Energy 113 (2016) 809–820

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Review

Financial analysis of energy saving via compressor replacement in industry

Diego Vittorini*, Roberto Cipollone

University of L'Aquila, Department of Industrial and Information Engineering and Economy, L'Aquila, Italy

A R T I C L E I N F O

Article history:
Received 12 February 2016
Received in revised form
23 June 2016
Accepted 15 July 2016

Keywords:
Compression
Efficiency
Energy saving
Energy cost
Investment cost
Financial analysis

A B S T R A C T

The compressed air sector (CAS) is currently receiving great attention, being responsible for an electric energy consumption equal up to 10% world-wide overall industry electricity needs and, accounting for all the other fluid compressor uses, up to 20% overall electricity needs. Consequently, the saving potential in CAS, usually 30–35% overall consumption, can be compared with the one of other energy measures (e.g. efficiency in other sectors, renewable energy generation, etc…) and the great potential toward the 20-20-20 European target can be appreciated.

Since the compressor technology alone accounts for a mean 30% CAS overall electricity consumption, it appears vital to pay attention to both the machines specific consumption and the spread in performances, among manufacturers. Based on data from the Compressed Air and Gas Institute and Pneurop, the potential saving simply due to compressor replacement can be estimated, as well as the directions of a further energy saving in current technology. One of the most important limiting factors, which not only prevents the substitution of existing energy inefficient machines, but also affects the choice in a preliminary phase, is the payback time of the additional investment, required by a more efficient compressor purchase.

Since the eligibility of a measure for actual application hinges on its benefits-to-costs ratio, rather than on its energy merit alone, the present study investigates, with reference to the current industrial CAS, the relationship between the energy cost reduction from an efficiency increase through compressor replacement, and the required additional investment, based on typical operating pressures, flow rates and machine types of interest for current applications.

Contents

1. Introduction

At a time when the market, at both global and local level, is uncertain it appears hard to find convergence on concerted climate actions on an international basis. The economic downturn affecting all the Countries in the World, as well as the social instability

* Corresponding author.
E-mail addresses: diego.vittorini@graduate.univaq.it (D. Vittorini), roberto.cipollone@univaq.it (R. Cipollone).

http://dx.doi.org/10.1016/j.energy.2016.07.073
0360-5442/

hitting different geographical areas, makes hard to define a shared energy policy able to offer a robust international solution to the issues of CO_2 emissions increase and local energy sources shortage. Nonetheless, energy saving and CO_2 emissions reduction are presently addressed as the most effective ways to deal with the sustainability issue: they have been receiving increased care in the last decades, especially on the energy intensive sectors side and markedly industry, due to the role it plays in the growth process of both developed and developing Countries. According to the most recent statistics [1–3], 6673 TWh (i.e. more than 50% global electricity demand) come from the industrial sector, with lower shares coming from the residential (3370 TWh, 25%) one. Transports and commercial sectors are responsible for 3100 TWh together, i.e. a 25% global electricity need (Fig. 1). The proportion among sectors is respected when the analysis is performed on a Country scale too, with industry responsible for an electricity demand always higher than 25%, ranking at 78% for China and 68% for India, thus suggesting where the energy saving and recovery could provide the greatest benefits.

Along with the 2012 datum on energy demand by sectors, Fig. 1 reports the expected trend for electricity demand, on a 20 years basis (2015–2035): for the main World Countries, electricity demand is expected to experience a continuous growth, with the value by 2035 expected to be 2.8 times, 2.2 times and 1.3 times the 2012 value, for India, China and Australia, respectively. This depicts a complex and dishomogeneous situation, in which it still appears hard to take shared energy initiatives [4–6].

Furthermore, the need to face a such rapidly growing energy demand leaves little opportunity to energy sources diversification, forcing the market to stick to fossil fuels rather than promoting renewables development: in a long term scenario no relevant changes in the proportion between fossil fuels and renewables has to be expected with respect to the present situation, where up to 90% final energy uses are covered with fossil fuels. The relevance of emissions-related climate changes and the fact that the above mentioned measures can be no longer postponed are both stated in many independent studies [2,7,8]. Among them, the one by the Intergovernmental Panel on Climate Change (IPCC) confirms that at the present greenhouse gases (GHG) emission rate, a warming exceeding 4 °C on the average global temperature by the end of the Century is going to be unavoidable. Such a rise in temperature almost doubles the 2 °C increase in the 21st Century, commonly accepted as a limit to avoid irreversible damage to climate systems and to prevent the socio-economic models from collapsing [2,9–11]. The datum on temperature rise fixes a cap on global GHG emissions by 2020, at 44 Gt_{CO2eq}. Projections, based on the current development scenario and on the current energy sources market composition (up to 87% energy demand covered with fossil fuels), bring global GHG emissions from 50 Gt_{CO2eq} in 2010 to 59 Gt_{CO2eq} in 2020, i.e. 15 Gt_{CO2eq} beyond the 44 Gt_{CO2eq} limit.

