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Overview of Renewable Energy Resources of India

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ABSTRACT: There is an urgent need for transition from existing fossil fuel based energy systems to one based on renewable resources to decrease reliance on depleting reserves of fossil fuels with the objective to assess whether India can sustain its growth and its society with renewable resources. This paper gives an overview of the renewable energies in India while evaluating the current status, major achievements and future aspects of renewable energy in India.

Keywords: Renewable Energy, Wind, Hydroelectric, Geothermal, Biomass, Solar, Ocean

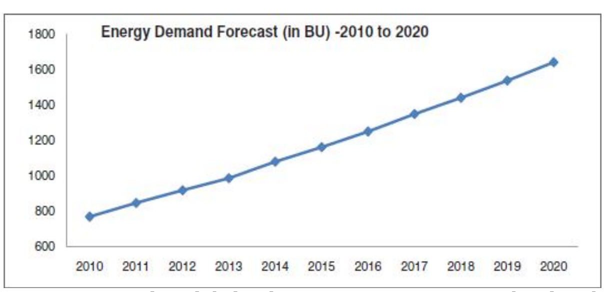
I. INTRODUCTION

India is the fourth largest energy consumer in the world after the United States, China, and Russia [1]. In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development. Rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to grow significantly. In order to sustain the production, industries have opted for inefficient diesel-fuelled back-up power. India's energy planning, which is based on the twin objectives of high economic growth and providing electricity to all, is failing to meet either.

The domestic power demand of India was 918 billion units in 2012. It is expected that at 9.8% annual growth the demand will reach 1,640 billion units by 2020. At this pace, India will require 390 GW in the next eight years which is almost double its current installed capacity of 210 gigawatts (GW). There is growing energy inequity between rural and urban areas and also between the developed and developing states. There are millions who are yet to be benefited from electricity in rural India. The scarcity of electricity in rural areas in comparison to urban areas seems to be biased in delivery through the centralized system. While the urban-rural difference in energy supply could be reduced through renewable energy, it is more complex to overcome the widening gap between developed and not so developed states [2].

Current centralized energy planning of India is dependent on coal and fossil fuel sources. The main concern arises on how to protect the fossil fuel for our coming generation with simultaneously utilizing the different resources of energy for high and sustained economic growth. Pressure to increase its energy supplies and the consequent negative environmental impact of fossil fuels has led India to a conscious policy toward renewable sources [3].

Current scenario of energy demand and supply demands the research and development activities in exploration of new reserves. There are huge amount of potential available in the renewable energy system which can be explored and harnessed to meet the energy demand.



Source: www.greenpeace.org/india/Global/india/report/2013/powering-ahead-with-renewables.pdf

Figure 1: Energy demand projection in India

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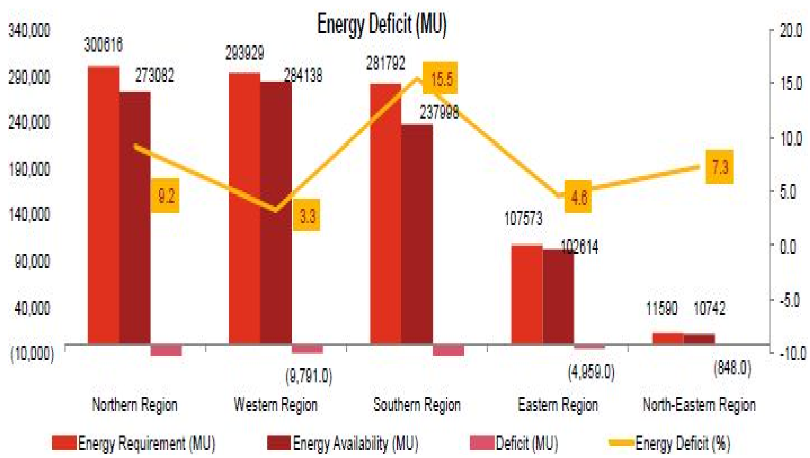
The anticipated all India power supply position indicates that the country is expected to experience energy shortage of 6.7% [4]. There is a clear need to step up capacities and energy availability as the economy grows.



