GREEN SCREENS, GREEN PIXELS AND GREEN SHOOTING

A REPORT ON VIRTUAL PRODUCTION AND ITS OPPORTUNITIES FOR SUSTAINABLE FILM PRODUCTIONS.

Sustainability and green producing are in high demand in all sectors of creative industries. Fortunately, this topic is very well received by film students and therefore offers an excellent opportunity for young talents who want to apply new and sustainable methods in creative processes. Virtualization and Virtual Production in particular are predestined to play an essential role in fulfilling this demand. Factors that can be considered here are travel needs, lighting energy consumption, post-production complexity, energy sources and many more. The pandemic did propel these Virtual Production technologies to common practice, in particular large LED walls for In-Camera VFX (ICVFX).

Some reports on the environmental impact of traditional film productions are available [Screen New Deal 2020] estimating an average CO2 demand of 2840 tonnes for tentpole film productions (figure 2). However, these tentpole productions did not consider VFX. To date, there is little to no knowledge on the sustainability of Virtual Production and how it compares to traditional offline VFX productions. We take a closer look at two comparable productions, one using traditional offline rendering and post-production, the other using an LED wall and ICVFX. Energy requirements, creative opportunities and scalability are subjects of investigation and further discussion.

INITIAL CONDITIONS

The productions compared here are the offline production "Sprout" from 2019 and the most recent production "Awakening" realized as a Virtual Production within the Set-Extension Workshop in 2021, an annual seminar at Filmakademie Baden-Württemberg. The workshop involves students of diverse creative departments (Production, Set Design, Directors of Photography, Lighting, Animation and VFX) teaching them to work within a green-screen set. The goal of the seminar is not necessary a fully produced film. However, as student engagement at Filmakademie is very high, some of the workshop results became successful productions. For example the "Obolus"[1] production was screened at multiple festivals and even won an award[2]. Since 2020 this workshop has been realized using an LED wall. "Awakening" used a 4x10 meter curved LED wall featuring LED panels with a 1.9 mm pixel pitch[3]. Pre- and post-production workstations as well as the displays power estimates were reduced by 30% to account for variations as students were also attending meetings and other appointments. Notice also that these workstations don't run at maximum load during the work day (compared to a render node at maximum capacity).

1 https://youtu.be/wt0JGtXjoNk
2 Spark Animation Festival 2017, WINNER, BEST VFX: Obolus
3 https://www.leditgo.de/files/pdf/LEDitgo_rXone_Datenblatt.pdf

FIGURE 1, ON SET THE "AWAKENING" PRODUCTION.

OFFLINE PRODUCTION "SPROUT"

The vast majority of power in this production was consumed in offline rendering for post-production. The studio recordings were realized in 2 days. The production had 8 shots with a total of 3233 frames including VFX. The estimate includes a usual amount of re-renders of the same shot. Our internal render management system[4] keeps track of all jobs in a database. This allowed us to access this data retrospect. Jobs were executed on blades in our data center and on idle workstations in student and classrooms. The blades provide power consumption data via an internal meter. Workstations were measured using an off the shelf power meter[5] and Cinebench R20 multi CPU benchmark[6]. We compared the measured data with spec sheets and system tools and found only minor deviations. Blades were calculated with 500 W each. The average render times were between 40 minutes and up to 2 hours. Workstations were estimated at 380 W. Pre-production (Previs, Techvis, Set Design) required 100 person days (8h a day). Post-production (Assets, Shading, Lighting, Animation, Render Test, Compositing) was accomplished within 300 person days. Displays were estimated with 80W. Pre- and post-production involved 5 students. As such the power consumption resulted in a total of 5073 kWh (figure 3 for details) consisting of 4% pre-production, 13% post-production, 79% offline rendering and 4% for the displays. (figure 4 left).

LED WALL PRODUCTION "AWAKENING"

This production did not use a green-screen but a curved LED Wall to extend the real set by a virtual background. 8 shots were produced with a total of 8898 frames. Energy consumption was measured during 2 days and 17 hours on 2 high voltage power lines. This period included the entire production time consisting of 1 day setup and 2 days of production. Professional energy meters[7] logged the current over time, from which we calculated the linear average power consumption at 4,6 kW for 65 hours.

