**Energy and the Industrial Revolution**

**能源与工业革命**

For years historians have sought to identify crucial elements in the eighteenth-century, rise in industry, technology, and economic power, known as the Industrial Revolution, and many give prominence to the problem of energy. Until the eighteenth century, people relied on energy derived from plants as well as animal and human muscle to provide power. Increased efficiency in the use of water and wind helped with such tasks as pumping, milling, or sailing. However, by the eighteenth century, Great Britain in particular was experiencing an energy shortage. Wood, the primary source of heat for homes and industries and also used in the iron industry as processed charcoal, was diminishing in supply. Great Britain had large amounts of coal; however, there were not yet efficient means by which to produce mechanical energy or to power machinery. This was to occur with progress in the development of the steam engine.

多年来，历史学家试图找到18世纪工业革命在工业、技术和经济领域兴起的关键因素，许多人把能源问题放在突出位置。直到18世纪，人们依靠工厂、畜力以及人力来提供动力。高效地利用水能和风能有助于完成诸如抽泵、碾磨或航海等工作。然而，到了18世纪，尤其是大不列颠却经历了能源短缺。木材这一主要能源，为家庭和工业供暖供能，同时也以加工木炭的形式被使用在钢铁工业中，其供应量日益减少。大不列颠有大量的煤矿；然而，还没有产生机械能或为机器提供动力的有效方法。这一切随着蒸汽机的改良而发生。

In the late 1700s James Watt designed an efficient and commercially viable steam engine that was soon applied to a variety of industrial uses as it became cheaper to use. The engine helped solve the problem of draining coal mines of groundwater and increased the production of coal needed to power steam engines elsewhere. A rotary engine attached to the steam engine enabled shafts to be turned and machines to be driven, resulting in mills using steam power to spin and weave cotton. Since the steam engine was fired by coal, the large mills did not need to be located by rivers, as had mills that used water-driven machines. The shift to increased mechanization in cotton production is apparent in the import of raw cotton and the sale of cotton goods. Between 1760 and 1850, the amount of raw cotton imported increased 230 times. Production of British cotton goods increased sixtyfold, and cotton cloth became Great Britain’s most important product, accounting for one-half of all exports. The success of the steam engine resulted in increased demands for coal, and the consequentincrease in coal production was made possible as the steam-powered pumps drained water from the ever-deeper coal seams found below the water table.

在18世纪末期，詹姆斯•瓦特设计了一款高效且具商业利益的蒸汽机，由于其价格低廉，很快就被运用到各项工业生产之中。这款蒸汽机帮助解决了煤矿中地下水的排水问题并且提高了煤的产量，这些煤用来为别处的蒸汽机提供动力。与蒸汽机相连的旋转式发动机带动轴承转动，从而驱动机器，运用蒸汽动力纺织棉布的纺织厂随之出现。因为蒸汽机靠燃煤而驱动，一些大型棉纺织厂就不再像那些使用水力驱动机器的工厂一样必须依河而建。这种棉纺织业日益机械化的转变在棉花原料的进口和棉纺产品的销售中得到突出的体现。在1760年到1850年间，原棉的进口量增长了230倍。英国棉纺产品的生产量增加了60倍，而棉布则成了英国最重要的产品，占出口总额的一半。蒸汽机的成功使煤需求量大增，蒸汽动力泵可以将地下水位下的更深的煤层中的水排出去，使煤产量的增加成为可能。

The availability of steam power and the demands for new machines facilitated the transformation of the iron industry. Charcoal, made from wood and thus in limited supply, was replaced with coal-derived coke (substance left after coal is heated) as steam-driven bellows came into use for producing of raw iron. Impurities were burnt away with the use of coke, producing a high-quality refined iron. Reduced cost was also instrumental in developing steam-powered rolling mills capable of producing finished iron of various shapes and sizes. The resulting boom in the iron industry expanded the annual iron output by more than 170 times between 1740 and 1840, and by the 1850s Great Britain was producing more tons of iron than the rest of the world combined. The developments in the iron industry were in part a response to the demand for more machines and the ever-widening use of higher-quality iron in other industries.

蒸汽动力的可利用性以及对新机器的需求促进了钢铁工业的转型。当蒸汽驱动风箱投入到生铁生产中后，木炭这种用木材烧成因此供应量有限的物质就被焦炭(煤加热后残留的物质)替代了。随着焦炭的使用，生铁中的杂质被燃烧完，从而生产出更高质量的精炼铁。成本下降也有助于那些蒸汽动力轧钢厂的发展，它们能够生产不同形状和尺寸的成品铁制品。因此导致的钢铁工业的繁荣使钢铁的年产量在1740年到1840年间增长了170多倍，到19世纪50年代，大不列颠生产的钢铁比世界其他地区生产的总和还要高。钢铁工业的发展从某种意义上说，是对更多机器的需求以及在其他工业中更广泛使用高质量铁的一种回应。

Steam power and iron combined to revolutionize transport, which in turn had further implications. Improvements in road construction and sailing had occurred, but shipping heavy freight over land remained expensive, even with the use of rivers and canals wherever possible. Parallel rails had long been used in mining operations to move bigger loads, but horses were still the primary source of power. However, the arrival of the steam engine initiated a complete transformation in rail transportation, entrenching and expanding the Industrial Revolution. As transportation improved, distant and larger markets within the nation could be reached, thereby encouraging the development of larger factories to keep pace with increasing sales. Greater productivity and rising demands provided entrepreneurs with profits that could be reinvested to take advantage of new technologies to further expand capacity, or to seek alternative investment opportunities. Also, the availability of jobs in railway construction attracted many rural laborers accustomedto seasonal and temporary employment. When the work was completed, many moved to other construction jobs or to factory work in cities and towns, where they became part of an expanding working class.

蒸汽动力和钢铁带来了交通运输的革新，反过来也有着更加深远的影响。道路设施以及航海的改善已经初见成效，但是船运重型货物到陆地的费用仍然很高，即使在可以使用河流和运河的地方。平行铁轨长期以来被用于采矿作业来运输大型货物，但是马匹仍然是主要的动力来源。然而，蒸汽机的到来引发了铁路运输的彻底变革，巩固和扩大了工业革命的成果。随着交通运输的改善，全国范围内更远更大的市场可以到达，因此鼓励着大型工厂的生产与日益增长的销售量保持同步。更大规模的生产和日益增长的需求给企业家带来了利润，这种利润可用于再投资新技术，进一步扩大产能或寻求其他的投资机会。同时，铁道建设方面的更多就业机会也吸引了那些习惯于季节性工作或者短工制的农村劳动力。一旦工作完成，其中的很多人就会参与到其他的建筑工作中或是城镇中的工厂工作中，并成为其中的不断壮大的工人阶级。