Source: Opportunities & issues in the Indian Renewable Energy Sector. IEEE: RE3P3

Fig 2: Energy Deficit in Various Regions

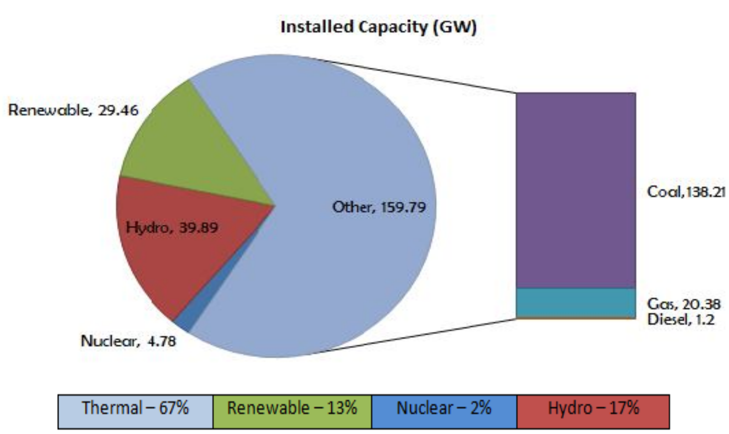
II. PRESENT POWER SCENARIO IN THE COUNTRY

India has transitioned from being the world's seventh-largest energy consumer in 2000 to fourth-largest one within a decade. The country has the fifth-largest power generation portfolio worldwide [5]. India's energy basket has a mix of all the resources available including renewables. The dominance of coal in the energy mix is likely to continue in near future. At present India's coal dependence is borne out from the fact that ~58 % of the total installed electricity generation capacity is coal based. Out of total thermal installed capacity 86% capacity is coal based [6]. Other renewables such as wind, geothermal, solar, and hydroelectricity represent a 2 percent share of the Indian fuel mix. Nuclear holds a 2% percent share [7].

Total installed capacity in the country stands at ~234 GW of which

(i) Thermal power accounts for 67 %

(ii) Renewable energy accounts for 13% [6]



Source: central electricity authority (CEA)

Figure 3: All India Installed Capacity as on 31st December 2013

Note: RES include SHP, BP, U&I, Solar and Wind Energy. Installed capacity in respect of RES (MNER) as on: 30.09.2013

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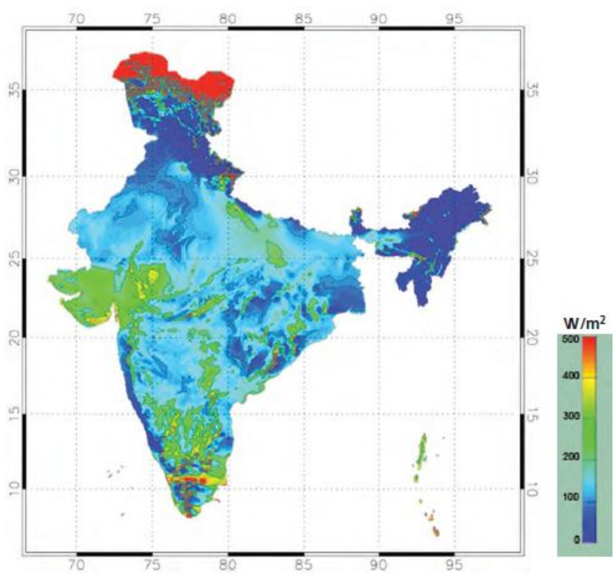
III. WIND ENERGY

Wind energy is one of the most promising alternative energy technologies of the future. During recent years, the amount of energy produced by wind-driven turbines has increased rapidly due to considerable advancement in turbine technologies, making wind power economically compatible with conventional sources of energy. The use of wind power in India has been gaining importance with rapid installation in the last few years. Wind energy makes up the majority about 68 per cent [8] of the total renewable energy capacity installed in India. Initial estimates from Centre for Wind Energy Technology (C-WET) suggest that wind energy potential at 80 metres height (with 2 per cent land availability) would be over 100 GW. Some studies have estimated even higher potential ranges up to 300 GW [9].

