Option	Technology / Process	Pros	Cons	Onward BAT Assessment	Comment
Venting	Direct Release of Gas to Atmosphere	• Simple. • Easy to install / versatile. • Well proven. • Broadly unaffected by gas composition (except for H2S or heavy ends). • Inexpensive. • Can be sized to manage wide flow range.	• Natural gas is a highly potent greenhouse gas (28 GWP). • Creates a potentially hazardous/flammable environment local to release. • Requires safe vent/sterile area to protect against toxic release or from thermal effects. • For station vents, height may be significant creating visual issues.	Yes	• Only considered suitable for small volume/ low pressure releases for the purposes of infrequent maintenance or safety relief. • May be required on sites as a back-up to primary waste gas handling systems if they are offline or cannot handle safety release flows.
Combustion	Elevated Flares (various types)	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Can accommodate a large range of flow – up to 1,000–4,000 tonnes per hour, with a turndown ratio of up to 6:1. • Sonic systems can operate with high back pressures. • Sonic tip and mixing assist systems can be optimised to enable efficiency of 98% or greater. • Effective for sour gas duty as the height of the stack will be set to ensure that unburnt hydrogen sulphide is dispersed without impacting personnel. More likely to be of use with associated gas. • Simple installation and operation. • Costs are low to medium compared with other solutions.	• Release of carbon dioxide contributes to global warming. • Large visible flame – significant issue in rural/non-industrial areas. • Typically, noisy >70dB(A), or very noisy >90dB(A) for sonic flares. • Basic open pipe flares may have efficiencies of between 75% and 90%. • High combustion efficiencies require additional utilities such as steam, compressed air or high pressure gas to improve mixing, which increases energy usage and means additional infrastructure is required. • Requires optimisation to prevent smoke generation, especially if there are heavier components in the gas. • Potentially requires a large sterile area to allow for ground level thermal effects. • Higher risk of pilot blowout compared with shrouded/ enclosed or ground-based systems. • Need a constant supply of gas for the flare pilot, which creates a constant combustion stream, potentially offsetting benefits. Would contribute to emissions covered by a site permit. This would be a more significant issue for purely gas developments where a flare would need to be kept live for safety purposes.	No	• High efficiency systems require some form of mixing assist, which in turn necessitates additional plant and energy costs. • Generally, more suited for sour gas operation as it improves safety for operators. Otherwise visual and noise impacts, as well as the sterile area footprint mean that elevated flares are not practical options.
	Shrouded Flares	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Can accommodate a large range of flow– up to 1,000–4,000 tonnes per hour, with a turndown ratio of up to 4:1. • Suitable for wide range of gas compositions. • Height is generally lower than elevated flares, due to lower thermal effects because of the shroud; therefore, lower visual impact. • Low risk of pilot blowout compared with elevated flares. • Noise is generally lower than for elevated flares as the shroud provides a degree of noise attenuation. • Lower thermal radiation emissions and therefore smaller sterile area required. • Simple installation and operation. • Capital costs are low to medium compared with other solutions (for example, enclosed flares).	• Release of carbon dioxide contributes to global warming. • Open pipe combustion is difficult to optimise, with combustion efficiencies typically between 70% and 80%. Increased potential for release of unburnt hydrocarbons or natural gas slip or smoke generation, particularly if there are heavy hydrocarbon components in the gas. • Efficiencies can fall significantly at low gas flow rates. • Requires optimisation to prevent smoke generation, especially if there are heavier components in the gas. • Potentially not suitable if hydrogen sulphide is present at hazardous concentrations due to health and safety considerations related to unburnt hydrogen sulphide. • Need a constant supply of gas for the flare pilot, which creates a constant combustion stream, potentially offsetting benefits. Would contribute to emissions covered by a site permit. This would be a more significant issue for purely gas developments where a flare would need to be kept live for safety purposes.	Yes	• Simple to install and operate. • Can be oversized without major cost penalty and therefore provides a good solution for safety-related releases. • Not the most efficient combustion option – potential hydrocarbon slip and increased NOx and SOx release. • Low capital cost.