The total energy consumption for the LED wall was 299 kWh. One square meter of our 10x4 meter setup required approximately 115 W.
The workstation providing the visuals for the LED wall had 2 Nvidia RTX A5000 graphics cards each running a resolution of 2560x2084 at 50 Hz. Maximum power consumption for this system was 550 W. This resulted in 11 kWh power consumption when considering running for 20 hours straight at maximum capacity over 1 day setup and 2 days production. We double this value as an additional operator workstation was required.

Pre-production required a higher demand on asset preparation as they needed to be final on the days of production in the studio. The workstations used in pre-production had recent graphics cards and their maximum system load was determined between 500 and 700 W. Notice that during pre-production the system will not run on maximum capacity all the time. Nevertheless, we used the average of

4 https://www.royalrender.de/
5 Dewenwils DHPM101A Energy Power Meter
6 https://www.maxon.net/en/cinebench
7 Fluke 1730, https://www.fluke.com/

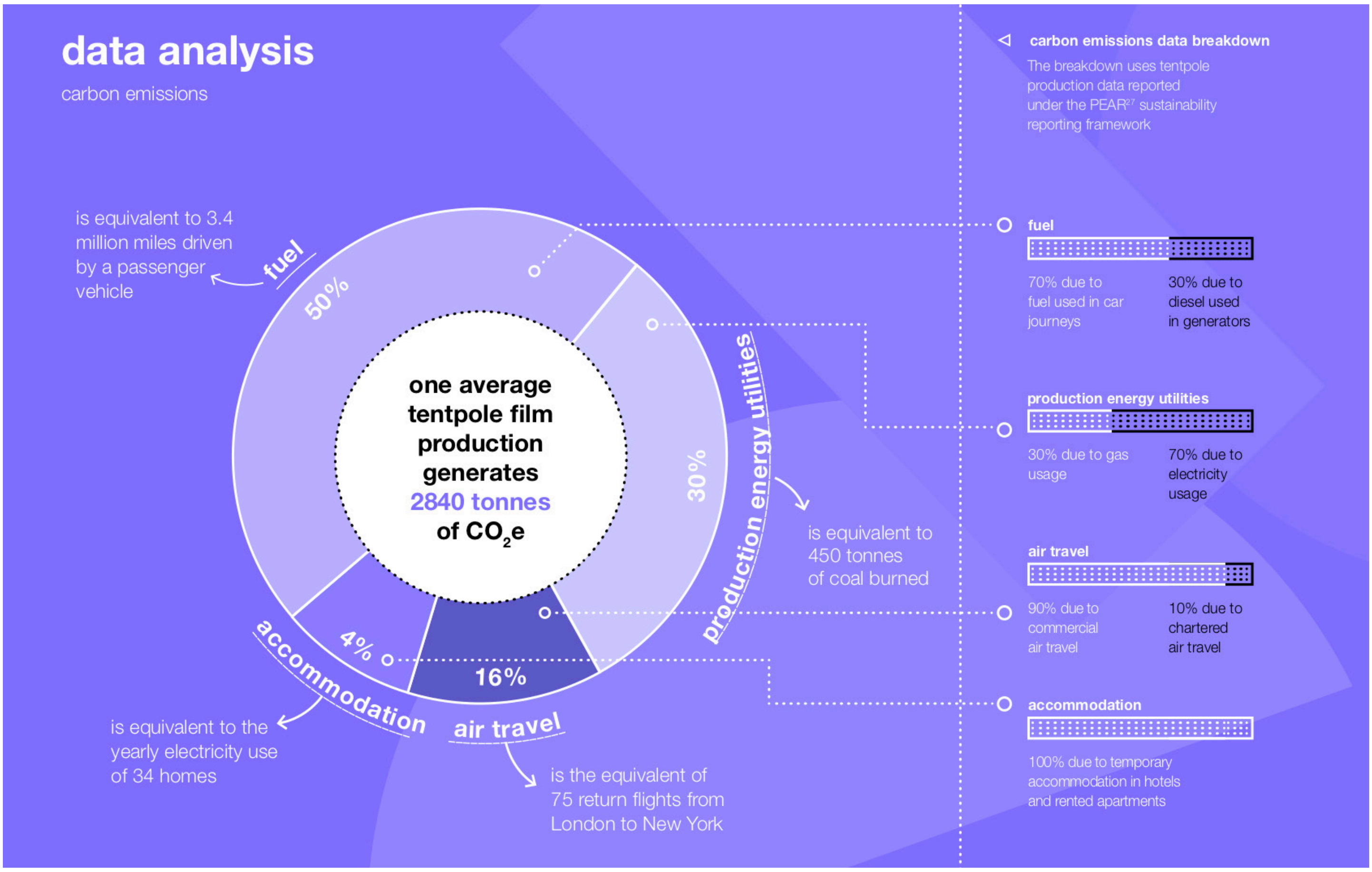

FIGURE 2, CARBON EMISSION FOR TENTPOLE FILM PRODUCTION ACCORDING TO SCREEN NEW DEAL REPORT FROM 2020

600 W for the 5 weeks of pre-production involving 7 students estimating a total of 588 kWh. Post-production involved 6 persons for another 5 weeks resulting in 504 kWh. One might expect a lower number here as the concept of ICVFX assumes all pixels shot on set are final. Notice that the total amount of frames is almost 3 times higher as in the offline production. The work carried out was in grading, digital atmospheric effects and transitioning to fully computer generated sequences. As such the total power consumption for the LED wall production was estimated at 1594 kWh (figure 3 for details) consisting of 37% pre-production, 31% post-production, 10% displays, 19% LED wall, 1% LED wall rendering and 2% offline rendering (figure 4 right).

ON-SET LIGHTING