By the end of October 2013, India had a total installed capacity of 19,933 megawatt (MW) [8], with 1,699 MW installed in 2012-13. The total wind power generation in 2011-12 was 23,399.5 gigawatt hour (GWh), or about three and a half times the output of a new 1,000-MW nuclear reactor. The 12th Five Year Plan aims to install 15,000 MW between 2012 and 2017, which will almost double the total capacity of wind power in India [10].

Map: Wind power density (W/m2) at 80 m hub height

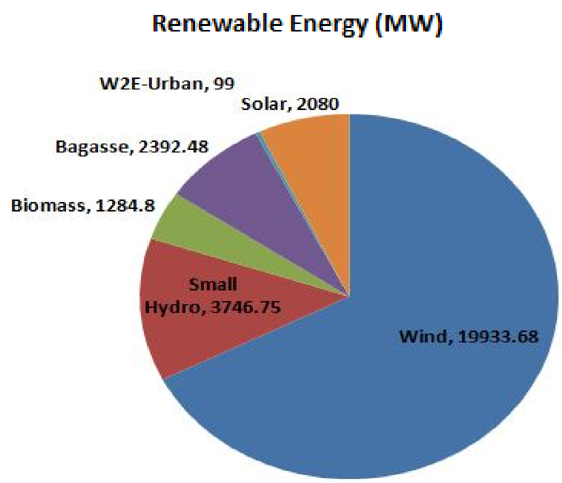


Source: http://www.cwet.tn.nic.in/html/departments_ewpp.html

IV. SMALL HYDRO POWER (SHP)

Hydro projects in India, which are under 25 MW in capacity, are classified as “small hydropower” and considered as a “renewable” energy source. The use of small hydro power (SHP) in India goes way back in history, with the country’s first SHP plant having come up in 1897. The sector has been growing rapidly for the last decade. The Number of SHP plants has doubled. SHP is by far the oldest renewable energy technology used to generate electricity in India.

The total installed capacity of SHP projects in India was 3,632 MW in March 2013. This is spread over 950 projects; hence, the average SHP project capacity is 3.8 MW. This does not include micro-hydel plants. The draft 12th Five Year Plan (2012-17) has, as its target, 2,100 MW of SHP capacity4. The total potential country-wide capacity is estimated at 19,749 MW, of which about 1,250 MW is under development [11]. The current total installed capacity of small hydro power plants is 3746.75 MW [8].



Source: MNRE achievements

Figure 4: Grid connected Break up of renewable energy sources in MW as on 31st October, 2013

V. GEOTHERMAL

The Geothermal energy of the Earth's crust originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. At the core of the Earth, temperatures may reach over 5000 degrees Celsius [12]. Geothermal energy comes from the natural heat of the Earth primarily due to the decay of the naturally radioactive isotopes of uranium, thorium and potassium. Because of the internal heat, the Earth's surface heat flow averages 82 mW/m^2 which amounts to a total heat of about 42 million megawatts [13].

According to its property, geothermal energy can be divided into four types: hydrothermal field, geo pressured geothermal resource, hot dry rock deposit and magma resource [14].The most promising geothermal fields in India are:

(i) NW Himalayas: Puga-Chumathang (Ladakh district, J&K) where a 1MWe plant is planned and Parbati Valley with the Manikaran field in Himachal Pradesh where in 1992 a 5kWe geothermal binary cycle plant was successfully run.

(ii) Central India: Tattapani region (Madhya Pradesh) where the installation of a 20MWe binary plant has been planned.
[15]

VI. BIOMASS & BIOGAS ENERGY

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, firewood, agricultural residues such as bagasse, crop straw, animal dung and wastes generated from agro-based industries.

