(1) Comment # 1: The authors give a review about the special technical field of thermo photovoltaics and in solar thermal with a focus on absorbers at high temperature. However as I will reason later the reviewed area should be specified even in the introduction more precise and differentiate from others like solar thermal for hot water and heating demands and photovoltaic-thermal collectors, which are already on the market.

**Response:** The referee raises a good point there is considerable breadth to solar thermal technologies in terms of their end uses and the considerations that come in to play in engineering systems for each end use. We agree that we should clearly differentiate the technologies covered in this review, which focuses on Solar Thermal and Solar Thermophotoltaic systems which operate at high temperature with the end purpose of converting sunlight into electricity. While Solar Thermal systems for heating (such as hot-water heating) are useful systems which are already on the market, they are not a focus of this article.

**Action:** We have added text to clarify the focus of this review on solar thermal and solar thermophotovoltaics for solar-to-electrical energy conversion in paragraph 1 of the Introduction.

(2) Comment # 2: The manuscript gives a good overview about the endeavour to manage the efforts at solar and infra-red spectral range to get high efficiency. Theoretical work, software solutions for simulation and experimental performance were likewise approached.

However I have an uncomfortable feeling about many referenced work or the status of the technical field in general. Insofar I am very grateful for this review, and it underlines its importance. I can demonstrate my objections by reference to Table 3 about the efficiency of solar thermal photovoltaic systems. With absorber temperatures exceeding 1200 K and PV-cells based on Ge- or III-V-semiconductors, one reaches very low efficiencies. Even simulated systems (Table 3) exceed only moderate values.

**Response:** We agree with the referee that real-world STPV system efficiencies remain low; however, they have made significant progress since their inception. Due to the high theoretical efficiency limits and natural advantages of STPV systems (such as the ability to store power as heat and the lack of moving parts or a thermal fluid), we see this area as one which shows great promise. A goal of this research paper is to draw more attention to this growing field.

**Action:** We added text describing the gap between theoretical potential and current practical performance of STPV, and outlined our view of the opportunities that exist in the field in paragraph 1 of page 3. We highlight our summary of particular advantages of STPV systems that make these opportunities compelling in the second paragraph of page 2.

Obviously something is going wrong throughout the scientific community. To my impression the theoretical base of endeavour seems not to be confirmed. The author reference [11] and [37] claiming higher efficiency than Shockley-Queisser limit (page 33 lines 763-765), which is impossible when one compares equivalent conditions (light intensity, solar cell temperature) because Shockley-Queisser based on detailed balance concept. Equivalent limits as Shockley and Queisser are found by Ross and Hsiao [J. Appl. Phys. 48, 4783 (1977)], who applies first and second law of thermodynamic for solar radiation as black body radiation.

**Response:** We appreciate the referees comment here, and appreciate the opportunity to clarify an important distinction between STPV and traditional solar energy conversion using traditional PVs. While the Shockley-Queisser limit holds true for single-junction PV cells operating under sunlight, it does not limit the efficiency of heat engines such as STPV systems. STPV systems transform the broadband solar spectrum to a narrow thermal emission. This eliminates losses due to below-bandgap radiation and thermalization, which make up a majority of the Shockley-Queisser limit for typical PV cells with a broad spectrum input. The limit can still be applied to PV cells absorbing the narrowed emission from an STPV emitter, but it will be much higher than the case of traditional PV cells, and will allow for extremely high efficiency operation as has been extensively discussed in the literature (see for example Refs 5, 11, 40, 129, 130 of the submission).

**Action:** We have added a paragraph clarifying this distinction between single-junction PV cells operating under sunlight and STPV system in paragraph 2 of Page 30, including several relevant references (Refs 5, 11, 40, 129, 130 of the submission) where details about this relevant limit are derived and discussed in greater detail than permitted by the scope of this review.

(3) Comment # 3: For clarity of efficiency values mentioned in Table 3 and any others in running text I urgently suggest adding the relevant environment conditions of the system. Especially I am missing the type of useful energy for which efficiency is indicated (work power, electrical power or heat), the concentration factor of solar irradiance and the temperature of the solar cell in case of STPV. Beside of absorber temperature these boundary conditions determine the upper theoretical efficiency limit, which could be available.

**Response:** We agree that these points could be clarified.

**Action:** We have added details about the environment conditions of the systems and their end use (generation of electrical power) in paragraph 4 of page 33.

(4) Comment # 4: Furthermore equation (5) (referenced from [45]) about spectral efficiency seems to be incorrect. The equation relates to a common mistake for calculating solar cell efficiency. It takes semiconductor band gap as (upper limit of) photo-voltage multiplying with the number of absorbed photons exceeding the band gap. This is fundamentally wrong and does not taken Shockleys/Queissers and Ross/Hsiao´s theory into account. Considering thermodynamic limit determining by radiant recombination the open circuit voltage is about 0.5 V below corresponding band gap energy (without light concentration). The available voltage at maximum power point is about further kT/e lower. Additionally Auger recombination is an unavoidable intrinsic effect, which lowers maximum power voltage. So, using equation (5) conducts to drastic overestimation of efficiency (about 20% absolute) and to erroneous choice of "optimal" semiconductor band gap. These aspects do not influence manuscript value, but I suggest the authors a very critical attitude in respect to the referenced publications.

