A-level

ENVIRONMENTAL SCIENCE
7447/1

Paper 1

Mark scheme

June 2021

Version: 1.0 Final Mark Scheme

216A7447/1/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk.

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Qu	Part	Marking guidance	Comments	Total marks	AO
01		**One** mark for each correct row.		5	AO1 1a

Contaminant	Treatment process					
	Activated carbon filtration	Phyto-remediation	Reverse osmosis	Screening	Sedimen-tation	UV light
Salt			✓			
Heavy metals		✓				
Litter				✓		
Organic pollutants	✓				✓	
Pathogens						✓
Suspended solids					✓	

No mark if too few or too many ticks in a row.

Qu	Part	Marking guidance	Comments	Total marks	AO
02	1	**Two** from: • persistent/long lived/chemically stable/do not react/not broken down/no 'sinks' in troposphere • dissociated/split by UV/absorbs UV • Cl/chlorine/chlorine free radical reacts with O_3/ozone.		2	AO1 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
02	2	Decrease in area depleted • 9.5×10^6 km^2 Mean annual rate of decrease to two sig fig: • 680 000 Also accept 6.8×10^5	2003 = 26×10^6 km^2 2017= 16.5×10^6 Decrease = 9.5×10^6 km^2 Annual rate= $(9.5/14) \times 10^6$ $= 0.6786 \times 10^6$ km^2 yr^{-1}	2	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
02	3	• Correct ref to reduction in Cl free radicals (from CFCs)/chemical equation/dynamic equilibrium restored. **Three** from: • banned production/use of CFCs/ODSs • named alternative material • named alternative process • named method of preventing release of waste CFCs • named waste disposal technique.		1 3	AO1 1b AO1 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
02	4	• Increased UV (reaching Earth's surface). **Causes** **One** from: • skin cancer/burns/DNA damage • cataracts • leaf tissue damage/reduced photosynthesis • damage to corals/plankton/algae.		1 1	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
03	1	Acid rain: • affects cation exchange (on humus/clay particles) (leading to) • loss/leaching of soil nutrients/named soil nutrient. **OR** Acid rain: • reduces soil decomposition/activity of decomposers (leading to) • reduction in soil nutrient availability/levels. **OR** Acid rain: • increases mobilisation of toxic ions/named toxin (in soil) (leading to) • (plant root) enzymes/proteins denatured/enzymes inhibited/named tissue damage.		2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
03	2	• H_O – there is no significant difference in the number of seeds germinating at different pHs.		1	AO3 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
03	3	• B – The data are counted in various categories and the students are investigating whether there is a difference between observed and expected results.		1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
03	4	• 90	340 – (56 + 96 + 98) = 90 **OR** $\sqrt{}(0.29 \times 85) + 85 = 89.9 = 90$	1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
03	5	• 13.59		1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
03	6	• C – 0.01		1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
03	7	**Three** from: • same growth medium • same temperature • same volume of solution • absence of light/same intensity of light/wavelength • same age of seeds • same variety of seeds • same time spent soaking in solution • same time period before checking.		3	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
04	1	**One** from: • (Lasky) exponential relationship • large range of values/data can be displayed.		1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
04	2	• Credit correct ref to data from graph, eg: 4×10^9, 4×10^8 **Two** from: • reserves decrease/resource remains same • previous reserves now become resource • previously exploitable/lower grade ores become uneconomic to mine.		1 2	AO3 1a AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
04	3	**One** mark for reason. **One** mark for linked explanation. • overburden hardness • increase costs of blasting • overburden stability/landslips • increase costs due to bench cuts/stepped sides needed • depth of overburden • increase engineering/pumping/ventilation costs as deep mines more liable to flood/accumulate toxic fumes • faulting/seismic problems • prohibitive costs due to seam slippage/inaccessible deposits • thin layered/irregular shaped deposit • increased costs due to increased area of excavation needed • areas of high landscape value/named designation /private land • legal restrictions on mining activity • chemical form/ease of chemical extraction • more energy needed greater the cost • ease of site access • increased costs due to infrastructure problems, eg transport, energy • workforce availability • influences salary costs • land use conflict/local opposition • increased resolution costs, eg mitigation of environmental impacts, compensation • political problems • socioeconomic instability, eg mining licence cancellations, increased taxes, contract reviews [R] unqualified economics	Up to max three reasons given with explanation.	6	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
05	1	decrease through the troposphere increase through the stratosphere decrease through mesosphere	All three changes needed for 1 mark.	1	AO1 1b