Biomass takes carbon out of the atmosphere while it is growing, and returns it as it is burned. If it is managed on a sustainable basis, biomass is harvested as part of a constantly replenished crop. Municipal solid wastes, animal and poultry wastes are also referred to as biomass as they are biodegradable in nature. The main biomass sources are as listed below.

(i) Wood and wood waste: forest wood, wood from energy plantations, saw dust, tree branches and leaves etc.

(ii) Agricultural residues: rice husk, bagasse, groundnut shells, coffee husk, straws, coconut shells, coconut husk, arhar stalks, jute sticks etc.

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(iii) Aquatic and marine biomass: algae, water hyacinth, aquatic weeds and plants, sea grass beds, kelp, coral reef etc.

(iv) Wastes: municipal solid waste, municipal sewage sludge, animal waste, paper waste, industrial waste etc [16].

In India, a total of 4,449 MW has been installed under bio energy, both in grid connected and off-grid capacities [17].

Table 1: Installations under Bio Energy (as on June 30, 2013)

Type	Grid connected	Capacity installed (MW)
Biomass Power	On-grid	1,265
Bagasse Cogeneration	On-grid	2,337
Waste to Power (urban)	On-grid	96
	Off-grid	116
Biomass (non-bagasse) cogeneration	Off-grid	475
Biomass gasifiers (rural)	Off-grid	17
Biomass gasifiers (industrial)	Off-grid	143
Total		**4,449**

Source: MNRE achievements

VII. SOLAR ENERGY

Using solar power to produce electricity is not the same as using solar to produce heat. Solar thermal principles are applied to produce hot fluids or air and photovoltaic principles are used to produce electricity. A solar cell is a semi-conductor device designed to turn solar irradiance into electricity. The solar power on the surface of earth is 10^{16}W. The total worldwide power demand of all needs of civilization is 10^{13}W. Therefore, the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require. [18]

Among the various renewable energy resources, solar energy potential is the highest in the country. The equivalent energy potential is about 6,000 million GWh of energy per year. As compared to this, the present level of generation of electricity in 2008-09 from all resources was 0.7 million GWh [19]. The National Solar Mission targeting 20,000 MW grid solar Power, 2,000 MW of off-grid capacity including 20 million solar lighting systems and 20 million square meters solar thermal collector area by 2022 is under implementation [20].

According to the latest update of the MNRE, Solar in India has crossed the 2 GW landmark (grid-connected and off-grid systems combined). As on 31st October 2013, the total solar installed capacity stood at 2219 MW, out of which grid-connected solar capacity was 2080 MW and off-grid systems was 139 MW [8].

VIII. TIDAL ENERGIES

Tide is periodic rise and fall of the water level of the sea. Tides occur due to the attraction of seawater by the moon. Tidal energy can be harnessed in two ways. The first, Tidal range technology uses a barrage to draw on the power of the water as it changes height between high tide and low tide in a similar way to a hydroelectric system. Another one, Tidal stream technology (or marine current) draws on the power of fast currents caused by tides flowing around headlands or through channels. Both offer the same benefits of tidal energy:

(i) It is reliable and predictable well into the future

(ii) Water is 800 times denser than air, which gives it huge potential for power extraction

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(iii) It is a renewable energy source with no harmful greenhouse emissions

These tides can be used to produce electrical power which is known as tidal power. When the water is above the mean sea level, it is called flood tide and when the level is below the mean level, it is called ebb tide. A dam is constructed in such a way that a basin gets separated from the sea and a difference in the water level is obtained between the basin and sea. The constructed basin is filled during high tide and emptied during low tide passing through sluices and turbine respectively. The Potential energy of the water stored in the basin is used to drive the turbine which in turn generates electricity as it is directly coupled to an alternator.

In the state of Gujarat, the Gulf of Kutch is an appropriate place for electrical energy from the energy generated by tall and powerful tides moving into small brook [21].