**Response:** We agree with the author that the overall device efficiency has a much more complicated dependence on component parameters than those given in Equation 5 (the spectral efficiency), and we appreciate the opportunity to further clarify the use of the Eq. 5 as an important, though idealized, metric for evaluating emitter components of STPV systems. In particular, we would like to clarify that Eq. 5 used to in the paper does not attempt to calculate the total efficiency of a STPV system. It only takes into account the specific losses due to thermal emission and the spectral mismatch between the emitted radiation and the PV cell. This is a useful tool because it captures the efficiency of the absorbing and emitting surfaces of the STPV system, and allows the surfaces to be optimized in isolation. While it is true that the wavelength dependence of PV cell EQE can have an effect on the optimum bandgap, this effect is small and does not significantly change the results of this equation. The fill factor and Voc of the cell will certainly lower device efficiency, but do not effect the relative comparison between various absorbing and emitting surfaces that this equation is meant to show.

**Action:** We have added text on paragraph 2 of page 33 that highlights the key factors that determine overall device efficiency which are NOT captured by Eq. 5, and also have highlighted text that clarifies that Eq. 5 should be seen as a figure of merit for the emitting surface only, not of the overall device.

(5) Comment #5: The reviewed claim about so-called thermophotovoltaic and solar thermophotovoltaic approaches is a questionable scientific field. Hardly spoken thermophotovoltaic is the science of constructing an incandescent light source effectively irradiating a solar cell matched perfectly to each other. And solar thermophotovoltaic is the special science when the mentioned light source is powered by solar irradiation instead of heat - more precisely: a spectral light source powered by solar irradiation illuminating the absorber from the same side as itself illuminates the photovoltaic cell. The concept is to absorb solar irradiation as much as possible for heating, and to reduce radiation losses as fare as possible except of a small bandwidth which couple perfectly with the solar cell band gap. This concept has to be failed as all the realized systems show too! A direct solar irradiation of the solar cell is generally more effective for electrical power. This holds for theoretical reasons and even in praxis, independent on concentration factor of solar irradiation. Solar irradiation corresponds to black body radiation at about 5900 K. No system being in thermal balance with the sun (including solar concentration) could have a higher emittance at any spectral range as the sunny black body equivalent. So the direct solar illumination of solar cell is always much more effective than via an absorber of any kind whatsoever constructed.

**Response:** While it is true that the maximum thermal emission per unit area of the STPV emitter will be lower than that of the sun (because its upper bound emission will be blackbody emission at a lower temperature), the area of the emitter will be much higher than the absorber in a high-efficiency STPV system. This will allow the STPV system to output more energy in total than the sun at a specific wavelength. To accomplish this, good control of absorbing and emitting surfaces is required. Additionally, because the output spectrum of the STPV system is well-matched to the PV cell, and thermalization losses are greatly reduced, there will be much less thermal energy absorbed by the PV cell. This results in a lower PV cell operating temperature and a reduced requirement for cell cooling.

We also wish to clarify that in an STPV device, the absorber is indeed illuminated from solar irradiation; however, the PV cell is not illuminated by the absorber. Rather, the absorber is in thermal contact with a selective emitter, and it is the emitter that illuminates the PV cell.

**Action:** We have added discussion of these points to paragraph 1 of page 5. We have added a schematic of an STPV device in Figure 1A and referenced the figure in the first paragraph of the introduction.

(6) Comment # 6: Solar to electrical power efficiency is available about 25%-34% with solar cells without any light concentration (solar modules with at least 20% efficiency are on the commercial market).

The authors claim (page 4, line48) Carnot limits efficiency of solar thermal (ST) and solar thermophotovoltaics (STPV) systems and reference a maximum efficiency of 85,4% at an operating temperature of 2600 K [33]. Using Carnot limit with absorber temperature as high temperature and environment as low temperature calculations is correct for transferring solar energy to power (exergy) by minds of a power-heat-machine. But the efficiency of solar thermal for heat use is higher, already in praxis! Absorbers for flat plate and vacuum tube collectors are annually produced with a quantity of several millions square meters, which have standardly a solar absorption between 95% and 97% and a thermal emissivity of about 3-5%. Flat plat collectors for domestic hot water or for heating works between environment temperature and about 80°C and reaches 85% solar-to-heat efficiency at environment temperature. So I firmly recommend a clear description which solar thermal systems author claim and which not.

**Response:** We agree these ST on the market for heating applications do have very impressive properties; however, current ST for solar-to-electrical power generation, which is the focus of this review, operate at relatively low temperatures. This limits the overall system efficiency by keeping the Carnot efficiency low. Increasing operating temperatures can alleviate this problem, but current ST technology will have very high thermal emission and low stability at increased temperatures. It is our view that both fundamental and applied research may overcome these challenges, and it is in part the purpose of this review to stimulate this research.