	Enclosed Ground Flare	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Can accommodate a good range of flow – up to 1,000–2,500 tonnes per hour, with a turndown ratio of up to 4:1. • Suitable for a wide range of gas compositions. • Burner design and control system monitoring allow high efficiencies to be achieved (>99%), meaning good emissions performance. • Efficiency maintained across the wide turndown range (4:1). • Low risk of pilot blowout compared with elevated flare. • No visible flame. • Lowest height for commonly used flare systems – best visual impact. • Lowest noise for commonly used flare systems <70 dB(A). • Thermally insulated enclosure means no ground level sterile area is required. • Best environmental performance for combustion based systems.	• Release of carbon dioxide contributes to global warming. • Not suitable if high hydrogen sulphide present due to health and safety considerations related to unburnt hydrogen sulphide. • Need a constant supply of gas for the flare pilot, which creates a constant combustion stream, potentially offsetting benefits. Would contribute to emissions covered by a site permit. This would be a more significant issue for purely gas developments where a flare would need to be kept live for safety purposes. • May need to be operated with multiple units and a vent manifold to manage highly variable flowrates. • More expensive than alternative flare technology.	Yes	• Best environmental performance due to efficient control of burners and flow control. • Thermal enclosure means that no sterile area is required. • More expensive than shrouded or elevated units. • Not ideal for safety duty due to backpressure issues. • Potentially significant standby emissions from pilot burners if used for safety duty.

Option	Technology / Process	Pros	Cons	Onward BAT Assessment	Comment
Heat Generation	Incinerators / Boilers	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Uses waste gas instead of using imported or product gas to generate a site utility and/or an exportable utility to local users. • Can typically operate with a wide range of gas compositions and/or dual fuels (for example, gas or oil).	• Site loads for heat or hot water or steam may be limited, typical applications being preheating before gas pressure reduction and dehydrator regeneration. Therefore gas usage could be low and thus additional systems will be still required for excess waste gas management or when steam/heat generation systems are unavailable. • If being used for heat export, a back-up gas supply (for example, propane or natural gas piped supply) may be needed to keep the incinerator/boiler operating when wellhead gas is not flowing. • Generally, not considered practical to export heat, hot water or steam unless users are very close to source (that is, <1km).	No	• If there is a high demand for heat, hot water or steam onsite, this option could be worth considering. But typically this will not be the case and other technologies could generate these utilities as a byproduct of their primary operation (for example, a heat recovery unit/ economiser on a gas turbine or engine (CHP)). • If there are opportunities to export the heat (that is, if close enough to industrial developments or large buildings), this should be considered as a BAT option. • Will still require a flare system for safety duty or balance of waste gas flow.
Power Generation	Spark Engines	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Uses waste gas instead of using imported or product gas to generate a site utility and/or exportable utility. • Wide range of power generation capability from <1MW to 50 MW shaft power, which provides sufficient power for site needs and potentially export. • Can typically operate with a wide range of gas compositions and/or dual fuels (for example, gas or oil). • Can recover exhaust heat to generate heat or hot water (that is, CHP).	• Back-up waste gas management systems will need to be sized for gas flow when engine(s) are offline. High noise output requires an acoustic enclosure to mitigate. • Back-up gas supplies (for example, propane) will be required if well gas is not available and power generation needs to be maintained to meet export commitments. • Viability of export depends on export cable power capacity for existing cables or distance to network high voltage connection. • Creates additional safety hazards onsite by introducing mechanical moving systems with associated gas handling and hazardous zoning requirements.	Yes	• Well-understood technology and readily available. • Possible to recover exhaust heat for other duties (that is, CHP). • Back-up fuel source may be required for periods when wellhead gas is not flowing. • Will still require a flare system for safety duty or balance of waste gas flow.