IX. OCEAN THERMAL ENERGY CONVERSION

OTEC, Ocean Thermal Energy Conversion is an energy technology that converts solar radiation to electric power. OTEC systems use the ocean's natural thermal gradient, consequently the temperature difference between the warm surface water and the cold deep water below 600 meters by about 20 C, an OTEC system can produce a significant amount of power. The oceans are thus a vast renewable resource, with the potential to help us produce billions of watts of electric power. The cold seawater used in the OTEC process is also rich in nutrients and it can be used to culture both marine organisms and plant life near the shore or on land.

The total influx of solar energy into the earth is of thousands of times as great as Mankind's total energy use. All of our coal, oil and natural gas are the result of the capture of solar energy by life of the past. There have been many projects for harnessing solar energy, but most have not been successful because they attempt to capture the energy directly. The problem with this is that huge collectors must be deployed to do this, and resulting in large costs. The idea behind OTEC is the use of all natural collectors, the sea, instead of artificial collector [22].

Unlike wind and solar, the Plant Load Factor (PLF) of these plants may be around 80 percent. India has built a 1MW floating OTEC pilot plant near Tamil Nadu [23]. A pilot plant of capacity 14 MW is proposed to be set up in the State [24].

X. HYDROGEN FUEL CELL

A fuel cell by definition is an electrical cell, which unlike storage cells can be continuously fed with a fuel so that the electrical power output is sustained indefinitely. Electrical energy is produced by converting hydrogen, or hydrogen-containing fuels, directly along with heat through the electrochemical reaction of hydrogen and oxygen into water. The process is known as electrolysis in reverse.

Overall Reaction: $2H_2$ gas + O_2 gas → H_2O + energy

Because hydrogen and oxygen gases are electrochemically converted into water, fuel cells have many advantages over heat engines. These include: high efficiency, virtually silent operation and, if hydrogen is the fuel, there are no pollutant emissions. If the production of hydrogen is from renewable energy sources (such as wind, solar, geothermal, and hydroelectric power), then the entire system is truly sustainable. Formation of water and carbon dioxide are the two principle reactions in the burning of any hydrocarbon fuel. With the formation of water becoming more significant, there is an increase in the hydrogen content in a fuel resulting in lower carbon dioxide emissions.

XI. CONCLUSION

The anticipated energy deficit in India during 2013-14 is 6.7%. To diminish the gap between demand and supply of energy we need to generate more power. India has plenty of renewable energy potential to bridge the gap between demand and supply.

The potential of renewable energy for different resources are:

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Table 2: Renewable Energy Potential (as on 15th April, 2013)

Resources	Estimated Potential (MW)
1. Solar Power (30-50 MW/sq. km)	100,000
2. Wind Power (AT 80 m. height)	100,000
3. Small Hydro Power (upto 25 MW)	20,000
4(i) Bio-Power (Agro-Residues)	17,000
4(ii) Bio-Power (Cogeneration – Bagasse)	5,000
4(iii) Waste to Energy (Municipal Solid Waste to Energy)	2,600
4(iv) Waste to Energy (Industrial Waste to Energy)	1,280
Total	2, 45,880

Source: http://data.gov.in

There is need to increase total domestic energy production in order to reduce import dependence, combined with the need to move away from fossil fuels in the longer run in view of climate change considerations and it points to the need for stronger efforts to increase the supply of energy from renewables.