Qu	Part	Marking guidance	Total marks	AO
05	2	**Stratosphere:** • (heated by) UV light/shortwave radiation/sunlight/insolation • absorbed by ozone and converted to heat. **Troposphere:** • infrared/longwave radiation emitted by Earth's surface • absorbed by greenhouse gases/named greenhouse gas, eg CO_2, CH_4, NOx, CFCs, (tropospheric) O_3.	2 2	AO1 1b

Qu	Part	Marking guidance	Total marks	AO
06	1	**Two** from: • lack of storage (at national/local level) • excessive run off due to flooding • pollution/contamination • precipitation falling on remote areas/low population • high evaporation rates (from surface stores) • uptake by vegetation/evapo-transpiration • salt water incursion.	2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
06	2	• 470 • 66.2% (award 1 mark for 66% with no working shown).	Difference = 1180 – 710 % increase = (470 / 710) × 100% 1 mark for correct calculation, 1 mark for correct sig figs. Award two marks for correct answer to 3 sig fig if no working shown.	2	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
06	3	**One** mark for method. **One** mark for linked explanation. • inter-basin transfers • transfer of water from areas of surplus to areas of shortage • low volume (drip) irrigation • water directly applied to plants, reducing evaporation losses • artificial recharge • pumping surplus water underground or into lagoons (to infiltrate slowly) • river regulation reservoirs • heavy rainfall – water is stored/low rainfall water is released from behind the dam • reforestation/afforestation • reduces fluctuations in river flow rate/reduces soil erosion • pollution control/water treatment • sewage treatment/control of mine waste/control of heavy metal waste/ landfill leachate treatment • water conservation/reducing demand/reducing water losses • low water appliances/xeriscaping/ recycling (grey) water/water metering	Up to max three reasons given with explanation.	6	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
07	1	• vegetation removal/deforestation • lack of root-binding/increased run-off/less infiltration/lack of windbreak so wind speeds increase/lack of leaf litter so kinetic energy of raindrops increases/less soil organic matter which binds soil particles/reduced soil biota • ploughing (vulnerable soils) • breaks up peds exposing soil particles to wind and rain • high stocking density of livestock • overgrazing/vegetation eaten faster than it grows /hoof action exposes soil and roots • use of farm machinery/livestock • soil compaction reduces infiltration/soil biota increases run-off • cultivating steep slopes • surface water flows more quickly/ has more kinetic energy so carries soil particles more easily • pesticide use • kills soil biota/decomposers leading to reduced humus production and reduced soil particle binding/ increases soil erodibility	Name of practice for one mark, plus explanation for second mark (three activities needed). Credit livestock only once	6	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
07	2	**Four** from: • transect • systematic sampling • appropriate number of sampling points (minimum 10) • calibrated meter/anemometer for measuring wind speed • same height (at ground level)/ facing same direction • measurements taken at same time • repeat transects for reliable mean • repeat at different times of year for seasonal variability.		4	**AO2**