In light of all the above mentioned factors, according to several independent sources, even if fully implemented, current pledges will lead to a cut of no more than 5 Gt_{CO2eq} by 2020, with a gap left on the target cut of 15 Gt_{CO2eq}, of about 10 Gt_{CO2eq} [8]. Thus, when the goal is the reaching of the 2 °C target, the adoption of mitigation policies is no longer an option and a compromise between the call for emissions reduction and the current development scenario, still strongly dependent on fossil fuels, is of the essence [1,5,11].

Among all others, in the last decade, electro-intensive (to which low characteristic conversion efficiency applies) sectors and applications underwent a massive resetting [12]. As a commodity, the CAS is an electricity user and exhibits a great potential for improvement: in the present scenario, up to 20% electricity demand in industry is compressed air related, i.e. about 1400 TWh/y. The contribution of the compression section to this figure ranks at

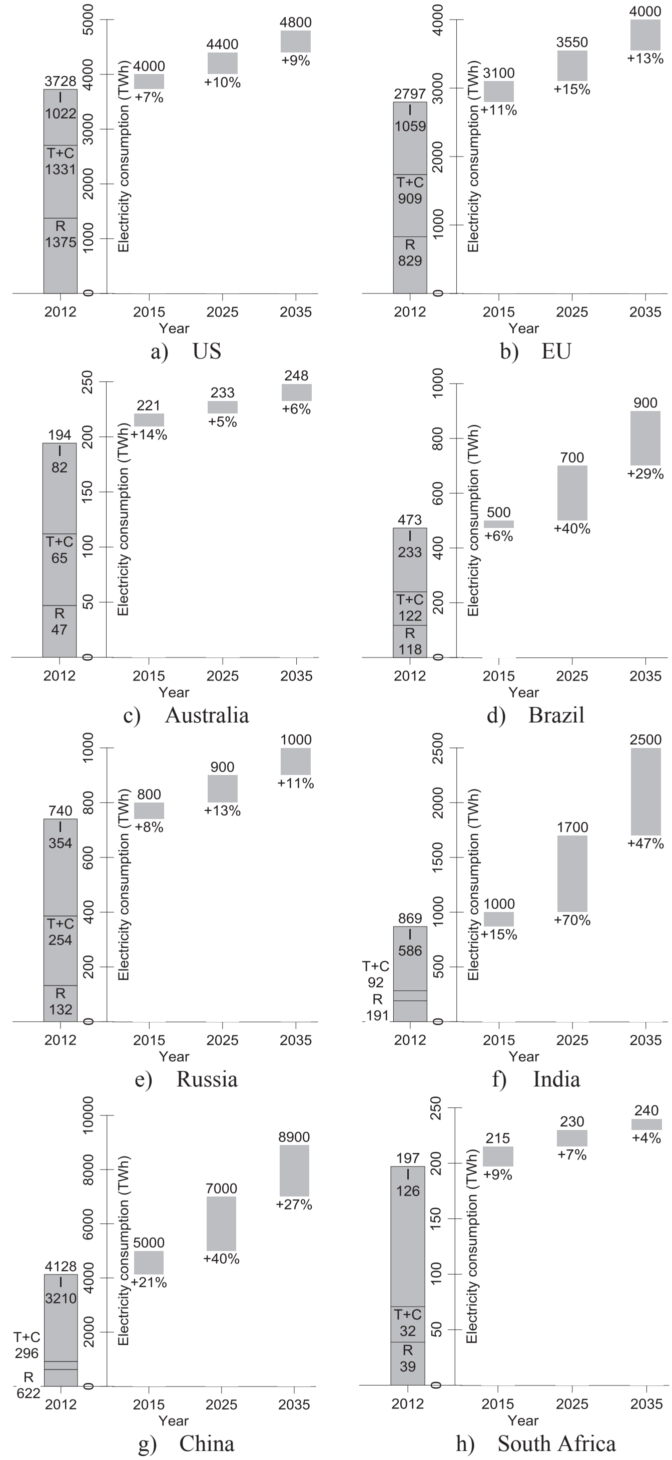

Fig. 1. Electricity demand by sectors (2012) and future trends (2015–2035).

about 20%, justifying the greatest interest and the growing care to compressor technology, when energy saving/recovery are in question. As from many independent sources, the major contribution to energy saving in compressed air comes from pressure refining, with a 10% saving, flow rate reduction and machine replacement, both ranking at 20–40% [13–17]. Recently in literature, extensive studies presented actual compressor technology in terms of specific energy consumption (or adiabatic efficiency) and Carbon dimension, based on Pneurop reports and CAGI datasheets