REFERENCES

[1] http://www.eia.gov/countries/analysisbriefs/India/india.pdf
[2] Powering Ahead With Renewables Leaders & Laggards, greenpeace, infraline energy, http://www.greenpeace.org/india/Global/india/report/2013/powering-ahead-with-renewables.pdf
[3] Dr. Tarlochan Kaur, "The Indian Power Sector – A Sustainable Way Forward," IEEE, IPEC2010, pp. 666-669.
[4] Load Generation Balance Report 2013-14, Government of India Central Electricity Authority, http://www.cea.nic.in/reports/yearly/lgbr_report.pdf
[5] Mapping India's Renewable Energy growth potential: Status and outlook 2013, http://www.ey.com/Publication/vwLUAssets/Mapping_Indias_Renewable_Energy_growth_potential/$FILE/EY-Mapping-Indias-Renewable-Energy-growth-potential.pdf
[6] http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf
[7] Energy Statistics 2013, central statistics office national statistical organisation ministry of statistics and programme implementation government of India, www.mospi.gov.in
[8] http://www.mnre.gov.in/mission-and-vision-/achievements
[9] energy, http://planningcommission.nic.in/hackathon/Energy.pdf
[10] Green Norms For Wind Power 2013, Centre For Science And Environment, www.cseindia.org
[11] Green Norms For energy Small Hydro Power 2013, Centre For Science And Environment, www.cseindia.org
[12] http://naturalscience.ku.edu.tr/wp-content/uploads/AKiraz_Scie111_Fall2013_12.pdf
[13] World Energy Resources 2013 survey, world Energy council,http://www.worldenergy.org/wp-content/uploads/2013/09/Complete_WER_2013_Survey.pdf
[14] Nan Wu and Xianfeng Liu, "Geothermal Energy Current State and Utilization in Oilfield, China:An Overview," IEEE 2011, 978-1-4244-8165-1/11
[15] A. Kumar, A. Garg, S. Kriplani and P. Sehrawat, "Utilization of Geothermal Energy Resources for Power Generation in India: A Review," 7th Internal conference & Exposition on Petrolium Geophysics, Hydrabad 2008,p-290
[16] P. C. Roy, "Role Of Biomass Energy For Sustainable development Of Rural India: Case Studies," International Journal of Emerging Technology and Advanced Engineering, Volume 3, Special Issue 3: ICERTSD 2013, Feb 2013, pages 577-582.
[17] Renewable energy in India 2013,Indo-German energy forum, http://energyforum.in/newsletter.html?file=tl_files/downloads/PDF%20News/RENEWABLE%20ENERGY%20IN%20INDIA%202013.pdf
[18] Vaddi Ramesh, P Anjappa and P.Dhanamjaya," Simulation and Implementation of Incremental Conductance MPPT with Direct Control Method Using Boost Converter," International journal of engineering science and innovative technology (ijesit) volume 2, issue 6, November 2013.
[19] Current Trends/Status in Solar Power Market, Workshop on "Challenges and Issues in Solar RPO Compliance/RECs" Hyderabad May 23, 2013.
[20] India's Energy Scenario in 2013 - Challenges & Prospects, http://www.hcasia.safan.com/mag/hcajanmar13/r06.pdf

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2014

[21] Sunil M.Satao, Dr.Vivek, Dr.Chetan, Nileema B.Patil and V.R.Naphade, "Utilization of Solar Energy as an Constituent of Green Energy Anticipated for Green Environment in India," IRACST- International Journal of Research in Management & Technology (IJRMTI), SSN: 2249-9563, Vol. 3, No.3, June 2013.

[22] Maria Bechtel and Erik Netz, Ocean thermal energy conversion, http:// www.exergy.se/ftp/cng97ot.pdf

[23] Ocean thermal energy conversion, http://www.mareasistemi.com/DIDATTICA%2014/Ocean%20thermal%20energy%20conversion.pdf

[24] Energy And Infrastructure, http://www.spc.tn.gov.in/12plan_english/9-Energy.pdf

[25] Opportunities & Issues in the Indian Renewable Energy Sector may 2013, IEEE: RE3P3,http://ieeebombay.org/wp-content/uploads/2013/05/PwC-RE3P3-03052013.pdf

[26] http://data.gov.in/sites/default/files/Estimated_Renewable_Energy_Potential_As_On_15th_April_2013.xls

BIOGRAPHY

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Prof. Tarlochan Kaur was born on August 1962 in Kanpur, India. She received her B.E (Honours), M.E and Ph.D degree of Electrical Engineering in 1984, 1985 and 1999 respectively all from PEC University of Technology. She started her academic career in 1987. At present she is Associate Professor in Electrical Department in PEC University of Technology, Chandigarh. Her area of interest includes electrical energy management and power systems and Renewable Energy Systems. Dr. Tarlochan is a life member of the Indian Society of Technical Education (MISTE), and member of Institution of Engineers (India).