	Gas Turbine	• Compared with cold venting of natural gas, greenhouse gas emissions performance is improved as carbon dioxide is a significantly less harmful greenhouse gas. • Uses waste gas instead of using imported or product gas to generate a site utility and/or exportable utility. • Typical sizes from 3MW to 500 MW shaft power, which provides sufficient power for site needs and export. • Can operate with dual fuels (for example, gas or oil). • Can recover exhaust heat to generate heat or hot water (that is, CHP).	• Gas turbine may be more sensitive to fuel composition changes than spark engines. • Back-up waste gas management systems will need to be sized for gas flow when engine(s) are offline. High noise output requires an acoustic enclosure to mitigate. Back-up gas supplies (for example, propane) will be required if well gas is not • available and power generation needs to be maintained to meet export commitments. • Viability of export depends on export cable power capacity for existing cables or distance to network high voltage connection. • Creates additional safety hazards onsite by introducing mechanical moving systems with associated gas handling and hazardous zoning requirements.	Yes	• Very good option where very large generation power generation capacities are required. • Well-understood technology and readily available. • Possible to recover exhaust heat for other duties (that is, CHP). • Back-up fuel source may be required for periods when wellhead gas is not flowing. • Will still require a flare system for safety duty or balance of waste gas flow.
	ORC (waste heat recovery)	• Captures waste heat and converts to electricity for site use or export, instead of sending to atmosphere. • Mature technology.	• Would typically recover heat from turbine, so depends on the inclusion of these in site scheme. • Payback period relies on continuous long-term operation, not the case for EFT phase.	Yes	• Payback period relies on continuous long-term operation, not the case for EFT phase.
Mini LNG	Liquefaction of natural gas	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Bulk storage allows flexible logistics scheduling. • Allows export of a product where there is no pipeline route available.	High capital cost. • Requires bulk LNG storage tank(s) on site, which increases hazard potential and, depending on size/total storage capacity, may have COMAH implications. • Location of storage in relation to other systems and operatives needs careful consideration due to potential for accident escalation risks. May increase site footprint. • Potential for high number of road tanker movements to export product – increased risk of spills and releases. Potential restrictions on road tanker movements on some routes (for example, bridges and tunnels due extreme flammability risks). • Onsite containment required to protect against spillages and releases – increase in civil engineering costs. • May require nitrogen utility for liquefaction process, increasing process or operational complexity (delivery versus onsite generation). • Limited market – there are only 3 UK LNG terminals that are set up for bulk marine deliveries. There is a potential market through bottled gas supplies, but it is untested and would need development. • Would require heat utility, which will increase overall complexity.	No	• High capital cost and limited UK LNG infrastructure for road tanker handling mean that it is not an economic proposal • Road tanker delivery logistics use fuel and generate local pollutants, which will offset some of the emissions reduction benefits of gas liquefaction.

Option	Technology / Process	Pros	Cons	Onward BAT Assessment	Comment
Conversion	Conversion of natural gas to liquids (GTL) – fuel base products	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Allows export of product where there is no piped export route. • May be used to fuel onsite vehicle/machinery requirements (that is, gasoline or diesel).	• High capital cost. • Several different processing technologies available. • Effectiveness is highly dependent on gas composition. • Some processes only work at large scale (for example, Fischer–Tropsch or ExxonMobil methanol to gasoline). • Process can be very difficult to optimise. • Requires bulk product storage tank(s) onsite, which increases hazard potential and, depending on size, may have COMAH implications. • Location of system in relation to other systems and operatives needs careful consideration due to potential for accident escalation risks. • Potential for high number of road tanker movements to export product – increased risk of spills and releases. • Onsite containment required to protect against spillages and releases – increase in civil engineering costs. • Reliance on proprietary catalyst solutions. • Would require heat utility, which will increase overall complexity.	No	• Can be used to generate diesel or gasoline or syngas. • Market for diesel is declining. • Technologies often based on proprietary catalysts and reactor technology. • High complexity. • Some technologies need pairing with precursor processes such as gas to methanol (which is then used as a feedstock). • Not all options are technically mature or can be difficult to optimise. • High capital cost. • Road tanker delivery logistics use fuel and generate local pollutants, which will offset some of the emissions reduction benefits of gas conversion process.