Qu	Part	Marking guidance	Comments	Total marks	AO
08	1	• 141.6(4)% • 28.33%, accept 28.32%	Difference = 13259 – 5487 = 7772 % change = (7772 ÷ 5487) × 100% = 141.64% Annual rate of change = 141.64% ÷ 5 = 28.33% Award one mark if correct answer but not correct sig figs. Award two marks for correct answer if no working shown.	2	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
08	2	**Two** of the following: • multijunction PV/multiple layers • absorb different wavelengths/more light absorbed and converted to electricity • anti-reflective surfaces/grooved/ textured surfaces • grooved or textured surfaces reflect light into the cells • PV/thermal hybrid systems • efficiency of PV declines at higher temperatures/resistance increases at higher temperatures /heat absorbed for space or water heating/efficiency of PV increases (PV cells cooled) • transparent PV cells • cells which let most light through used in windows • movable panels • alters the angle of the panel for optimum absorption of sunlight R: parabolic reflectors, CSP with thermal storage	**One** mark for method. **One** mark for linked explanation.	4	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
08	3	• 48 000 MWh	48 GWh = 48 000 MWh **and** 24 × 365 hours in a year = 8760 hours	1	AO3 1a
		• 5.47945 MW	48 000 ÷ 8760 = 5.47945 MW	1	
		• 27%	5.47945 × 100 ÷ 20 = 27%	1	

Qu	Part	Marking guidance	Comments	Total marks	AO
08	4	• thermal storage/molten salt/high volume storage		1	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
09	1	**Two** from: **Correct abiotic factor, eg:** • same geology/pH • same soil type/texture • same soil moisture content • same aspect/light levels/temperature/altitude. **Correct biotic factor, eg:** • same plant competitors • same grazing intensity.		2	AO3 1c

Qu	Part	Marking guidance	Comments	Total marks	AO
09	2	**Three from:** • same sized representative areas/same sized area sample (by quadrat) • random/systematic sampling • quadrats (appropriate size) • (large no. of samples) 10 or over/min 2% of sample area • count individuals (for population numbers) • repeats for reliability/stats test.		3	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
09	3	• appropriate stats test = Mann Whitney U **and** comparing averages/counted or calculated data		1	AO3 1c

Qu	Part	Marking guidance	Comments	Total marks	AO
09	4	• test strips • compare to colour chart **or** • electronic colorimeter/ photometer • reagent added, intensity of colour measured **or** • ion selective electrodes • electrode potential produced is a measure of the ion concentration	1 mark for method. 1 mark for description.	2	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
09	5	• ploughing (increases nitrates) • aeration/increases (bacterial) fixation/bacterial oxidation **or** • drainage (increases nitrates) • reduces anaerobic conditions/ denitrification **or** • drainage (decreases nitrates) • increases leaching **or** • cultivation of legume crops (increases nitrates) • increases fixation by root nodule bacteria/Rhizobium **or** • ploughing (reduces nitrates) • increases soil disturbance – increased leaching of nitrates/ erosion	1 mark for farming activity. 1 mark for explanation. .	2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	1	(Further north/deeper/cooler:) • within range of tolerance • more food available • less predation.		2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	2	**Two** from: • similar stage of breeding cycle • similar amount of food available • similar weather conditions • similar water temperature.	[R] reference to migration unless linked to breeding/ food availability.	2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	3	• 1990 is more reliable • as SD is smaller/less variation around the mean		2	AO3 1a AO3 1c

Qu	Part	Marking guidance	Comments	Total marks	AO
10	4	**Indicative content** **Species disadvantaged:** - absence of a suitable habitat to colonise - unable to adapt to new habitats/conditions outside range of tolerance/named habitat problem - no suitable habitat nearby - no biological corridor to enable colonisation/dispersal - rate of change too fast/colonisation too slow - loss of essential inter-species relationships eg pollinators/seed dispersal agents - over-population of habitat by new arrivals, causing more intra-species competition - named examples/taxa to illustrate difficulties (eg coral reefs). **Species advantaged:** - species who can migrate/colonise/adapt to new habitats will benefit - outcompete existing species - exploit new food sources/niches - named examples/taxa to illustrate.		9	AO1 1b = 4 AO2 = 3 AO3 1b = 2

Examiners are reminded that AO1, AO2 and AO3 are regarded as interdependent. When deciding on a mark all should be considered together using the best fit approach. In doing so, examiners should bear in mind the relative weightings of the assessment objectives. More weight should therefore be given to AO1 than AO2 and AO3.

