperature change and avoided premature deaths

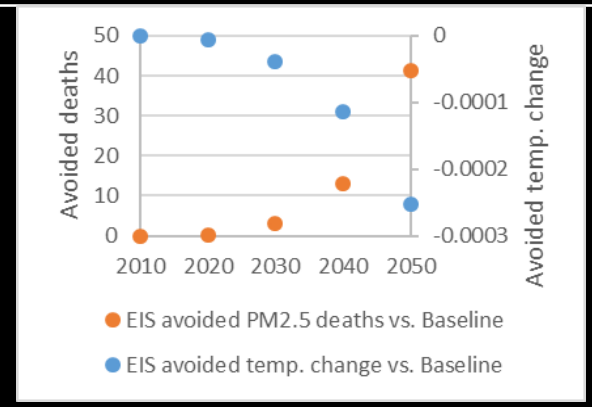


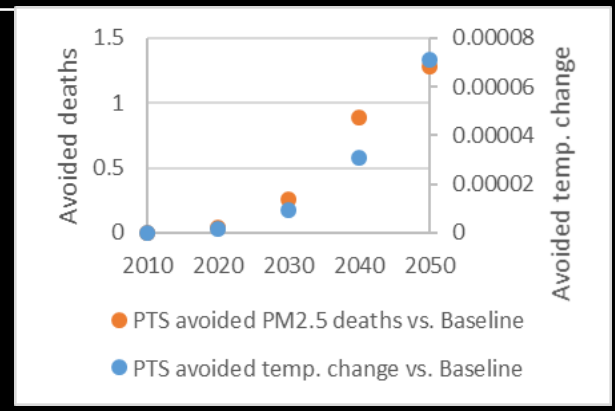












Source: Albusaidi, J 2020, ‘Integrating air quality and climate change strategies in Oman’, PhD thesis, University of York, York. CH. 6.5

Thank you