**Action:** We have added text to paragraph 1 of page 28 to distinguish the remaining challenges in ST systems for solar-to-electrical power generation, text to paragraph 1 of page 2 to indicate that we are principally concerned with solar-to-electrical power generation throughout this review, and text to paragraph 1 of page 3 to emphasize our view that the community may find solutions to some of the outstanding challenges through fundamental and applied research.

(7) Comment #7: Furthermore the used term thermophotovoltaic, which is used in this manuscript for high temperature applications, should be clearly distinguished from systems well known as photovoltaic thermal hybrid collectors. These systems are already on the market. The actively cooled PV-modules use electrical and heat power. Theses systems should be mentioned in the introduction.

**Response:** This is an excellent point, and we appreciate the opportunity to clarify the distinction between TPV systems (the focus of this work), where basic research is still ongoing, and hybrid PV/ST systems which have commercial application currently.

**Action:** We have distinguished between these different systems in Paragraph 1 of the Introduction.

(8) Comment #8: Chapter 2 gives a well overview about many efforts and technics optimizing absorbers as the importance of nanostructures, light straying and simulation technics. Authors reference publications for coatings as [21], [27] and [28] or calculations for sophisticated structures as [62-64, 68, 81]. Chapter 3 presents endeavours about so-called large area fabrication. The mentioned techniques are extremely expensive related to the prepared area, not available for square meters and even less for production lines. To my opinion these endeavours may have only academic interest or may applicable for small area applications if absorber costs are irrelevant in respect to other system costs. For reliability I suggest to communicate maximum area, expected specific costs or potential field of application for the presented techniques (interference lithography, laser writing, sintering and texturing.

**Response:** The referee raises a valid point that large area fabrication methods are not available for square meters and even less for production lines; however it is important to note that in solar thermophotovoltaics the incident sun light is highly concentrated with concentration factor of many 1000 times, so the focused light beam size is relatively small (less than an inch in diameter). So, the discussed methods are still applicable. In terms of reduction of cost, one can consider utilizing an imprinting process using a master for low cost fabrication process.

**Action:**We have added text to the first paragraph in section 3 in the revised manuscript to address this point (paragraph 2 of page 24).

(9) Comment #9: However the referenced results seem to be moderate compared to technical products being already on the market for parabolic trough technology. The PTR 70 receiver from Schott and UVAC 2010 from Siemens get 95-96% solar absorbance and 10-14% respectively less than 9% emissivity at 400°C. In both cases the absorber is deposited on stainless steel pipes, which are installed inside of an evacuated quartz glass pipe. Another example I know from the Israeli company Acktar, which produce absorbers with standard vacuum techniques. The strong absorbance of the coating is based on a broad scaling range rough structure, similar to fractal structure. Solar thermal (ST) systems are solar powered devices that generate

**Response:** We agree that these ST systems on the market do have very impressive properties; however, they operate at relatively low temperatures. This limits the overall system efficiency by keeping the Carnot efficiency low. Increasing operating temperatures can alleviate this problem, but current ST technology with have very high thermal emission and low stability at increased temperatures.

**Action:** We have added text to Paragraph 1 in Section 4 on page 28 of the revised manuscript emphasizing the need to increase operating temperatures for ST systems with the end goal of solar-to-electrical power generation.

(10) Comment #10: Several times tungsten is referenced as absorber at high temperature (e.g. at 1700K, table 2, page 32). It was not mentioned that W and other metals with high melting points are very easily oxidized in air and their oxides evaporate even at low temperature. So all these concepts requires expensive vacuum systems.

**Response:** This is also an excellent point, and we appreciate the opportunity to elaborate upon it in our review. It is indeed true that tungsten readily oxidizes and several of its oxides evaporate at the high temperatures mentioned in this review, there are several practical strategies which are very effective in mitigating this effect. One approach is to introduce an inert gas as is done in the lightbulb industry, where only a partial vacuum is required to eliminate oxygen and water and argon gas is used as the fill gas. Additionally, dielectric coatings on tungsten that are themselves non-oxidizing (several examples include halfnium oxide, silicon nitride, and yttria stabilized zirconia) may be used to protect tungsten from oxidation; in fact, the use of such coatings may be used to improves the emissive properties of tungsten as was the case for several high-efficiency emitter structures reported in table 2.

**Action:** We have elaborated on this issue, and several practical mitigating strategies with supporting references, in paragraph 1 of page 7.

(11) Comment #11: Insofar I am missing a justification for all these sophistic activities. I would be very thankful when authors could work out the unsolved challenges.

**Response:** We appreciate the referee’s comments, and would like to emphasize that it is our view that a combination of fundamental and applied research in the scientific community (which all authors of this work are involved in) will lead to advances that overcome these unsolved challenges. There have also been a recent resurgence in activity in this field, as evidenced by recent publications and conferences focusing on these topics, so we believe that this review is timely.

**Action:** We have added text on paragraph 1 of page 3 emphasizing the view of the authors concerning continued fundamental and applied research to overcome these unsolved challenges, and we have highlighted some of the key research areas that we will lead to these advances in the final paragraph on page 37.