Level	Marks	Descriptor
3	7–9	A comprehensive response to the question, with the focus sustained. A conclusion is presented in a logical and coherent way, fully supported by relevant judgements. A wide range of knowledge and understanding of natural processes/systems is applied. The answer clearly identifies relationships between environmental issues. Relevant environmental terminology is used consistently and accurately throughout, with no more than minor omissions and errors.
2	4–6	A response to the question which is focussed in parts but lacking appropriate depth. A conclusion may be present, supported by some judgements, but it is likely not all will be relevant. A range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there may be a few inconsistencies, errors and/or omissions. The answer attempts to identify relationships between environmental issues, with some success. Environmental terminology is used, but not always consistently.
1	1–3	A response to the question which is unbalanced and lacking focus. It is likely to consist of fragmented points that are unrelated. A conclusion may be stated, but it is not supported by any judgments and is likely to be irrelevant. A limited range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there are fundamental errors and/or omissions. The answer may attempt to identify relationship between environmental issues, but is rarely successful. Limited environmental terminology is used, and a lack of understanding is evident.
	0	Nothing written worthy of credit.

Level	Marks	Descriptors
5	21–25	A comprehensive response with a clear and sustained focus. Content is accurate and detailed. Relationships are identified, reflecting the holistic nature of environmental science and the answer as a whole is coherent. A wide range of relevant natural processes/systems and environmental issues are described and articulated clearly. These are applied systematically to the question, with clear relevance to the context. Where conclusions are made, these are fully supported by judgements and presented in a logical and coherent way. Relevant environmental terminology is used consistently and accurately throughout. If there are errors, these are very minor indeed and not sufficient to detract from the answer.
4	16–20	A response in which the focus is largely sustained, with content that is mainly accurate and detailed. Relationships are identified and the answer is largely coherent. A range of natural processes/systems and environmental issues are described and articulated clearly. In most cases, these are applied appropriately to the question but, in some, it is less clear why they are relevant. Where conclusions are made, these are supported by judgements which are mostly coherent and relevant. Relevant environmental terminology is used consistently and throughout, with no more than minor errors.
3	11–15	A partial response which is focused in parts. The content is mostly accurate but not always detailed. There is an attempt at identifying relationships, but the answer as a whole is not fully coherent. A range of natural processes/systems and environmental issues are described, most are articulated clearly. In some cases, these are applied appropriately to the context but, in most, it is less clear why they are relevant. Where conclusions are made, it is not always clear how they relate to the judgments given and are likely to contain errors. Relevant environmental terminology is used, but not consistently and there may be errors.
2	6–10	An unbalanced response, lacking in focus. The content may be inaccurate and lacking detail. There is some attempt at identifying relationships, but the answer is not coherent. A limited range of natural processes/systems and environmental issues are described but not articulated clearly and likely to contain errors and/or omissions. There is a limited attempt to apply them to the context. Any conclusions are likely to be asserted, with no supporting judgements and

		fundamental errors. Environmental terminology is used, but not always appropriately and sometimes with clear errors.
1	1–5	Fragmented points, whose relevance to the question and relationships to each other are unclear. A few natural processes/systems and environmental issues are listed, but unlikely to be described and many may be irrelevant. There is no clear attempt to apply them to the context. It is unlikely that a conclusion will be present. There is an attempt to use environmental terminology, but seldom appropriately.
	0	Nothing written worthy of credit.

Qu	Part	Marking guidance	Comments	Total marks	AO
11	**1**			**25**	AO1 = 10 AO2 = 10 AO3 = 5

- Control methods to reduce production, release and damage caused by pollutants.
- Control methods to include specific legislative agreements, eg Kyoto/Paris/Montreal to bring about a behavioural change and development of other technologies.