	Conversion of natural gas to liquids (GTL) – commodity products (for example, methanol, ammonia)	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Allows export of product where there is no piped export route. • May have higher value than fuel-based GTL.	• High capital cost. • Several different processing technologies available. • Effectiveness is highly dependent on gas composition. Process can be very difficult to optimise. • Requires bulk product storage tank(s) onsite, which increases hazard potential and, depending on size, may have COMAH implications. • Location of system in relation to other systems and operatives needs careful consideration due to potential for accident escalation risks. • Potential for high number of road tanker movements to export product – increased risk of spills and releases. • On site containment required to protect against spillages and releases – increase in civil engineering costs. • Reliance on proprietary catalyst solutions. Would require heat utility, which will increase overall complexity.	No	• Potentially more attractive than GTL to fuels due to high value of products. • Technologies often based on proprietary catalysts and reactor technology. • High complexity. • Not all options are technically mature or can be difficult to optimise. • High capital cost. • Road tanker delivery logistics use fuel and generate local pollutants, which will offset some of the emissions reduction benefits of gas conversion process.
Gas Processing and NGL Recovery	Recovery of NGLs (ethane, propane, butane and pentane) from natural gas	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Bulk storage allows flexible logistics scheduling. • Allows export of a product where there is no pipeline route available.	• Competition from imported supplies means price point is low compared with the cost of processing in the UK. • Easier to export raw condensate for processing at a refinery. • Highly dependent on gas composition; needs a rich gas stream to be considered practical and so best with associated gas. • Requires complex additional systems (for example, turbo expanders, fractionation columns, potentially nitrogen and mercury rejection), meaning an increase in capital cost, operating complexity and footprint. • Requires bulk product storage vessel(s) onsite, which increases hazard potential and, depending on size, may have COMAH implications. • Location of storage in relation to other systems and operatives needs careful consideration due to potential for accident escalation risks. • May increase site footprint. • Onsite containment required to protect against spillages and releases – increase in civil engineering costs.	No	• Potentially option for rich gas (for example, associated gas), which cannot be fed directly into other utilisation technologies such as gas engines or conversion processes, or for compression for export. • Based on established and well- understood technology. • Economics capital and operating profit in competition with cheaper imports do not support this option. • Export of raw condensate to refinery considered a more practical option.
CNG	Compression to CNG for road tanker export	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Bulk storage allows flexible logistics scheduling. • Allows export of a product where there is no pipeline route available.	• No established market for CNG via road tanker. • Works best with lean gas. Otherwise requires removal of heavy components, which adds to costs and complexity, and therefore potentially not good for associated gas. • As a compressed gas, export via road tanker is significantly less efficient than for liquids. • Requires bulk product storage vessel(s) onsite, which increases hazard potential and, depending on size, may have COMAH implications. • Location of storage in relation to other systems and operatives needs careful consideration due to potential for accident escalation risks. • May increase site footprint. • Potential for high number of road tanker movements to export product – increased risk of releases.	No	• Lack of infrastructure or market for road tanker compressed gas. • Requires lean gas to keep process simpler and costs lower; would suit coal bed or coal mine methane or gas only developments. • If flow rates are high, the number of tanker movements may become problematic. • No established infrastructure for compressed gas fuelling of vehicles in the UK. • Road tanker delivery logistics use fuel and generate local pollutants, which will offset some of the emissions reduction benefits of gas compression.
	Compression to CNG for export via pipeline	• Removes need to vent any greenhouse gases at source (for example, natural gas or carbon dioxide). • Converts natural gas to a saleable product. • Allows export of product.	• CNG systems normally operate at higher pressures than receiving networks could accommodate. If gas is to be exported, this would be best achieved via traditional pipeline compression systems.	No	• Refer to 'Export via pipeline' entry under 'Collection and reinjection/recycling' option.

