Large scale imports into the UK of wood pellets are primarily driven by those generators who have converted power station units to burn wood. UK legislation requires the fuel to come from a sustainable source; sustainable generally means from ‘farmed or managed forests’ with an audited regime of re-planting and a harvesting cycle of 60 to 80 years.

Conversion
To date, RWE, E.ON, and more notably Drax, have been, or are in the process of, converting generating units to operate on biomass – predominantly wood pellets, with Lynemouth Power looking like being the next to do so. One of the quirks of the mathematics is that in round numbers 1m3/h of wood pellets will produce the heat to raise enough steam to generate 1 MWh of electricity.

A 500MW unit will consume approximately 500m3/h or 300 tph of pellets, and while operating for 8000 hours per year, a unit will consume approximately 2.4 million tonnes of wood pellets. If all conversion plans come to fruition, a market for some 19.5 million tonnes per year of wood pellets will have been created. However, in reality, this is more likely to be 12 to 13 million tonnes per year.

Currently tonnages imported into the UK are rising. Imported wood fuel in 2012 totalled 3.5 million tonnes, and even by conservative estimations, by 2016 the demand looks to grow to four times that number.

Logistical issues
To illustrate the logistical challenges using the lower figure of 12 MTPA, this equates to the bulk carrying capacity of some 207 Panamax vessels a year delivering the fuel to UK ports for offloading, storage and forward shipment to the power stations. Existing port infrastructure is geared up for these tonnages of coal, but biomass and particularly wood pellets pose their own set of unique challenges.

To comply with legislation, the pellet producers are prohibited from using any form of artificial binder. Pellets are formed at such a pressure that friction heating melts the lignin in the cell walls to form a natural binder. This bond is not particularly strong, so from the moment the pellet is formed, it starts to degrade.

By the time pellets reach the UK, up to 10% of the cargo may have reverted to sawdust. Another major problem is that pellets swell and revert back to sawdust if they get wet.

Wood dust is also a fire hazard; in the correct concentrations, pellets can explode. The lower explosive limit (LEL) is generally agreed to be 30 grams of dust in a cubic metre of air. However, pellets can arrive in the UK ‘hot’ (generally up to 50 degrees C), and they are also prone to self-heating, especially if they get wet prior to long-term storage. The risk of combustion is therefore ever present, be it from self-heating or a spark by an ignition source.

Furthermore, with the material being organic, it is technically rotting all the time and thereby steadily gives off carbon monoxide, which in ship holds and in silo or shed storage systems leads to oxygen depletion in the atmosphere. Over longer periods of time, the risk of methane off-gassing increases.

Handling challenges summarised
• Keep it dry
• Control Fugitive Dust Emissions (EH40 – 5mg/m3 8hr TWA limit before PPE required)
• Design to comply with ATEX regulations
• Monitor product temperature and moisture
• Check for high CO and CH4 concentrations in enclosed spaces
• Be prepared for a fire (detection and suppression)

Focussing on the Rail Loading System Design
The driving design parameters are:
• The time available to load the train
• The length of the train
• The number of rail cars making up the train
• The percentage fill required

The time available to load the train is often the starting point of the design, typically this is specified as the total turn round time of site (90 minutes is common). To allow time for shunting, re-fuelling, driver change and so forth, Spencer settled on loading a train in better than 1 hour in order to guarantee the 90 minute turn around.

The technology Spencer had in mind to perform the loading function was already in existence in the US, having a 40-year track record of loading bulk materials into rail wagons (particularly coal and iron ore). Spencer saw the potential in the Pebco rail loading technology to load biomass trains quickly and efficiently. The total length of a train is important. Biomass has a relatively low bulk density, typically 600 to 650 kg/m3 so haulage volume takes precedence over haulage weight up to a maximum weight the locomotive can haul. Nowadays, 30 wagon trains up to 600 metres long are being considered. Coal trains are often less than 400 metres long.

In many cases, as the existing site infrastructure is designed to suit coal train lengths, it follows that most existing infrastructure usually requires extending. Train length also directly influences the time to load; in-motion loading systems operate at a fixed speed, so the longer the train, the longer the time to load. The number of rail cars making up the train dictates the maximum load each train...
transports, and the percentage fill (often 97% or better) is a function of train speed and the instantaneous fill rate.

**By way of example**
A 30 wagon train some 600 metres long travelling at 0.5mph will take 46 minutes to pass a point on the track. During this time each wagon should be loaded with better than 65 tonnes (108m³) of wood pellets. Allowing for the gaps between the wagons when no material can be discharged, the calculated instantaneous loading rate to achieve the fill is in excess of 3000 TPH (5000 m³/h). These material reclaim and conveying rates are achievable but at high cost. Spencer concluded that having a train load of material in a silo above the loading point ready to discharge into the rail wagons would be lower risk and a more cost-effective method of ensuring material was available at the point of loading.

As train lengths have got longer and wagon capacities have increased, so silo volumes have increased from 2000m³ (at Tyne) to 3000m³ (at Hull). To control the fill rate of an individual rail wagon the Spencer/Pebco system employs a ‘flood loading’ philosophy.

**Flood loading**
Flood loading is achieved when the instantaneous loading rate is so large that the material floods into the receiving rail car, back up and chokes the discharge chute.

Once the chute is choked, material can only flow from the chute at a rate dictated by the movement of the train under the chute. Providing the choke is maintained, then control of the loading operation is straightforward.

In simple terms, on detection of the front of a rail car, the chute is lowered to the loading height and the discharge gate opened. An instantaneous flow rate of 10,000m³/h ensures that the choked state is achieved in approximately 8 seconds (during which time the rail car would have moved 1.8 metres).

The balance of the rail car is filled as it moves under the chute presenting a void into which material floods in to maintain the choke. The end of the car is detected and the discharge gate closed, allowing sufficient time for the material in the chute (the in-flight material) to fill the back of the car without over-spilling the back and the chute retracted until the next rail car presents itself.

The control system monitors train speed, wagon position and in the case of biomass wagons, verifies the top doors of the wagon are open before allowing loading to proceed. Whilst in this instance wagons are volumetrically loaded, an independent track weighing system completes the loading system, providing tare and gross weight information for each axel of each wagon to an accuracy approved by trading standards.

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**About the author**
Ian Atkinson graduated in 1984 with a degree in Mechanical Engineering, later becoming a Chartered Engineer in 1993. With over 30 years experience in bulk materials handling and processing, Atkinson’s career has spanned the mining, quarrying, power and port infrastructure industries.

**About the organisation**
Spencer Group is one of the UK’s largest privately owned multidisciplinary engineering businesses that provides pioneering engineering solutions across the transport, infrastructure, energy and industrial sectors. Safety, innovation and value creation are at the heart of everything Spencer does and they have a robust skill set which can be deployed at any stage of the project life cycle; from concept design through to commissioning, operation and maintenance.

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