Topic areas/spec ref	**Pollutant and source**	**Control method**	**Extent of impact reduction**
Atmospheric pollutants			
GHGs 3.2.1.2	Fossil fuels CO_2/CH_4/NO_x/CFCs tropospheric O_3	Role of international agreements to reduce use of fossil fuels (FF) and CFC production, eg Kyoto/Paris/Montreal Carbon reduction/neutral targets	Reduction of global CFC production and reduction in loss of stratospheric ozone Other GHGs – CO_2 – access to alternative energy sources to FF – problem for countries
Smoke/PM10s 3.4.3.2.1	Incomplete combustion of coal, diesel, wood, crop waste Industrial, domestic and transport sources	Clean air act Bag filters Switch from coal to gas/smokeless fuel Coal treatment Electrostatic precipitators	Legislation – large impact in reducing pollutant release. Fewer smogs, respiratory disease, eg London smogs Reduction of 75+% of particulates from diesel vehicles

		Cyclone separators Diesel Particulate Filters Turbo chargers	PM10s – still a problem – large number of vehicles on roads
Acid rain 3.4.3.2.2	SO_x/sulphurous/sulfuric acids Fossil fuel combustion Sulfide ore smelting	Switch from FF use to renewables Desulfurise fuel Wet & dry FGD	Reduced acid rain/transboundary impacts Reduced impacts on taxa, eg fish gills, exoskeletons, stomata
Acid rain 3.4.3.2.2	NO_x nitric acid Vehicles – FF Fertiliser use	Catalytic converters, urea sprays	Reduced respiratory disease Reduced photochemical smogs. Reduced acid rain Reduced GCC NO_x still a problem – large number of vehicles on roads
Ozone – tropospheric 3.4.3.2.2	Secondary pollutant FF use	Catalytic converters – control NO_x to control O_3	Reduced respiratory impacts – ozone levels still high – sunny days – urban areas
Hydrocarbons 3.4.3.2.4	FF	Catalytic converters Activated carbon filters	Reduced GHG emissions Diesel engines problem
CO 3.4.3.2.5	Incomplete combustion of FF	Cats/improved combustion efficiency	Reduced carboxy-haemoglobin
Hydrosphere pollutants			
Oil pollution 3.4.3.2.7	Oil/pipelines, tankers	Tanker design and operation. Oil spill clean-up methods	Reduced tanker accidents Reduced oil pollution impacts Containment and clean-up methods have improved. Early methods – involving dispersants which were toxic in themselves Use of skimmers to remove oil
Agricultural pollutants 3.4.3.2.9	Inorganic nutrients Fertiliser use Organic wastes Pesticides	Legislation, role of EA Cultural change, use of alternatives, green manure, timing of applications etc. Sewage treatment	Reduced eutrophication/deoxygenation

Acid mine drainage 3.4.3.2.10	Mine water leachate	Management of 'mothballed' mines Pumping operations and containment Treatment with lime	Not all old mines are inspected? Reduced acidification of rivers/streams
Solid waste 3.4.3.2.12	Domestic/radioactive	Legislation controls/taxes/ incentives. Landfill, compost, incineration, recycling Strict controls of handling and treatment of radioactive materials/waste	Badly constructed landfills pollution of waterways, atmosphere CH_4. Increased fly-tipping. Incineration and toxic emissions. Recycling driving waste stream. Under emphasis on reuse and reduce Reduces exposure and contamination. Long-term storage still a problem
Noise Pollution 3.4.3.2.13	Aircraft Road traffic Railway Industrial	Legislation Aeroplane/train/train track design/car design/infrastructure and timing of operations	Reduced noise stress levels and health impacts Reduction in noise near villages towns from motorways, airports, tracks etc.

Qu	Part	Marking guidance	Comments	Total marks	AO
11	**2**			**25**	AO1 = 10 AO2 = 10 AO3 = 5

- Students should demonstrate that they are aware that the energy conservation methods discussed have not totally eradicated the impacts of fuel extraction and subsequent energy use. Where another source of energy is replacing use of FF, environmental impacts have been shifted elsewhere.
- Two aspects to energy conservation need to be covered, improving efficiency and reducing wastage.