Option	Technology / Process	Pros	Cons	Onward BAT Assessment	Comment
Collection and Reinjection / Recycling	Enhanced oil recovery	• Potential to boost oil flow in wells by maintaining well pressure by gas reinjection.	• Would only be of benefit in associated gas scenarios where gas can be used to enhance oil recovery.	No	
	Recycling of waste gases	• Established technology. • Ensures that gas losses are minimised. • Simple solution, which utilises existing plant. • Boosts product generation capacity • Recovered gas could be used for fuel gas (for example, steam boiler, power turbine).	• Ideally gas needs to come off at high pressure to allow it to be used elsewhere in the process. • Less practical for associated gas as there are less opportunities to recycle/reinject the gas in to the process. Better in these cases to seek use for gas as a fuel supply. See 'Power generation 'entry.	No	• Opportunities for waste gas reuse and reprocessing in the main processing train should form a fundamental requirement of the design basis of any operation.
	Export via pipeline	• Established technology – pipeline gas compression. • Simple installation and site infrastructure. • Mature supplier market. • Flexible flow solution. • Can be started and stopped with little penalty. • Can be used as part of heat recovery system to generate heat.	• Potentially not suitable where an export pipeline does not already exist (that is, associated gas); pipeline installation would be subject to assessment of the capital cost to connect into the distribution network – a function of distance, and required pressure and capacity requirements. • Pressure and capacity of receiving network needs to be suitable to ensure no restriction of flow from the site. • Mercaptan odorant may need to be stored and delivered to site, which will potentially introduce new hazards and operational requirements. • Application process to agree export to network may be lengthy and complex. • Planning process for pipeline routing.	No	• If a pipeline already exists, this is should be a default option unless flows are very low. • If pipeline connection economics are not prohibitive and the receiving network can guarantee to take the export gas, this is the most practical solution for recovering and utilising waste gas.
Vapour Recovery	Capture of Vapour/Gas from Process Operations	• See entry 'Recycling of waste gases' under the 'Collection and reinjection / recycling' option.	• See entry 'Recycling of waste gases' under the 'collection and reinjection / recycling' option.	No	• Specialist systems are available for the capture and processing of vapours. These would typically be associated with large storage facilities where there may not be associated process systems that could utilise/process the vapours or gases produced from filling and emptying storage tanks. • More attractive for rich gas or condensate storage tanks, as liquid product can be generated. • For OOG sites where gas processing equipment exists (particularly gas developments), dedicated vapour recovery systems are considered BAT as there are opportunities to recycle/reprocess vented gases of vapours.
Energy Storage	Electricity	• Portable power. • Easy to transport to customers.	• Requires a matched power generation system. • No developed infrastructure or market. • Novel – as yet, relatively unproven technology. • Storage capacity limitations may require multiple charging units and batteries to • make viable use of waste gas. • Increase in vehicle movements. • Not available for rental in the UK.	No	• Could be a viable in the future but not yet considered available. • Technology not mature. • Lack of market.
	Thermal	• Portable power. • Easy to transport to customers.	• Requires heat recovery systems to be in place (for example, CHP). • No developed infrastructure or market. • Novel – as yet, relatively unproven technology. • Storage capacity limitations may require multiple regeneration units and thermal cubes to make viable use of waste gas. • Increase in vehicle movements. • Technical limit on heat storage time not known. • Customers need to be set up to recover energy.	No	• Technology is not mature. • Lack of market.
Zero Emission Technologies	Valve Actuators	• Does not use direct gas actuation – therefore no gas emissions. • Safer – no flammability risk.	• More expensive actuators. • Potentially bigger actuators (gas actuators can run at higher pressures and therefore tend to have smaller piston arrangements). • May have to install additional infrastructure (for example, instrument air compression and distribution network).	No	• By restricting the gas the well is shut in and cannot produce.