Both productions involved studio lighting, which is remarkable when considering energy budgets. We did not include this into the energy calculation as both productions used additional lighting to equal amounts. The LED Wall itself did act as a light source but needed additional lighting.

EXEMPTIONS

Cooling and data storage energy consumption were no factors of consideration at this point in time. Given the current numbers, we assume that the offline production required more cooling and storage as the data has been produced over a longer period of time. We plan to investigate these topics in future reports.

	Max power considered
Render node	0,5 kW
Workstation	0,38 kW
Display	0,085 kW
Real-time Workstation	0,6 kW
LED wall render slave	0,55 kW

	Sprout (Offline)		Awakening (Virtual Production)	
Production days in studio	2 days		2 days	
Final frames with VFX	3233 frames		8898 frames	
Pre-production	100 person days	213 kWh	175 person days	588 kWh
Post-production	300 person days	638 kWh	150 person days	504 kWh
Displays (Pre and Post-prod.)	400 person days	190 kWh	325 person days	155 kWh
Offline Rendering		4032 kWh		27 kWh
LED wall				299 kWh
Real-time Rendering				22 kWh
		5073 kWh		**1594 kWh**

Figure 3, Individual energy demands. Notice that displays, pre- and postproduction were reduced by 30% due to systems not running at max power for 8 hours straight in a realistic work day scenario.

CONCLUSION

Several aspects appear interesting to us. Most prominently, figure 3 shows that a Virtual Production can consume about a third of the energy needed for an comparable offline rendered production. Therefore, Virtual Production can be considered a sustainable and also green shooting solution especially if run on renewable energy as practiced at Filmakademie Baden-Württemberg.
Furthermore, travel costs can be reduced as real sets can be digitized into virtual environments for LED volumes. Multiple LED volume studios opened recently all over the world. Such studio facilities are available for hire locally so companies willing to adapt Virtual Production do not necessarily need their own studio. In the discussed example, the LED Wall production produced more material (frames) in equal time on set compared to the offline production.