Topic/spec ref 3.3.4.2/3.3.3/ 3.4/3.4.3.2.3, 4.5	**Area of application**	**Method of conservation**	**Impact of energy conservation method**
Transport energy conservation	Vehicle design Road, rail and aircraft	Aero/hydrodynamics Reduce friction with air. Smooth air flow over vehicle Tyre/wheel design Materials with low embodied energy KERS (using energy under braking) including trains. In trains, electricity fed back to NG **Electric/hybrid vehicle:** • KERS(Using energy under braking) The recovered energy is stored in a reservoir (for example a flywheel or a battery or supercapacitor) for later use under acceleration. • additional supply by solar cells • improved mechanical energy transmission system • increasing of efficiency of power convertors • using supercapacitors, fuel	Improved efficiency More mpg/more miles per charge Less fossil fuel used Less electricity (electric cars) Less CO_2 released/reduced GW Reduced exhaust pollutants Less FF used – less resource extraction More miles per charge –improved efficiency. Reduces waste heat from brake friction by converting to another form Mechanical KERS system is more compact, efficient, lighter and environmentally friendly solution than electrical battery systems But using solar cells, fuel cells, lithium-based batteries, rare earth metals leads to increased resource mining of metals, their manufacture and processing along with associated environmental impacts, eg habitat loss, soil degradation, aquatic pollution Electric vehicles currently limited to cars etc not large transporter lorries re battery technology

		cells and new generation batteries • route selection on the criterion of minimum consumption in real time • parameter monitoring inside and outside of the vehicle and computerised system control with optimisation of energy consumption.	
		Lighter vehicles: • plastics, composites instead of metal inside • lighter steel alloys outside • neodymium speaker magnets • aluminium engine blocks • less wiring • higher energy density batteries • electric control of aircraft wingtips rather than pneumatic systems.	Improved efficiency More mpg/more miles per charge Less fossil fuel used Less electricity (electric cars) Less CO_2 released/reduced GW. But more rarer metal mining etc.
		Tyre/wheel design: • self-inflating tyres to ensure correct tyre pressure.	Underinflated tyres create more friction and heat loss
		End of life design: • easily dismantled, identifiable, recyclable parts.	Reduced resource demand Reduced material to landfill
		Materials with low embodied energy: • use of recycled materials.	Reduced resource demand
		Driving mode: • avoid slow driving etc. by automatic stop starting	Increases efficiency, more mpg, miles per charge

		• higher gear.	
	Bulk transport	Larger loads on fewer vehicles	Improves overall efficiency Greater numbers of larger vehicles add to diesel pollution. Road impacts and repairs
	Transport infrastructure	Integrated transport systems Active traffic management Smart motorways	Reduced energy wastage from start and stop
	Vehicle re-cycling	Recyclable components Id/dismantling and material separation	Reduced resource mining and mining impacts. Less disposal to landfill/incineration Lowers embodied energy
Building energy conservation	Building design	Orientation-passive solar SA:VOL – Terracing High thermal mass, eg concrete	Reduced heating, reduced energy use. Reduced demand for ff use and reduced GW
	Materials/methods and embodied energy	Egs given of materials Earth sheltered buildings	Limecrete/Concrete etc. reduces demand for energy by reducing temp extremes Rammed earth Lime mortar
	Thermal conductivity	Double/triple glazing /Low e glass Insulation SIPs design	Reduces energy for heating Reduces noise pollution Insulating materials from waste materials reduces embodied energy, eg Sheep wool, shredded paper
	Management technologies	Smart meters Occupancy sensors Heat exchangers Thermostats Water heating	Ventilation and heat recovery reduces demand for energy
	Low energy appliances	Lighting White goods, eg given	Improved efficiency Less electricity Less CO_2 released/reduced GW Less FF used – less resource extraction

Industrial energy conservation	Heat management	Bulk storage Heat exchangers District heating/CHP	Reclaiming waste heat Reduced impact on release to environment, eg thermal pollution from power stations Reduced need for energy for heating during industrial process. Used in other production processes, eg tomatoes and green houses
	Integrated manufacture	Manufacturing processes on same site	Transport – FF saved
	Recycling	eg Aluminium cans	Energy and raw material reduced Mining activities reduced Recycling glass bottles not as energy efficient due to weight involved. Not all recycling saves energy in the long run
	Electricity infrastructure management	HV grid Pump storage HEP Manage supply & demand Locational factors	Reduction in heating the ‘air’, less energy loss through heating Less energy wasted Less demand for FF