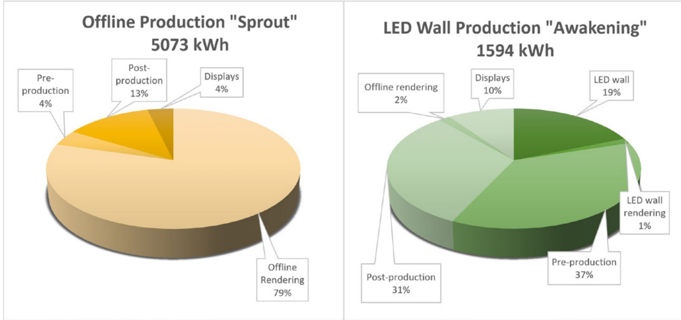

Figure 4, Offline and LED wall productions' total power consumption

Apart from sustainability aspects, Virtual Production also allows for a unique opportunity of democratization in filmmaking beyond shooting with LED walls. Tools for digital collaborative previsualiztation, set design, lighting and shot planning are available at low costs [SAUCE 2020, VPET 2018] for consumer hardware. One of the primary objectives in Virtual Production was to bring creative decisions back onto the film set while providing real-time interactive previews for actors, DoPs and other set staff. Potentially, the final image can even be captured on set without the need for extensive post-production like compositing. Thereby, creativity and efficiency in general can be considered to be increased as post-production is no longer separated from the actual shoot. However, this comes with an increased demand on technical understanding in all departments and a willingness to adapt to new procedures and methodology. Filmakademie Baden-Württemberg is keen on addressing these challenges in its global curriculum, by its internal R&D department and engagement in industry and academic research projects.

As this conclusion might sound like a clear vote for Virtual Production, we think that it is not a solution for all aspects of a film production. It should be considered as a fantastic opportunity in times of need for environmental friendly and sustainable solutions. Therefore, traditional greenscreen will remain part of our curriculum.

Lastly, we would like to consider scalability of the results as the LED wall was relatively small compared to professional studio spaces with ceiling and sidewalls. Given the smaller scale of the offline student production ("Sprout") in terms of complexity and render times it also does not compare to a recent blockbuster production involving multiple post-production facilities.

ADDITIONAL OBSERVATIONS

Hopefully, this report did send a clear signal towards the opportunities of new production technology and methods. However, questions arise about common practice in major studios, where average render times of up to 350 hours per frame are a reality [Pixar 2021]. While this example is certainly not practice for all shots of a movie some questions remain: Is physical correctness really a requirement for an animated movie? Could something less energy hungry be equally visually impressive (e.g. by utilizing clever optimisation as common practice in game development due to hardware limitations)? Can smart uses of compositing achieve a somewhat similar result? The mindset to use all resources to their maximum capacity just because they are available should be reconsidered, facing the need to make film productions more sustainable.

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REFERENCES

Steve May. 2021. Pixar Special Event:
How Pixar Sees Real Time Technologies Impacting Feature Animation Pipelines.
Real-time Conference 2021. Retrieved January 17, 2022 from https://realtimeconference.com/

Simon Spielmann, Volker Helzle, Andreas Schuster, Jonas Trottnow, Kai Götz, and Patricia Rohr. 2018.
VPET: Virtual Production Editing Tools.
In: ACM SIGGRAPH 2018 Emerging Technologies (Vancouver, British Columbia, Canada)(SIGGRAPH '18).
Association for Computing Machinery, New York, NY, USA, Article 22, 2 pages.
https://doi.org/10.1145/3214907.3233760

Jonas Trottnow, William Greenly, Christian Shaw, Sam Hudson, Volker Helzle, Henry Vera, and Dan Ring. 2020.
SAUCE: Asset Libraries of the Future.
In: The DigitalProduction Symposium (Virtual Event, USA) (DigiPro '20). Association for Computing Machinery, New York, NY, USA, Article 3, 5 pages.
https://doi.org/10.1145/3403736.3403941

albert, 2020.
Screen New Deal. [online].
[Accessed 02/02/2022]. Available from:
https://bit.ly/3GkyKoe

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